Productivity, (Mis)allocation and Trade*

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Abstract

We examine the impact of international trade on aggregate welfare and productivity. We show theoretically and numerically that bilateral and unilateral export liberalizations increase aggregate welfare and productivity, while unilateral import liberalization can either raise or reduce them. However, all three trade reforms have ambiguous effects in the presence of resource misallocation across heterogeneous firms. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we empirically establish that exogenous shocks to both export demand and import competition generate large aggregate productivity gains. We develop a precise mapping between theory and empirics, and provide evidence for the adjustment mechanisms. First, both trade aspects increase average firm productivity, but export expansion also reallocates activity towards more productive firms, while import penetration acts in reverse. Second, both export and import exposure raise the productivity threshold for survival, but the latter is not a summary statistic for aggregate productivity. Finally, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion. We conclude that the effects of globalization operate through firm selection and reallocation in the presence of resource misallocation.

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1 Introduction

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

Economics theory provides a clear rationale for trade liberalization: it enables a more efficient organization of production across countries, sectors and firms, which generates aggregate productivity and welfare gains. In particular, heterogeneous-firm trade models emphasize the importance of firm selection and the reallocation of activity across firms as key channels 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 impact of international trade on aggregate productivity. We show theoretically and numerically that bilateral and unilateral export liberalizations increase aggregate productivity and welfare, while unilateral import liberalization can either raise or reduce them. However, all three trade reforms have ambiguous effects in the presence of resource misallocation across heterogeneous firms. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we empirically establish that exogenous shocks to both export demand and import competition generate large aggregate productivity gains. We develop a precise mapping between theory and empirics, and provide evidence that unpacks the adjustment mechanisms. First, we decompose the aggregate productivity gains. We find that both trade activities increase average firm productivity, but export expansion also reallocates activity towards more productive firms, while import penetration acts in reverse. Second, we show that both export and import exposure raise the minimum productivity among active firms. Finally, we document that efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion. We conclude that the effects of globalization operate through firm selection and reallocation in the presence of resource misallocation.

Our first contribution is theoretical. We examine the impact of trade liberalization in a standard heterogeneous-firm trade model with potential resource misallocation. We also numerically simulate the model to assess its qualitative and quantitative predictions. We emphasize two main results.

First, in the absence of misallocation, reductions in bilateral trade costs and in unilateral export costs unambiguously raise aggregate productivity and welfare, as in Melitz (2003) and Melitz and Redding

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

(2014). On the extensive margin, such reforms raise the productivity threshold above which domestic firms can operate. On the intensive margin, they shift activity from less towards more productive firms. By constrast, unilateral import reforms have ambiguous consequences because they increase market competitiveness both in the liberalizing country and in its trade partner, with opposite effects on the productivity cut-off at home. This results in welfare and productivity gains when wages are flexible, but leads to Metzler-paradox losses when wages are fixed in an outside sector, as in Demidova and Rodriguez-Clare (2013) and Bagwell and Lee (2016).

Second, with resource misallocation, the impact of both bilateral and unilateral trade liberalization on aggregate productivity and welfare becomes ambiguous. Moreover, this impact is not monotonic in the degree of misallocation, such that more severe distortions may amplify, dampen or reverse the gains from trade. In the model, firms receive two exogenous draws, productivity φ and distortion η. Distortions η create a wedge between the social and the private marginal cost of production, and generate an inefficient allocation of production 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 productivity and welfare effects because distorted economies operate in a second-best equilbirum and trade reforms can worsen or improve allocative efficiency.

Our second contribution is methodological and provides an important bridge between theory and empirics. We demonstrate how key theoretical concepts in the model map to empirically observable variables, and how theoretical mechanisms can be assessed with available data. We first show that firm productivity measured by real value added per worker is monotonic in theoretical firm productivity, conditional on export status. We then demonstrate that welfare is generally not monotonic in measured aggregate domestic productivity, defined as employment-weighted average firm productivity. The two are proportional only in the special case of no misallocation, flexible wages, and free entry with Pareto-distributed productivity. In practice, they also move together in a wide segment of the parameter space away from this special case, but only in the absence of misallocation.

We next decompose measured aggregate productivity into the measured unweighted average firm productivity and the measured covariance of firms' productivity and employment share, as in Olley and Pakes (1996). While it may be intuitive that the latter should capture allocative efficiency, we show that it is not a sufficient statistic either for the model parameters governing misallocation or for the extent of realized misallocation. Nevertheless, the OP decomposition is very informative as it has testable and falsifiable implications: Numerical simulations indicate that trade reforms can move the two OP components of aggregate productivity in opposite directions if and only if there is resource misallocation.

Our third contribution is empirical. Guided by theory, we empirically assess the effect of international trade on aggregate productivity and the mechanisms through which this effect operates. We use rich new data assembled by the Competitive Research Network at the ECB on aggregate labor productivity for 14 European countries and 20 manufacturing industries during 1998-2011. These data are unique in capturing not only aggregate outcomes, but also multiple 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 countries' trade exposure are their gross exports and imports by sector from the World Input-Output Database. Since these trade outcomes are endogenous, we exploit a 2SLS IV strategy to identify the causal impact of plausibly exogenous shocks to export demand and import competition. This strategy uses the variation in the initial composition of countries' trade flows, and capitalizes on two WIOD features: the distinction between gross and value-added trade flows, and the information on the sector of final use for each trade flow. We instrument for export demand with a Bartik-style weighted average of absorption across a country's export destinations, by sector. We instrument for import supply with import tariffs and a Bartik-style weighted average of value-added exports for final consumption across a country's import origins, by sector. We provide consistent results when we alternatively consider (instrumented) import competition specifically from China, and confirm the stability of our findings to a series of robustness exercises.

We first establish that both export expansion and import penetration significantly increase aggregate productivity. Our estimates imply that a 20% rise in export demand would boost overall productivity by 7.6%-8.2% depending on the specification, while a comparable change in import competition would generate productivity gains in the 1%-10% range. We then perform three empirical exercises to understand the mechanisms generating these effects.

First, the OP decomposition reveals that the productivity gains from export and import activity are mediated through different channels. Export growth both induces higher average firm productivity and reallocates economic activity towards more productive firms, with the latter contributing 23%-39% of the total impact. By contrast, all of the benefits from import competition result from improved average firm productivity, with 17%-36% of these gains in fact negated by a shift in activity towards less productive firms. Through the lens of the model, the sign pattern of these effects can only be rationalized with trade inducing reallocations across heterogeneous firms in the presence of resource misallocation.

Second, both export and import exposure raise the minimum productivity among active firms, consistent with international 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 impact of trade on aggregate or average productivity. This contradicts a strict prediction of our model without misallocation, with the caveat that minimum productivity may be measured with error and alternative modeling choices may weaken the sufficient-statistic argument.

Finally, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion. We measure broad institutional quality with rule of law and corruption, and exploit indices for labor market flexibility, creditor rights' protection and product market regulation to proxy institutional frictions in input and output markets. While the impact of resource misallocation on the gains from trade is theoretically ambiguous, this constitutes direct evidence that misallocation indeed moderates the impact of globalization.

Together, our empirical findings indicate that firm heterogeneity and resource misallocation jointly determine the effects of trade liberalization on aggregate welfare and productivity. They also suggest that distorted economies adjust asymmetrically in response to positive versus negative shocks to domestic firms, such as growing export demand compared to tougher import competition.

This paper characterizes and quantifies the aggregate productivity gains from import and export expansion in the presence of firm heterogeneity and resource misallocation. It thus contributes to several active strands of literature.

At a broad level, we advance research on the role of firm heterogeneity for the gains from international trade, and inform the empirical validity of the thereotical mechanisms it highlights. 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 typically analyzed one-sided trade liberalization episodes in specific countries, often exploiting micro-level data. For example, Bernard et al. (2006) show that following a decline in trade barriers in the U.S., liberalized sectors experienced faster productivity growth both because the least productive firms exited and because more productive firms expanded operations. Pavcnik (2002) estimates that about 2/3 of the aggregate productivity gains from trade reforms in Chile in the late 1970s resulted from improvements in the OP covariance term. On the other hand, Harrison et al. (2013) conclude that most of the productivity benefits from trade liberalization in India during 1990-2010 came from changes in the average productivity of surviving firms.[2] Our contribution is to provide systematic cross-country evidence for high- and middle-income countries, that nevertheless examines the firm dimension, establishes causality, and compares export access and import competition.

Separately, our work 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 and lower aggregate productivity. Thus cross-country differences both in the primitive firm productivity distribution and in the degree of resource misallocation help explain aggregate productivity differences across nations (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). While these conclusions have been shown robust to alternative micro-foundations for misallocation, however, different economic environments deliver different predictions for the cross-firm dispersion in measured productivity and marginal products of capital and labor. We demonstrate how these insights about firm heterogeneity and misallocation extend to and generate additional effects in an open economy, general-equilibrium trade model. We also analyze the disconnect between conceptual and measured productivity and gains from trade with and without misallocation.[3]

[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 multiple 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 reallocations of activity among domestic firms.

[3] Burstein and Cravino (2015) explore the relationship between measured aggregate productivity, real GDP, real con-

Most directly, we contribute to vibrant recent research at the intersection of the above two literatures. While international economics has traditionally assumed that resources are efficiently and instantaneously reallocated across firms, a growing body of work examines the impact of institutional and market frictions for international trade. Credit constraints have been shown to deter export entry, distort multiple dimensions of import and export participation at the firm level, and reduce aggregate trade flows (e.g. Chor and Manova 2012, Manova 2013, Foley and Manova 2015 literature review). Similarly, various search and matching 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 welfare and productivity gains from trade. Our analysis relates to several studies in this vein. The closest is Bai et al. (2018), who 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 these distortions result in TFP losses and lower welfare gains following trade liberalization. Instead of distortions to firms' input costs, 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. Other types of product market distortions can also matter. 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 capital, labor and product market frictions, variable mark-ups that are absent from our framework can result in 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 2018).

The rest of the paper is organized as follows. Section 2 theoretically and numerically examines the impact of globalization on aggregate productivity. Section 3 introduces the CompNet and WIOD data. Section 4 presents the baseline OLS estimates, while Section 5 develops the IV estimation strategy and reports the main IV results. Section 6 explores the mechanisms through which international trade operates. 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). We formalize the main theoretical results and provide intuition for the underlying mechanisms in this section, and

sumption and gains from trade in the absence of misallocation.

[4] Ding et al. (2016) document that import competition reduces observed productivity dispersion in China due to the exit of less productive firms. This is consistent with an improvement in allocative efficiency under certain modeling assumptions, such as those in Hsieh and Klenow (2009).

relegate detailed proofs to Appendix A.

Our goal is threefold. First, we highlight that in the absence of resource 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 presense of misallocation. Third, we characterize the relationship between the concepts of welfare and productivity in the model and productivity measures in the data to provide a bridge between theory and empirics.

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 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. It proves important to distinguish between two cases. When β is sufficiently low, both countries produce the homogeneous good, such that it serves as the numeraire, $P_{iH} = 1$, and fixes worldwide 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 given by $P_i = P_{iQ}^{\beta}$.

In each country, a continuum of monopolistically competitive firms produce horizontally differentiated goods 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

[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.

[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.

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 resource 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 $\underline{\varphi} = \varphi\eta$, 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.

Finally, in our model misallocation stems from the inefficient allocation of production resources and consequently market shares across firms in the differentiated sector, as well as across sectors when $\beta < 1$. Since CES preferences and monopolistic competition will imply constant mark-ups, no additional misallocation arises from variable mark-ups across firms as in Dhingra and Morrow (2016).

2.2 Economy Equilibrium

Firm behavior: We first characterize firms' optimal behavior in the absence of resource misallocation. Producers choose their sales price $p_{ij}(\varphi)$ and quantity $q_{ij}(\varphi)$ to maximize profits $\pi_{ij}(\varphi)$ separately

[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).

[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 each market j they serve. The problem of a firm with productivity φ and its first-best outcomes are:

$$\begin{aligned}
\max_{p,q} \pi_{ij}(\varphi) &= p_{ij}(\varphi)q_{ij}(\varphi) - w_i\tau_{ij}q_{ij}(\varphi)/\varphi - w_i f_{ij} \quad \text{s.t.} \quad q_{ij}(\varphi) = \beta E_j P_{jQ}^{\sigma-1} p_{ij}(\varphi)^{-\sigma} && (2.2)\\
p_{ij}(\varphi) &= \frac{w_i\tau_{ij}}{\alpha\varphi}, \quad q_{ij}(\varphi) = \beta E_j P_{jQ}^{\sigma-1}\left(\frac{\alpha\varphi}{w_i\tau_{ij}}\right)^{\sigma}, && (2.3)\\
l_{ij}(\varphi) &= f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi)}{\varphi}, \quad c_{ij}(\varphi) = w_i\left(f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi)}{\varphi}\right), && (2.4)\\
r_{ij}(\varphi) &= \beta E_j\left(\frac{\alpha P_{jQ}\varphi}{w_i\tau_{ij}}\right)^{\sigma-1}, \quad \pi_{ij}(\varphi) = \frac{r_{ij}(\varphi)}{\sigma} - w_i f_{ij}. && (2.5)
\end{aligned}$$

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:

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

We assume as standard that the parameter space guarantees $\varphi_{ij}^* > \varphi_{ii}^*$ for any $\tau_{ij} > 1$. Along with consumer love of variety and fixed operation costs, this implies selection into exporting, such that no firm exports without also selling at home. In turn, firms commence production upon entry only if their productivity draw is above φ_{ii}^*, and exit otherwise.

Following the same solution concept, we next determine firms' constrained-optimal behavior 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:

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

$$\begin{aligned}
p_{ij}(\varphi,\eta) &= \frac{w_i\tau_{ij}}{\alpha\varphi\eta}, \quad q_{ij}(\varphi,\eta) = \beta E_j P_{jQ}^{\sigma-1}\left(\frac{\alpha\varphi\eta}{w_i\tau_{ij}}\right)^{\sigma}, && (2.8)\\
l_{ij}(\varphi,\eta) &= f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi,\eta)}{\varphi}, \quad c_{ij}(\varphi,\eta) = w_i\left(f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi,\eta)}{\varphi\eta}\right), && (2.9)\\
r_{ij}(\varphi,\eta) &= \beta E_j\left(\frac{\alpha P_{jQ}\varphi\eta}{w_i\tau_{ij}}\right)^{\sigma-1}, \quad \pi_{ij}(\varphi,\eta) = \frac{r_{ij}(\varphi,\eta)}{\sigma} - w_i f_{ij}. && (2.10)
\end{aligned}$$

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) distortion draws η produce and earn less (more) than in the first best, while charging consumers higher (lower) prices than efficient. Along the extensive margin, a highly productive firm might be forced to exit if it endures prohibitively high distortive taxes, while a less productive firm might be able to operate or export if it benefits from especially high subsidies. In particular, firms now sell in the domestic and foreign market as long as 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 international trade balance in each country.

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

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

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, threshold 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} denote total labor employed in the homogeneous-good sector and L_{iQ} denote total labor employed in the differentiated-good sector, which includes labor used in entry, domestic production, and exporting. 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 and there is no binding constraint on L_{iQ}. When $\beta = 1$ and $L_{iH} = 0$, by contrast, wages are flexible and determined by $L_i = L_{iQ}$.

In equilibrium, aggregate consumer 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]

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

Consider next the case of resource 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 to labor costs, 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:

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

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

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

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

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

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

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 $\chi_i < 1$; even if less realistic, it is in principle also possible that $\chi_i > 1$.Misallocation also affects welfare through distortions to firm selection on the extensive margin and firm pricing on the intensive margin, both of which influence P_i.

One can show that the real wage, and therefore also welfare, is a function only of model parameters (market size L_i, fixed production costs f_{ii}, demand elasticities β and σ) and two endogenous equilibrium outcomes: the (distorted) productivity cut-off for domestic production, φ_{ii}^* or $\underline{\varphi}_{ii}^*$, and the ratio of disposable to gross income, χ_i:[13]

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

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.

2.3 From Theory to Empirics

A key challenge in empirically evaluating the gains from trade is that the theoretical concepts of productivity and welfare are not directly observed in the data. We now show that measurement error

[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 $\beta < 1$.

and resource misallocation generate important disconnect between these theoretical objects and their measured counterparts that the literature typically ignores. This will closely guide our empirical design.

We focus the discussion on firm and aggregate productivity in the differentiated-goods sector. While the latter is equivalent to economy-wide productivity only in the single-sector model, it is also the object of interest in the two-sector model since then the homogeneous sector features CRS production. We are however careful to always define welfare and the consumer price index at the economy level.

Theoretical vs. measured firm productivity: The theoretical concept of firm productivity φ is quantity-based (TFPQ), while empirical measures $\Phi_i(\varphi)$ are generally revenue-based (e.g. TFPR or labor productivity). Measured real value added per worker, however, is an attractive choice for $\Phi_i(\varphi)$ for our purposes.

Observed value added corresponds to total firm revenues from domestic sales and any exports, $r_i(\varphi) = \sum_j r_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$ in the model. 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 $P_{iQ} = P_i^{1/\beta}$, real value added per worker is:

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

One can show that conditional on export status, measured firm productivity increases monotonically with theoretical firm productivity, $\Phi_i'(\varphi|\varphi < \varphi_{ij}^*) > 0$ and $\Phi_i'(\varphi|\varphi \geq \varphi_{ij}^*) > 0$. Although the ratio of sales to variable employment, $r_i(\varphi)/[l_i(\varphi) - f_i(\varphi)]$, is invariant across firms because all firms charge the same mark-up, the ratio of sales to total employment, $r_i(\varphi)/l_i(\varphi)$, rises with φ because of economies of scale. However, 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 $r_{ii}(\varphi_{ij}^*)/l_{ii}(\varphi_{ij}^*) > r_{ij}(\varphi_{ij}^*)/l_{ij}(\varphi_{ij}^*)$. Note also that measured firm productivity increases with the real wage, w_i/P_i, and implicitly depends on the productivity thresholds, φ_{ii}^* and φ_{ij}^*, through their impact on P_i.

In the case of misallocation, there is an analogous relationship between theoretical and observed distorted productivity, $\underline{\varphi} = \varphi\eta$ and $\underline{\Phi}_i(\varphi, \eta)$:

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

Measured aggregate productivity and OP decomposition: Define measured aggregate productivity $\tilde{\Phi}_i$ as the employment-weighted average of measured firm productivity:

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

where $\theta_i(\varphi) = l_i(\varphi) / \left[\int_{\varphi_{ii}^*}^{\infty} l_i(\varphi)\, \frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)}\right]$ is firm φ's share of aggregate employment.[14]

[14] 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. This ensures that the residual in the OP decomposition is the covariance of $\Phi_i(\varphi)$ and $\theta_i(\varphi)$. Also, the denominator in $\theta_i(\varphi)$ excludes labor used towards unobserved sunk entry costs.

As an accounting identity, aggregate measured productivity $\tilde{\Phi}_i$ can be decomposed into the unweighted average measured productivity across firms, $\overline{\Phi}_i$, and the covariance between firms' measured 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 $\tilde{\Phi}_i$. 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: Welfare W_i differs from measured aggregate productivity $\tilde{\Phi}_i$ for two reasons. First, measured firm productivity $\Phi_i(\varphi)$ is a monotonic function of theoretical firm productivity φ only conditional on export status. An aggregate based on $\Phi_i(\varphi)$ need not be monotonic in an aggregate based on φ. Second, 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. Implicitly, W_i is related to the weighted average productivity of all domestic and foreign firms supplying i, using their sales in i as weights. By contrast, $\tilde{\Phi}_i$ is the weighted average productivity of all domestic firms, using their total employment as weights. This distinction is irrelevant only with 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. From a policy perspective, welfare and domestic aggregate productivity matter for different objectives: While W_i captures consumer utility at a point in time, $\tilde{\Phi}_i$ indicates a country's productive capacity, improvements in which drive growth over time.

One can show that aggregate measured productivity is proportional to $w_i/P_i^{1/\beta}$ under efficient resource allocation, but not under misallocation. In particular:

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

$$\text{where } \tilde{\eta}_i = \frac{\sum_j \mathbf{E}_i \left[\eta r_{ij}(\varphi, \eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}{\sum_j \mathbf{E}_i \left[r_{ij}(\varphi, \eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}. \tag{2.26}$$

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.

Together, equations (2.19) and (2.25) imply that measured aggregate productivity $\tilde{\Phi}_i$ is monotonic in and thus a summary statistic for unobserved welfare W_i only in the absence of misallocation.[15] In

[15] With free entry, $\tilde{\Phi}_i$ depends on the endogenous mass of firms, M_i. In the absence of misallocation, M_i is a constant determined by model parameters when productivity is Pareto distributed. This Pareto assumption is sufficient but not

addition, 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 extent of misallocation $\tilde{\eta}_i$. This implies the following lemma:

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

Given this theoretical ambiguity, we numerically explore the association between welfare, measured aggregate productivity, and the misallocation parameters. We simulate the model with trade between two symmetric countries using standard parameters from the literature (see Section 2.5). We consider a joint log-normal distribution for the productivity and distortion draws $G_i(\varphi, \eta)$ with $\mu_\varphi = \mu_\eta = 1$, $\sigma_\varphi = 1$, and various degrees of distortion dispersion $\sigma_\eta \in [0, 0.5]$ and productivity-distortion correlation $\rho(\varphi, \eta) \in [-0.4, 0.4]$. Note that this parameterization produces Pareto-distributed distorted productivity $\underline{\varphi} = \varphi\eta$, and admits no closed-form solutions for W_i, $\tilde{\Phi}_i$, $\overline{\Phi}_i$ or $\ddot{\Phi}_i$ as functions of σ_η and $\rho(\varphi, \eta)$.

Figures 1A and 1B illustrate how aggregate welfare and measured aggregate productivity vary with the misallocation parameters. All else constant, welfare decreases as the dispersion in distortion draws widens, and increases as the distortion and productivity draws become more positively correlated. As expected, welfare peaks at $\sigma_\eta = \rho(\varphi, \eta) = 0$.[16] Moreover, measured aggregate productivity exhibits very similar patterns under this parametrization. Unreported numerical exercises nevertheless confirm that W_i and $\tilde{\Phi}_i$ need not co-move under alternative distributional assumptions. For completeness, we plot average productivity $\overline{\Phi}_i$ against the misallocation parameters in Figure 1B.

OP covariance vs. misallocation: The OP covariance is related to allocative efficiency in the sense that $\ddot{\Phi}_i$is positive in a frictionless economy because both $\Phi_i(\varphi)$ and $\theta_i(\varphi)$ (conditionally) increase in φ, but it can be positive or negative in the presence of distortions.[17] However, one cannot interpret a rise in $\ddot{\Phi}_i$ as an improvement in allocative efficiency, because the optimal allocation of resources across firms depends on the economic environment (i.e. demand structure, cost structure, market structure, productivity distribution). Even if the optimal covariance $\ddot{\Phi}_i^*$ were known for a given economy, 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.

Under the same parameterization as above, 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

necessary to ensure that $\tilde{\Phi}_i$ is monotonic in W_i; numerical simulations indicate that W_i and $\tilde{\Phi}_i$ also move in the same direction under alternative productivity distributions and reasonable parameter assumptions from the literature.

In the case of misallocation, the Pareto assumption for distorted productivity delivers tractable expressions for W_i and $\tilde{\Phi}_i$ that help build intuition for the role of distortions. However, this assumption no longer guarantees a monotonic relationship between W_i and $\tilde{\Phi}_i$.

[16] Hsieh and Klenow (2009) also consider the welfare implications of misallocation when firms receive productivity and distortion draws that are joint log-normal, and find that welfare is invariant with $\rho(\varphi, \eta)$. This invariance result does not hold in our model because we allow for free entry and $\rho(\varphi, \eta)$ affects firm selection along the extensive margin.

[17] 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.

dispersion is associated with lower $\ddot{\Phi}_i$, consistent with relatively productive firms being sub-optimally small when input costs vary more across firms. Holding σ_η constant, higher $\rho(\varphi, \eta)$ tends to be associated with lower $\ddot{\Phi}_i$; although productive firms get inefficiently large, this counterintuitive pattern reflects the measurement error in $\Phi_i(\varphi, \eta)$ induced by misallocation. While misallocation would intuitively be lowest for $\rho(\varphi, \eta) = 0$ away from low values of σ_η. $\ddot{\Phi}_i$ does not peak at that point; this is again partly due to η affecting both true employment and mis-measured productivity. Alternative parameterizations can also produce non-monotonic patterns for $\ddot{\Phi}_i$ in σ_η and $\rho(\varphi, \eta)$. These findings are consistent with results in Bartelsman et al. (2013).

Inspecting Figures 1A and 1D, the comparative statics for W_i and $\ddot{\Phi}_i$ are thus aligned with respect to σ_η, but reversed with respect to $\rho(\varphi, \eta)$. This reinforces the conclusion that $\ddot{\Phi}_i$ cannot fully capture the welfare cost of misallocation.

To summarize, a rise (fall) in $\ddot{\Phi}_i$ in response to an exogenous shock can be interpreted as an improvement (deterioration) in allocative efficiency only if one believes that an economy lies below its optimum covariance both before and after the shock. Since it is difficult to validate this assumption, such inference is likely to be flawed. However, below we show that the OP decomposition is nevertheless informative because the combined effect of trade shocks on the three OP terms *can* reveal 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 and flexible wages

In the case of efficient resource allocation and no outside sector ($\beta = 1$), equilibrium wages w_i are determined by labor market clearing and balanced trade. Wages thus endogenously respond to changes in market conditions, including trade reforms.

Consider first a symmetric bilateral liberalization. On the export side, a fall in τ_{ij} creates more export opportunities for firms in i, as lower delivery costs allow them to charge lower prices in j and thereby 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. This bids up labor demand and wages in i, making it more difficult for less productive firms in i to survive. These forces act to raise the productivity threshold for survival, φ^*_{ii}. On the import side, a decline in τ_{ji} enables foreign firms to sell more cheaply to i. This intensifies import competition in i, reducing the aggregate price index and demand for locally produced varieties. This depresses domestic sales for all firms, and reinforces the rise in φ^*_{ii}. It follows from Lemmas 1 and 2 that bilateral trade liberalization unambiguously increases welfare W_i and measured aggregate productivity $\tilde{\Phi}_i$, as in Melitz (2003), Melitz and Redding (2014), and Arkolakis et al. (2012). This results from the reallocation of economic 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.

In the case of flexible wages, unilateral export and import liberalization spur the same adjustment processes and exert the same effects as bilateral reforms, as in Demidova and Rodriguez-Clare (2013).

Turning to the OP decomposition, it is clear that if globalization raises $\tilde{\Phi}_i$, then either average productivity $\overline{\Phi}_i$, or the productivity covariance $\ddot{\Phi}_i$, or both must rise 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 aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$.*

2.4.2 Efficient allocation and fixed wages

With efficient resource allocation and an outside sector ($\beta < 1$), wages are exogenously determined and do not respond to trade reforms. One can show that bilateral and unilateral export liberalizations exert the same welfare- and productivity-enhancing effects as with flexible wages. By contrast, unilateral import liberalization now lowers W_i and $\tilde{\Phi}_i$ in the liberalizing country.[18]

With exogenous wages, the unilateral reduction in import costs τ_{ji} triggers two mechanisms that are also active with endogenous wages, but their net impact is now reversed. The direct effect of the reform is to lower the productivity cut-off for exporting from country j to the liberalizing economy i, φ^*_{ji}, and to induce continuing foreign exporters to sell more in i. This intensifies import competition in i, reducing demand for its home varieties and pushing its domestic productivity cut-off, φ^*_{ii}, upwards. The indirect effect of the reform is to raise the 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 endogenous adjustment dampens the indirect effect and the direct effect dominates: Since expected firm profits depend both on wages and productivity cut-offs, smaller cut-off movements are required for the free-entry condition to continue to hold when wages can move as well. Conversely, when wages are fixed, the indirect effect dominates. As a result, cut-off productivity φ^*_{ii} and welfare W_i decline as in Demidova (2008) and Bagwell and Lee (2016), and so does measured aggregate productivity $\tilde{\Phi}$ as we show. The impact on $\overline{\Phi}_i$ and $\ddot{\Phi}_i$ remains ambiguous.

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 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 $\ddot{\Phi}_i$.*

[18] It also increases the consumer price index, a phenomenon known as the Metzler paradox.

2.4.3 Resource misallocation

In the presence of resource misallocation, economies operate in a sub-optimal equilibrium both before and after any trade reforms. From the theory of the second best, it is therefore not possible to unambiguously determine the impact of trade liberalization on aggregate welfare and productivity: It hinges on initial state variables and model parameters, in particular the shape of the joint distribution $H_i(\varphi, \eta)$. Moreover, the effects of trade need not be monotonic in the initial degree of misallocation, such that initially more severe market frictions may amplify, dampen or reverse the gains from globalization. This occurs because trade triggers resource reallocation across firms based on distorted productivity $\underline{\varphi}$ rather than true productivity φ, which can improve or worsen allocative efficiency.

Intuitively, misallocation acts by distorting firm selection on the extensive margin and firm market shares on the intensive margin. Hence the gains from trade depend on how different firms respond. 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 are able to expand their activity relatively more than firms with inefficiently constrained resources. 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.

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, aggregate productivity $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$, and covariance $\ddot{\Phi}_i$.*

2.5 Numerical Simulation

Given the theoretically ambiguous effects of globalization in different economic environments, we explore the impact of counterfactual trade reforms through numerical simulations. We study the effects of reducing trade costs by 20% from an initial value of $\tau_{ij} = \tau_{ji} = 1.81$ in three scenarios: bilateral trade liberalization (shocks to both τ_{ij} and τ_{ji}), unilateral export liberalization (shock to τ_{ij}), and unilateral 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 be symmetrically distributed in both countries, and provide simulation results for Pareto ($\varphi \sim G(\varphi) = 1 - (\varphi^m/\varphi)^\theta$, $\varphi^m = 1$, $\theta = 2.567$) and log-Normal distributions ($\ln\varphi \sim \mathcal{N}\left(\mu_\varphi, \sigma_\varphi\right)$, $\mu_\varphi = 0$, $\sigma_\varphi = 1$).[19] In the case of misallocation, we assume the productivity and distortion draws follow a bivariate log-Normal distribution:

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

[19] The value for the Pareto parameter θ is based on Head et al. (2014), whose preferred estimate $(\sigma-1)/\theta = 0.779$ implies $\theta = (3-1)/0.779 = 2.567$ when $\sigma = 3$.

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 the range $\sigma_\eta \in \{0, 0.05, 0.15\}$ and $\rho \in [-0.5, 0.5]$ in Home.

Figure 2 visualizes the full results of these numerical exercises under fixed wages, $w_i = 1$; without loss of generality, we set the expenditure share of differentiated goods to $\beta = 0.7$. Table 1 presents an instructive snapshot for the case of either no misallocation or misallocation with high distortion dispersion ($\sigma_\eta = 0.15$) and negative, zero or positive productivity-distortion correlation ($\rho \in \{-0.4, 0, 0.4\}$).[20] Table 1 considers environments with either flexible or fixed wages.

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). Compare the results in Panels B and 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 much more nuanced with fixed wages. Bilateral and unilateral export liberalization 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 ($\rho \approx 0$), 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 values for ρ, and there are more likely to be productivity gains when $\rho > 0$. However in general, misallocation can enlarge, moderate or overturn the sign of the productivity gains that obtain without misallocation.

Finally, the two components of aggregate productivity $\tilde{\Phi}_i$ - average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$ - can move in different directions only under misallocation and fixed wages. Without distortions, $\overline{\Phi}_i$ and $\ddot{\Phi}_i$ always move together. On average, changes in average productivity account for 75% of the change in aggregate productivity, while allocative efficiency mediates 25%. With misallocation by contrast, it is possible for $\tilde{\Phi}_i$ and $\overline{\Phi}_i$ to both rise while $\ddot{\Phi}_i$ falls in response to the same shock. Extensive numerical exercises indicate that this result cannot obtain in the absence of misallocation under reasonable parameter assumptions. This 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.

It is useful to foreshadow our empirical findings in light of this simulation analysis. Using baseline IV estimates, we tabulate the implied productivity effects of a 20% unilateral expansion in export and import activity in Panel D. The empirical results are consistent with the sign pattern in Columns 6-8 and 10-12 in the last row of Panel C (misallocation with fixed wages and $\rho = 0.4$). The implied magnitudes

[20] We hold σ_η fixed in Table 1 in order to draw attention to the key insights of the numerical exercise: Given ρ, higher values of σ_η produce qualitatively similar welfare and productivity effects of higher magnitudes. By contrast, given σ_η, different values of ρ produce qualitatively and quantitatively different results.

are well in line with the numerical calculations for export reforms, and notably higher for import reforms. This anticipates our conclusion that in practice, export access and import competition both stimulate aggregate productivity, but they operate through different channels and their impact is moderated by resource misallocation.

2.6 Discussion

We conclude by discussing two model features that allow us to transition to the empirical analysis. First, for expositional simplicity, we have analyzed an economy with a single differentiated-good sector. We show in Appendix C that our main theoretical conclusions 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 productivity $\tilde{\Phi}_{ik}$. A uniform trade cost reduction affects $\tilde{\Phi}_{ik}$ equally across sectors, while a disproportionately bigger shock to sector k' changes $\tilde{\Phi}_{ik'}$ disproportionately more. This justifies our empirical estimation strategy which exploits variation across countries, sectors and time for identification purposes.

Second, in studying trade liberalization, we have considered the impact of reductions to trade costs, τ_{ij} and τ_{ji}. Intuitively, the effect of an exogenous shock to foreign demand - such as an increase to 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 an exogenous shock 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 data sources, CompNet and WIOD. This section describes the key variables of interest, and presents stylized facts about the variation in productivity and trade activity in the panel.

3.1 CompNet Productivity Data

We exploit unique new data on the evolution of macroeconomic indicators for 20 NACE 2-digit manufacturing sectors in 14 European countries over the 1998-2011 period from the CompNet Micro-Based Dataset.[21] Two features of the data make it unprecedented in detail and ideally suited to our analysis.

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

First, it contains not only aggregate measures at the country-sector-year level, but also multiple moments of the underlying distribution of economic activity across firms in each country-sector-year cell. This includes for example means, standard deviations and skewness of various firm characteristics, as well as key 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.[22]

Second, CompNet includes several productivity measures that are constructed specifically to permit an Olley-Pakes (1996) decomposition of aggregate productivity in country i, sector k and year t ($AggProd_{ikt}$) into unweighted average firm productivity ($AvgProd_{ikt}$) and the covariance of firm productivity and firm share of economic activity ($CovProd_{ikt}$).[23]

We examine labor productivity defined as log real value added per worker, and weight firms by their share of total employment at the country-sector-year level.[24,25]These measures correspond exactly to $\Phi_i(\varphi)$ and $\theta_i(\varphi)$ in Section 2.4.1, such that the measured aggregate productivity terms also map exactly to the OP decomposition in Section 2.4.2, i.e. $\tilde{\Phi}_i \equiv AggProd_{ikt}$, $\overline{\Phi}_i \equiv AvgProd_{ikt}$, and $\ddot{\Phi}_i \equiv CovProd_{ikt}$. The labor productivity measure also has the advantage that it is based on directly observable data, rather than on a TFPR residual from production function estimates that is subject to endogeneity and omitted variable concerns.

Table 2 documents the variation in aggregate productivity and its constituent terms across countries, sectors and years in the panel. We report additional summary statistics for the variation across sectors and years within countries in Appendix Table 1. The panel 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 allocative efficiency contributing 0.23 (7.2%) on average as proxied by the covariance term (standard deviation 0.22). However, there are sizable differences in the level and composition of $AggProd_{ikt}$ across countries, 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

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

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

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

[24]The empirical results are unchanged if we instead use firm sales as weights. We prefer employment weights because they produce a model-consistent measure of aggregate productivity that can be linked to welfare and because they are immune to potential variation in the price deflator across firms.

[25]In Section 2.4.1, firm productivity $\Phi_i(\varphi)$ deflates firm value added by the consumer price index in a given country-sector-year triplet, CPI_{ikt}, which is not available in the data. As standard with measures of firm productivity and aggregate real GDP, we therefore deflate firm value added by the value-added producer price index by country-industry-year, PPI_{ikt}. Since the regressions include country-year and industry-year fixed effects, the two approaches are conceptually equivalent. Deflating by PPI_{ikt} is conceptually appealing also because measured value added accounts for producers' input purchases that are not formalized in Section 2.

deviation of aggregate productivity across sectors and years reaches 0.56 for the average country, while the corresponding number for allocative efficiency stands at 0.17. 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 the reallocation of labor across firms can account for a substantial share of aggregate labor productivity growth, as is the case for Austria, Italy, Hungary and Lithuania prior to the 2008-2009 global financial crisis.

3.2 WIOD Trade Data

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

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

We proxy export demand for exporting country i in sector k and year t, $ExpDemand_{ikt}$, with the log value of i's gross exports in sector k. We do not distinguish between exports used for final consumption or downstream production abroad, since both represent foreign demand from the perspective of i. By contrast, we measure import competition in importing country i, sector k and year t, $ImpComp_{ikt}$, with the log of the value of i's imports in sector k, less the value of sector k imports used by i in the production of sector k goods. We intentionally do not remove sector k imports used in i by producers in other sectors, since such imports too 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 provides summary statistics for $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ across the 14 countries and 20 NACE-2 sectors in our 1998-2011 sample with CompNet productivity 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 prior to the 2008-2009 financial crisis, they underwent a sharp contraction in 2009 before regaining some ground by 2011 (Figure 4A). Although EU-15 members and new EU member states display broadly comparable import activity, the latter saw dramatically faster export growth during the period we study (Figures 4B and 4C).

4 Trade and Aggregate Productivity: OLS Correlation

We empirically examine the effects of international trade on aggregate productivity 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 capacity. 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. In particular, we exploit import tariffs and Bartik-style shocks to foreign export supply and foreign import demand, as well as the rise of China on world markets. Finally, in Section 6 we perform additional analyses to explore the channels through which export demand and import competition shape aggregate productivity.

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 two subcomponents, the unweighted average firm productivity, $AvgProd_{ikt}$, and the covariance between firm productivity and employment share, $CovProd_{ikt}$. By the properties of OLS and the OP decomposition, the coefficient estimates from the regressions for $AvgProd_{ikt}$ and $CovProd_{ikt}$ will mechanically sum to the coefficient estimates from the regression for $AggProd_{ikt}$. There is nevertheless value in separately estimating all three regressions in order to determine the sign, economic magnitude and statistical significance of the effects on each productivity outcome. There are no efficiency gains from estimating the three regressions as a simultaneous system of equations because they all include the same set of fixed effects and right-hand side variables.

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 include several control variables 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 active firms, $\overline{\ln N}_{kt}$, and the average log employment, $\overline{\ln L}_{kt}$, by sector-year, which we obtain by averaging $\ln N_{ikt}$ and $\ln L_{ikt}$ across countries.

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

Finally, we implement two sample corrections to ensure that our results are not driven by 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 of interest ($AggProd_{ikt}$, $AvgProd_{ikt}$, $CovProd_{ikt}$, $ExpDemand_{ikt}$, $ImpComp_{ikt}$, $\ln N_{ikt}$). 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. In Columns 1-3 of Table 3, we estimate specification (4.1) for log total output, log value added and log employment by country, sector and year as the outcome variable Y_{ikt}. We find that export expansion is associated with higher manufacturing output, value added and employment. Conversely, more intense import penetration is correlated with lower total 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 $AvgProd_{ikt}$ and increased concentration of activity in more productive firms $CovProd_{ikt}$, 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 in the data. A point represents average values across country-sector-year triplets within each of 100 percentile bin, after demeaning by country-year fixed effects. The plots indicate that aggregate productivity is strongly positively correlated with both export and import activity 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 mechanisms.

Specification (4.1) identifies the long-run correlation between productivity and trade activity. We explore this correlation in the short to medium term in Appendix Table 2, where we analyze how changes in productivity co-move with concurrent changes in imports and exports over 1-, 3- and 5-year overlapping periods.[26] By first-differencing all left- and right-hand side variables and including year fixed effects, we implicitly subsume country-sector pair fixed effects and accommodate global growth shocks. We observe that 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 results capture the correlation between countries' participation in international trade and their aggregate productivity performance. This correlation may not identify the causal effect of globalization 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 endogenously affect trade activity. In general equilibrium, observed export flows reflect both endogenous supply conditions in the exporting country and exogenous demand conditions in the importing country. Trade theory implies that firms in a more productive country-sector would be more competitive on world markets and therefore undertake more exports. As a result, the OLS estimates of β_{EX} would be positively biased. Symmetrically, observed import flows reflect both endogenous demand conditions in the importing country and exogenous supply conditions in the exporting country. Given local demand, a less productive domestic country-sector would be less competitive from the perspective of foreign firms and induce more entry by foreign suppliers. This would introduce negative bias in the OLS estimates of β_{IM}. These examples illustrate only two of various possible mechanisms that could generate reverse causality and bias OLS estimates of the productivity impact of globalization either upwards or downwards.

5.2 IV Strategy

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

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

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 continue to condition on controls Z_{ikt} and country-year pair 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 for foreign export supply and foreign import demand, which we construct by combining information on countries' trade structure at the beginning of the panel with the contemporaneous global trade flows of their trade partners.[27] 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 picks up total expenditure in destination d on sector k which is the relevant measure of market size in the model. Symmetrically, 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 country o may use imported inputs in producing k products, and aims to isolate supply shocks specific to o by considering only its own value added embedded in its exports. We focus on o's exports for final consumption to capture the import competition rather than the imported-input supply emanating from origin 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 in our sample, we thus instrument export demand with foreign demand conditions, $FDemand_{ikt}$, computed as the weighted average absorption across i's export destinations using i's initial export shares as weights. We instrument import competition with foreign supply capacity, $FSupply_{ikt}$, calculated as the weighted average export value added for final consumption across i's import origins, using i's initial import shares as weights. We construct both instruments using

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

the WIOD data. To guard against outliers due to measurement error or business cycle fluctuations, we average the initial import and export weights across the first three years in our data, 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 all products p in sector k at time t using tariff data from WITS, where NP_k denotes the number of products mapped to a sector. $MTariff_{ikt}$ captures trade policy shocks that affect the degree of import competition by influencing foreign producers' incentives to enter the domestic market. In our panel, these tariffs vary primarily across sectors rather than across countries or over time.

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

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

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

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 as IV_{ikt} for both endogenous variables in the IV first stage.

5.3 Baseline IV Results

The results in Table 4 indicate that the three instruments perform well in the first stage and meet the relevance requirement. The Bartik measure of exogenous foreign demand has a positive impact 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. The most conservative estimates in Columns 3 and 6 (with both country-year and sector-year fixed effects) 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% across the various specifications.

Table 5 presents the second-stage estimates for the causal effect of international trade on aggregate productivity. 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, a 20% growth in export demand boosts overall productivity by 8%, while a 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, export demand and import competition exert large effects of comparable magnitudes: The aggregate productivity gains following a 20% increase in export demand and import penetration now amount to 7.3% and 10%, respectively.

Second, Table 5 reveals that the productivity gains from export and import expansion are mediated through different channels. Export growth induces both sizeable improvements in average firm productivity, $AvgProd_{ikt}$, and a reallocation of economic activity towards more productive firms as manifested in higher $CovProd_{ikt}$. The reallocation of activity towards more productive firms contributes 26% (Column 3) to 38% (Column 9) of the total productivity benefit. By contrast, all of the productivity gains from import competition result from higher average firm productivity, and these gains are moreover partly offset by a shift in economic activity 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 signals 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 our results. We record consistently large and significant effects of export demand and import competition on all three productivity outcomes, with an imprecisely estimated impact only of $ImpComp_{ikt}$ on $CovProd_{ikt}$ in specifications with both 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 activity, 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 are virtually unchanged 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 the gradual adjustment in economic activity within and across firms.

Alternative measures The results are also robust to using a relative instead of an absolute indicator of import competition. The baseline measure $ImpComp_{ikt}$ identifies the scale of foreign suppliers' activity in the home market, where the country-year fixed effects implicitly control for 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 findings when we estimate specification (5.1) using $ImpCompRatio_{ikt}$ in place of $ImpComp_{ikt}$ and an analagously constructed instrument $FSupplyRatio_{ikt}$ in place of $FSupply_{ikt}$.[28]

Alternative outlier treatment We conduct additional tests to ensure that outliers are not driving the results. The baseline specification already excludes observations at the country-sector-year level that have been aggregated across fewer than 20 firms or that 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 in levels 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 in a model with multiple differentiated industries, the effect of globalization on economy-wide aggregate productivity is a weighted average of the response of sector-level productivity across secrors. In the baseline specification, sectors are treated 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 share of overall activity and its contribution to economy-wide productivity.

In Europe as in other advanced countries, the services sector has grown to capture a large majority of aggregate employment and production. Since aggregate productivity and trade data is available only for manufacturing industries, the baseline analysis quantifies the impact of globalization on manufacturing only. We can nevertheless account for the variation in the size of the service 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 compared to the baseline. These estimates would reflect the impact of globalzation 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.

[28] 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.

5.5.2 Chinese import competition

A major shock to the global economy in the 21st century has been the dramatic rise of China. Chinese exports grew rapidly after China joined the WTO in 2001 and after MFA binding quotas on Chinese 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, lower-wage country.

We compare the impact of Chinese import competition vs. import competition from the rest of the world (ROW) on aggregate productivity in Europe. This informs how local firms respond to competition from foreign firms with relatively low vs. high levels of productivity, factor costs, and quality. We measure import competition from China, $ChinaImpComp_{ikt}$, 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 import competition from ROW, $ROWImpComp_{ikt}$, as in the baseline, excluding China from the calculation. We also adapt the baseline instrument for import penetration to construct two new instruments for $ChinaImpComp_{ikt}$ and $ROWImpComp_{ikt}$, $ChinaSupply_{ikt}$ and $ROWSupply_{ikt}$. For example, $ChinaSupply_{ikt}$ captures China's global export supply in sector k and year t with Chinese total export value added for final consumption, $XVA^{final}_{China,kt}$, and recognizes that the impact of this supply shock will vary across importing countries i based on China's initial share of i's imports of k goods at time $t = 0$, $\frac{M_{China \to ik,t=0}}{M_{ik,t=0}}$. We continue to exploit $MTariff_{ikt}$ as instruments in the first stage as well.

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

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 both stimulate aggregate measured productivity. They also both operate by raising average productivity while lowering the productivity covariance term. At the same time, the gains induced by Chinese competition are about a third of those triggered 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 (negative) 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 alone, in practice firms may also differ in the skill of their labor force. This may arise because of the endogenous hiring decisions that firms make, or because of exogenous variation in worker skill or firm-worker match quality that 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 would have different implications for the interpretation of the results: In the latter case skill heterogeneity across firms poses the threat of omitted variable bias, while in the former case it is 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 the CompNet database. The baseline results remain unchanged.

A separate concern is the potential for mark-up heterogeneity across firms. The model in Section 2 explicitly shuts down variable mark-ups by assuming CES consumption and monopolistic competition, in order to highlight the role of misallocation arising 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 and thereby in aggregate productivity, average productivity and the productivity-size covarianceat 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 proxy for mark-up dispersion that is systematically available from the CompNet database.

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 numerical results of the model in Section 2 that the empirical findings can be rationalized only under misallocation with fixed wages. Second, the effect of trade on firm selection is not a summary statistic for its aggregate productivity impact, counter to model implications in the absence of distortions. Finally, trade exerts differential effects on aggregate productivity depending on countries' measured institutional and market efficiency. Although the impact of misallocation on the gains from trade is in principle ambiguous, finding that institutional frictions do moderate these gains implies that misallocation plays a role. Thus the first two arguments for misallocation rely on indirect inference, while the last one constitutes direct evidence.

6.1 Pattern of Trade Effects

Empirically, the sign pattern for the effect of $ExpDemand_{ikt}$ on $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$ is $\{+,+,+\}$, while that for $ImpComp_{ikt}$ is $\{+,+,-\}$. Our extensive numerical exercises indicate that the model in Section 2 can only generate this pattern when wages cannot adjust and 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 last line of Panel C in Table 1). This suggests that export expansion and import competition both improve aggregate productivity. However, export expansion generates productivity gains both through the exit of relatively less productive firms and the reallocation of market share towards more productive firms, while import competition exerts a cleansing effect along the extensive margin, but worsens allocative efficiency along the intensive margin.

6.2 Firm Selection

We next examine the impact of trade exposure on the extensive margin of firm selection. 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} would be 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 observed minimum productivity across firms in a given country-sector-year, $\min Prod_{ikt}$, would be the empirical counterpart to φ^*_{ii}. 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.

Guided by theory, we assess how globalization affects firm selection at the bottom end of the productivity distribution. We measure $\min Prod_{ikt}$ with the first percentile of log value added per worker across firms in CompNet, in order to guard against outliers due to measurement error or idiosyncratic firm shocks. We find in Panel A of Table 7 that export demand and import competition both raise $\min Prod_{ikt}$ (Columns 1 and 5). 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.[29] Higher $\min Prod_{ikt}$ is associated with higher aggregate and average productivity, but lower productivity-size covariance. Compared to the baseline in Table 5, the point estimates for β_{EX} and β_{IM} are reduced by 48% and 57% in the regressions for $AvgProd_{ikt}$ (Column 3). In the specification for $CovProd_{ikt}$, coefficient β_{EX} increases by 20%, while β_{IM} falls by 38% (Column 4). Overall, controlling for measured $\min Prod_{ikt}$ leaves large residual effects of export demand and import competition on aggregate productivity $AggProd_{ikt}$, which correspond to 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).

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 resource misallocation, whereby international trade influences aggregate productivity in part by changing the efficiency with which resources are allocated across firms.[30]

6.3 Imperfect Institutions and Market Frictions

In order to provide more direct evidence for the role of resource misallocation, we finally exploit the cross-country variation in the measured strength of institutions that govern the efficiency of factor and product markets. This approach rests on two premises. First, institutional imperfections constitute structural problems in an economy that generate an inefficient allocation of production inputs and market shares across firms. Institutional indicators thus identify primitive root causes that microfound resource misallocation in theoretical frameworks. Our model considers distortions to input costs that can be mapped to institutional measures of labor and capital market frictions. The theoretical results would be qualitatively similar with revenue or profit distortions via sales or corporate taxes, which can be mapped to institutional 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

[29] 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.

[30] 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 examine the aggregate amount of productivity upgrading using CompNet data on 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.

misallocation, and these effects need not vary smoothly with the degree of misallocation.[31] 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 of institutional strength, defined such that high $Institution_{it}$ signifies more efficient and effective institutions. The first two are rule of law and corruption, from the *World Bank Governance Indicators* (Kaufmann et al. 2010). These are comprehensive indices respectively of general institutional capacity and scope for rent extraction for private gains, which arguably affect economic efficiency in both input and output markets. Rule of law has a mean of 1.11 and a standard deviation of 0.49 in the panel; the corresponding statistics for (inverse) corruption are 1.07 and 0.69.

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

Table 8 reveals consistent patterns across all five institutional measures: Strong rule of law, low corruption, efficient factor and product markets amplify the productivity gains from import competition and dampen the productivity gains from export expansion. This is true for 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.[32]

These results indicate the complex interactions between international trade and market frictions in shaping aggregate productivity. They also point to 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 heightened import competition, can engender more cleansing reallocation under more

[31] On the one hand, countries with more efficient resource allocation may more effectively adjust to trade reforms and reap greater productivity gains from globalization. On the other hand, such countries are closer to the first best to begin with, and may gain less on the margin from trade liberalization.

[32] These findings are generally robust to adding sector-year fixed effects, although several interaction terms become imprecisely estimated (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). Additional provisions under collective regular contracts, as well as the governance of temporary employment contracts play a much lesser role.

efficient markets and institutions, such that less productive firms downsize disproportinately more.[33] Aside from market forces, 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. Although these measures have theoretical micro-foundations, they are valid under modeling assumptions that 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 in price-cost mark-ups (PCM) across firms signals output-market distortions.

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, these 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. On market structure, Foster et al. (2008) and Berman et al. (2012) show that TFPR, MRPK and MRPL dispersion implies misallocation of production inputs under constant mark-ups, but not under variable mark-ups. 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. On production technology, 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 quantity-based productivity (TFPQ). 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. Using our IV strategy, we generally find positive significant effects of import exposure across the four $Dispersion_{ikt}$ metrics, but mixed results for export demand (see also DeLoecker and Warczinsky 2012 on PCM). Were $Dispersion_{ikt}$ indicative of misallocation, our conclusion that export expansion (import competition) enhances (reduces) allocative efficiency would

[33] The interaction analysis in 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.

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 liberalization increase aggregate productivity, while unilateral import liberalization can either raise or reduce it. However, all three trade reforms have ambiguous effects in the presence of resource misallocation. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we establish empirically that exogenous shocks to both export demand and import competition generate large gains in aggregate productivity. Although both trade activities increase average firm productivity, 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. Moreover, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion.

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

There remains much scope for further research. Richer data would make it possible to examine how international trade affects the incentives for technological upgrading across the firm productivity distribution. From a policy perspective, it would also be valuable to assess the impact of different frictions in capital, labor and product markets on firm selection, 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. and Rodriguez-Clare, A. (2012). "New Trade Models, Same Old Gains?" American Economic Review, 102(1), 94-130.

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. (2018). "Misallocation Under Trade Liberalization." LSE 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.

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.

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.

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.

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.

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." The 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, 4th ed, 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.

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 predicted by different model scenarios with free entry and endogenous or exogenous wages. 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 distortion are joint Log-Normal with σ_η=0.15 and $\rho(\varphi,\eta)$={-0.4,0,0.4}. All other parameter values are calibrated 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)												
Endogenous *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%
Exogenous *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)												
Endogenous *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%
Exogenous *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)												
Endogenous *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%
Exogenous *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, productivity, international trade activity, institutional and market frictions across countries, sectors and years in the 1998-2011 panel. All variables are defined in the paper. 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 Economic Activity: 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 log output, log value added, log employment, or aggregate productivity terms from the OP decomposition as indicated in the column heading. All columns include country-year pair fixed effects, and control for the log number of firms by country-sector-year, 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 export supply, foreign import demand and import tariffs on export and import activity at the country-sector-year level. The outcome variable is indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 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 variables follow the OP productivity decomposition and are indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 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. It replicates the regressions in Columns 1-3 and 7-9 in Table 5, but introduces a different modification in each panel. 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 a sector in manufacturing employment. Panel C distinguishes between import competition from China vs. Rest Of the World. Panels D and E control respectively for skill and mark-up dispersion across firms with the 90th-10th inter-percentile ratio in firm-level wage and price-to-cost margin. 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. OVB: Skill Dispersion						
^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. OVB: Mark-Up Dispersion						
^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 mechanisms through which export demand and import competition affect aggregate productivity at the country-sector-year level. The outcome variables in Columns 2-4 and 6-8 follow the OP productivity decomposition and are indicated in the column heading. The outcome variable in Columns 1 and 5 is log firm productivity at the first percentile in Panel A and log R&D expenditure in Panel B. 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 variables follow the OP productivity decomposition and are indicated in the column heading. Institutional efficiency is measured by rule of law in Columns 1-3, the inverse of corruption in Columns 4-6, labor market flexibility in Columns 7-9, creditor rights protection in Columns 10-12, and the inverse of product market regulation in Columns 13-15. 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 Growth: OLS First Differences

This table examines the relationship between aggregate productivity and trade exposure at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. All left and right-hand side variables are first differences over rolling 1-year, 3-year 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. It replicates the regressions in Columns 1-3 and 7-9 in Table 5, but implements a different robustness check in each panel. Panels A and 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 1%, 5%,

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. It replicates the regressions in Table 8, but adds sector-year pair fixed effects in Panel A, and examines different aspects of labor market flexibility in Panel B. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

Panel A. Sector-Year Pair FE

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

Panel B. Different Components of Labor Market Flexibility

LMF Component:	1. Baseline: Regular Contracts (Individual & Collective)			1a. Individual Regular Contracts			1b. Collective Regular Contracts (Additional Provisions)			2. Temporary Employment Contracts			Synthetic Indicator (Regular & Temporary Contracts)		
	ln Agg Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Agg Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Agg Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Agg Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Agg Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	1.121***	0.763***	0.358***	0.611***	0.482***	0.129***	0.376***	0.204**	0.172***	0.336	0.069	0.267***	0.276	0.028	0.248***
	(0.261)	(0.238)	(0.063)	(0.072)	(0.067)	(0.022)	(0.095)	(0.093)	(0.027)	(0.275)	(0.233)	(0.073)	(0.223)	(0.187)	(0.063)
^Imp Comp (ikt)	-0.202**	-0.102	-0.100***	-0.122***	-0.081***	-0.042***	-0.019	0.022	-0.040**	0.220***	0.270***	-0.050***	0.225***	0.275***	-0.050***
	(0.096)	(0.089)	(0.027)	(0.033)	(0.031)	(0.010)	(0.057)	(0.055)	(0.016)	(0.059)	(0.051)	(0.018)	(0.053)	(0.046)	(0.017)
^Exp Dem (ikt) x	**-0.218*** **	**-0.143** **	**-0.075*** **	**-0.089*** **	**-0.077*** **	**-0.012** **	**0.000**	**0.017**	**-0.017** **	**0.014**	**0.060**	**-0.046** **	**0.031**	**0.071**	**-0.041** **
Institution (it)	**(0.069)**	**(0.063)**	**(0.016)**	**(0.016)**	**(0.015)**	**(0.005)**	**(0.017)**	**(0.017)**	**(0.007)**	**(0.071)**	**(0.059)**	**(0.019)**	**(0.056)**	**(0.047)**	**(0.016)**
^Imp Comp (ikt) x	**0.083*** **	**0.060** **	**0.024*** **	**0.077*** **	**0.068*** **	**0.009** **	**0.025* **	**0.020**	**0.005**	**-0.040*** **	**-0.048*** **	**0.008* **	**-0.042*** **	**-0.050*** **	**0.008* **
Institution (it)	**(0.027)**	**(0.026)**	**(0.008)**	**(0.010)**	**(0.010)**	**(0.003)**	**(0.013)**	**(0.013)**	**(0.004)**	**(0.015)**	**(0.013)**	**(0.005)**	**(0.013)**	**(0.012)**	**(0.005)**
N	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
R2	0.747	0.802	0.447	0.758	0.809	0.463	0.752	0.805	0.455	0.748	0.802	0.456	0.748	0.802	0.457
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Appendix Table 5. Impact of Trade on Productivity and Mark-Up Dispersion

This table examines the impact of export demand and import competition on productivity and mark-up dispersion across firms at the country-sector-year level. The outcome variable is the standard deviation of the marginal revenue product of capital, the standard deviation of the marginal revenue product of labor, the standard deviation of revenue-based total factor productivity, 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
R^2	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 its OP components, and the parameters governing misallocation based on numerical model simulations. In each figure, the productivity-distortion correlation ρ(φ,η) varies along the x-axis and the standard deviation of distortion ση varies along the y-axis. Figures A, B, C and D plot respectively welfare, aggregate producivity, average productivity and the productivity-size covariance on the z-axis. All other parameter values are chosen as discussed in the text.

Figure 1A. Welfare

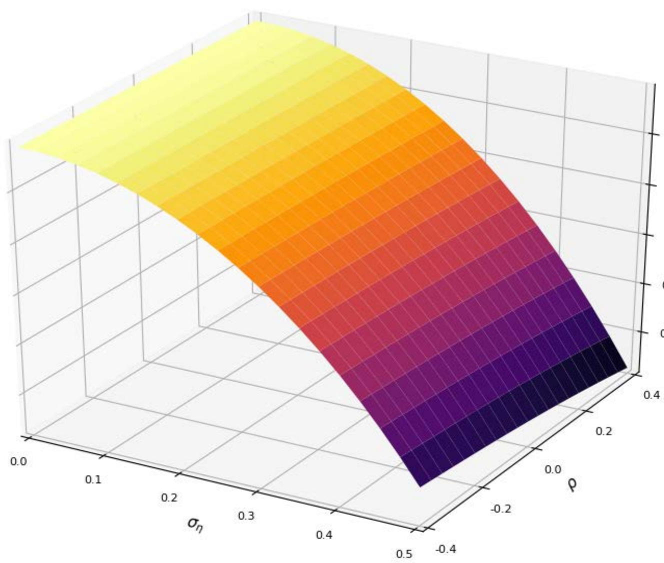

Figure 1B. (log) Aggregate Productivity

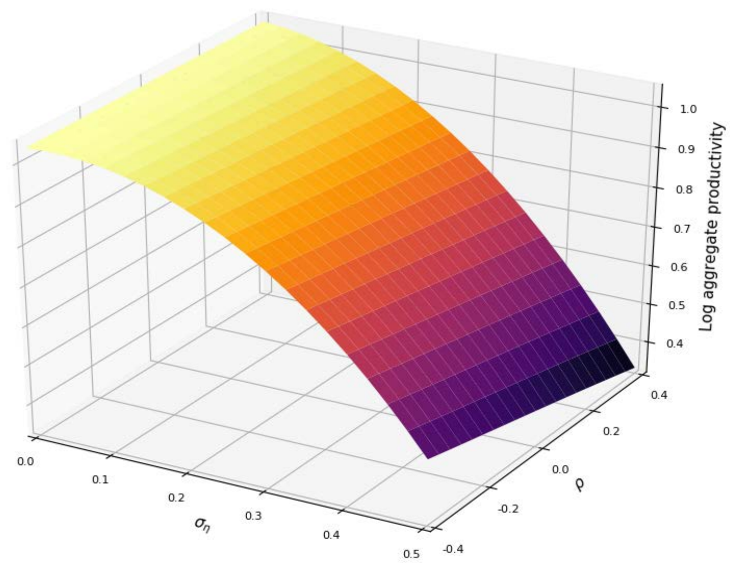

Figure 1C. (log) Average Productivity

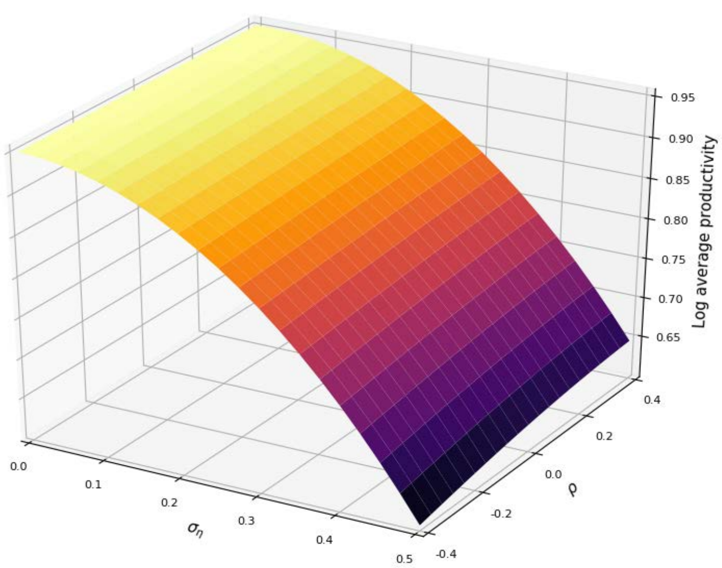

Figure 1D. (log) Productivity-Size Covariance

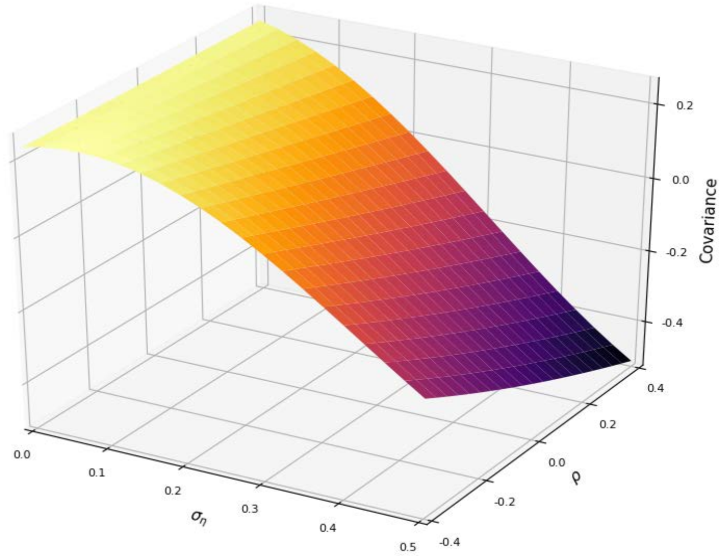

Figure 2. Numerical Simulation: Trade Liberalization

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

Figure 2A. Bilateral Trade Liberalization

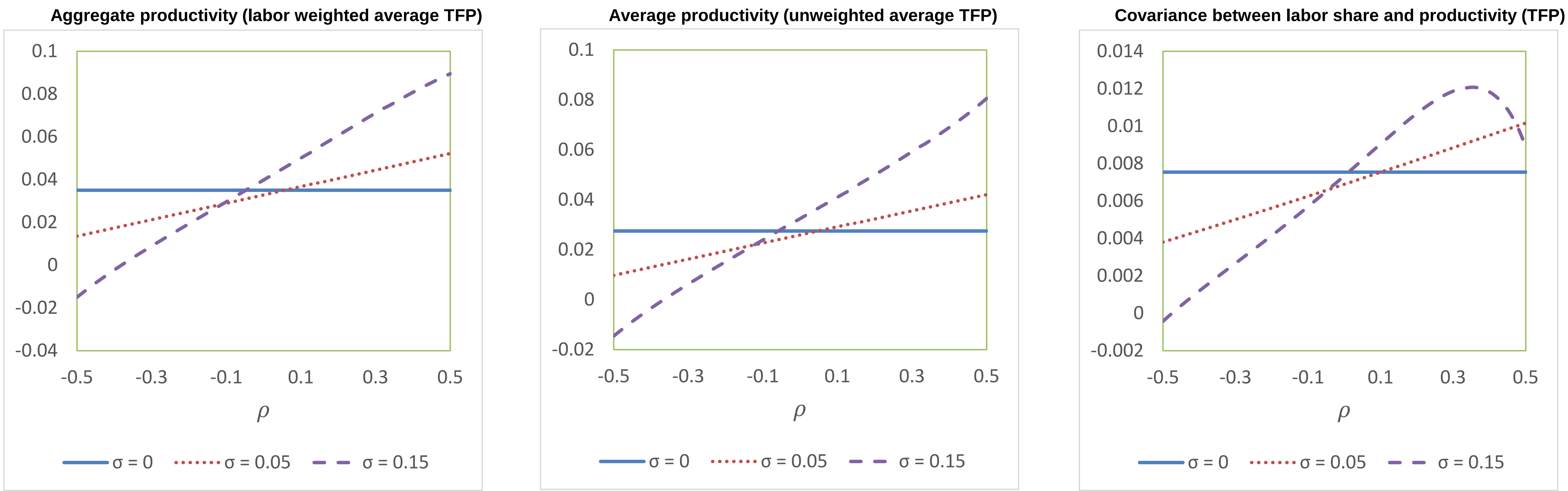

Figure 2. Numerical Simulation: Trade Liberalization (cont.)

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

Figure 2B. Unilateral Export Liberalization

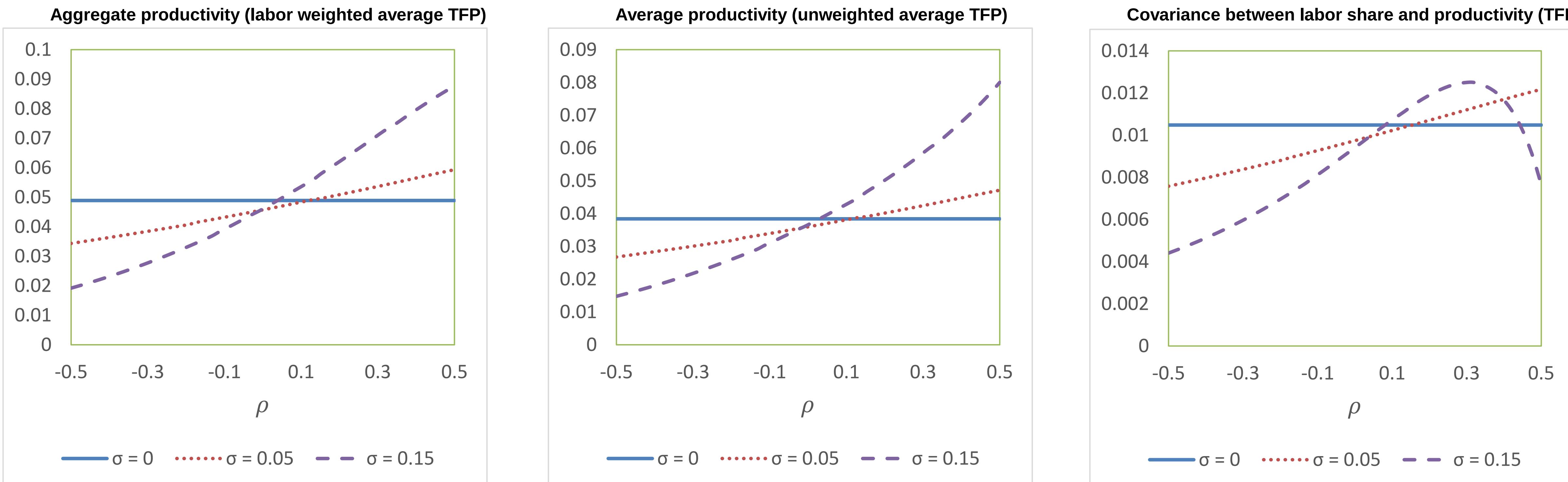

Figure 2C. Unilateral Import Liberalization

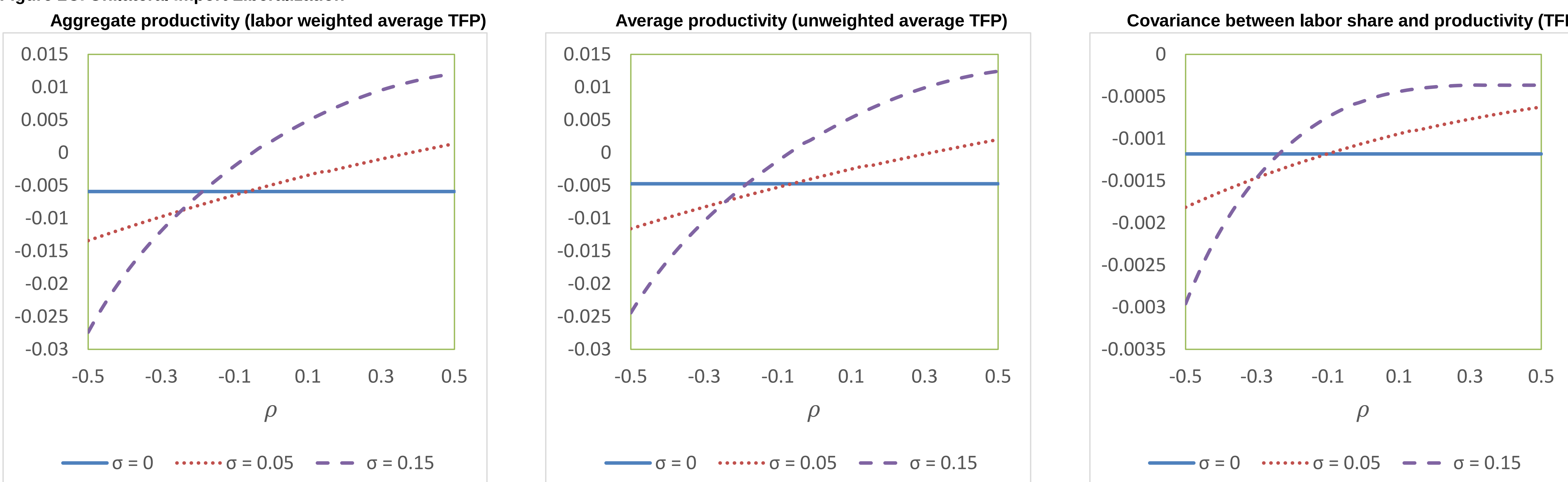

Figure 3. Sources of Productivity Growth: Overlapping 3-Year Growth Rates

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

Figure 3A. Growth 2003-2007

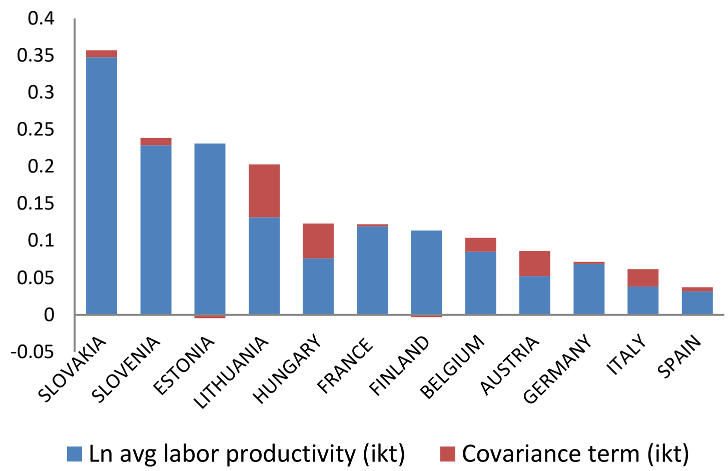

Figure 3B. Growth 2008-2011

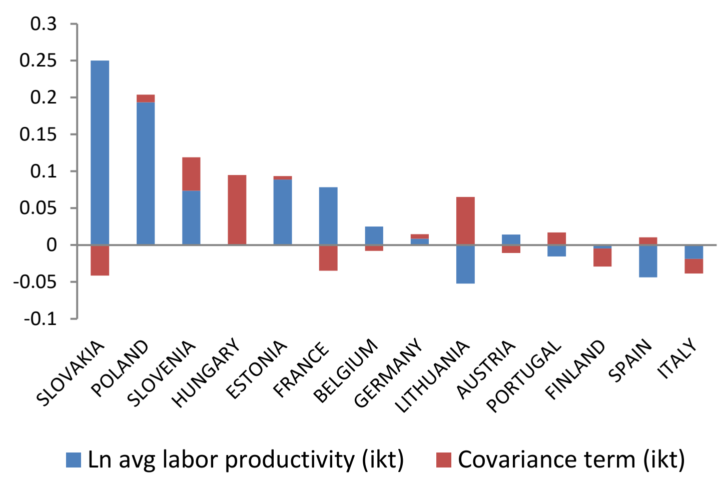

Figure 4. Trade Exposure Over Time

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

Figure 4A. All countries

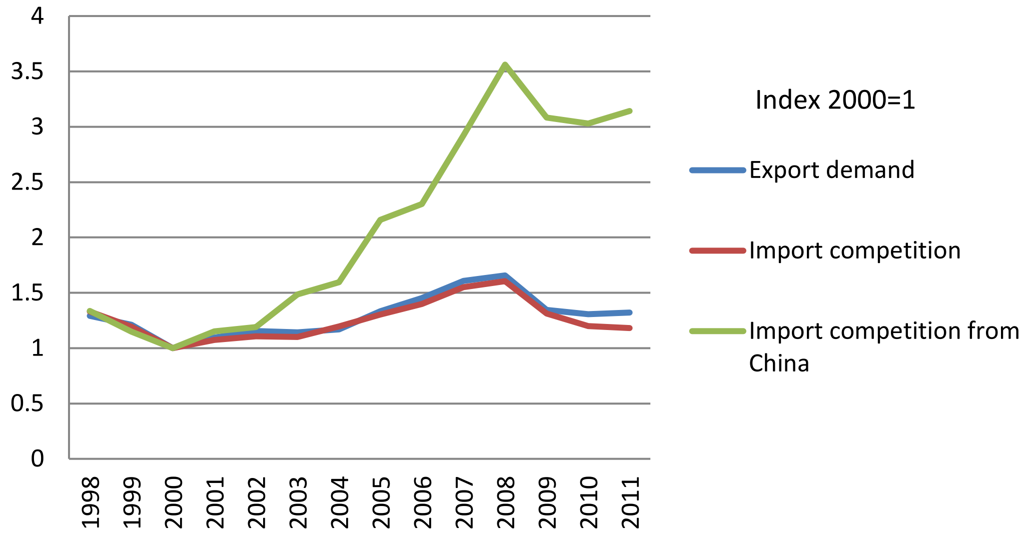

Figure 4B. New member states

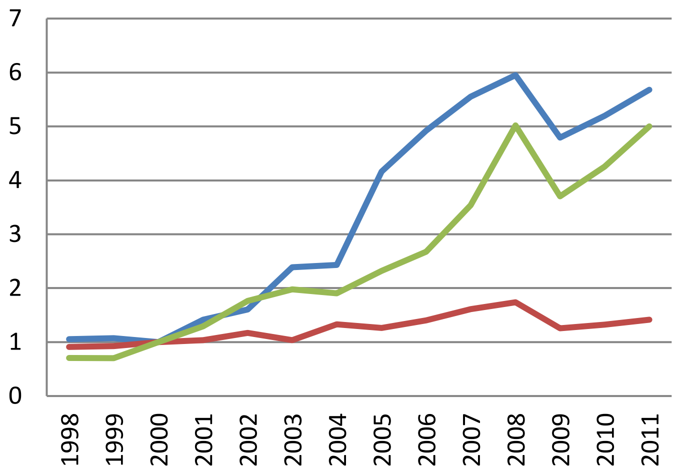

Figure 4C. EU 15 countries

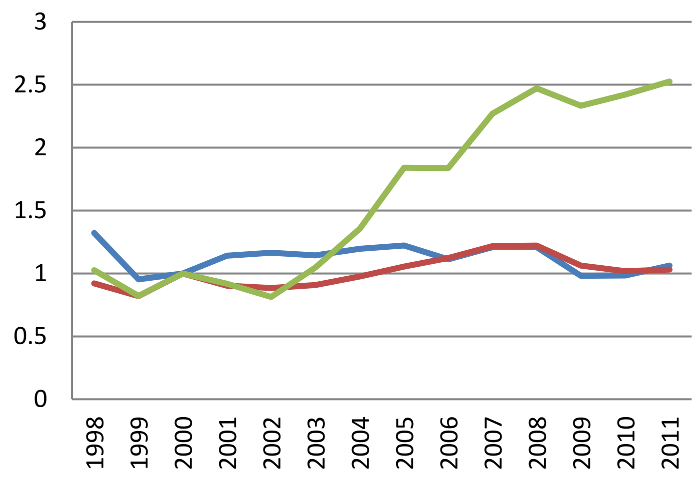

Figure 5. Trade Exposure and Aggregate Productivity

These bin scatters display the raw correlations 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 effects.