Misallocation and Technology Upgrading under Trade Liberalization

Simeng Zeng *

November 2023

Click here for the most recent version.

Abstract

This paper examines the influence of resource misallocation on firms' technology investment decisions and its impact on trade gains in developing countries. Literature finds that trade liberalization in distorted economies could result in limited gains or even losses due to worsening resource misallocation. However, trade can also promote technology upgrades and innovation. To explore whether the innovation channel can enhance the gains from trade, I construct a two-country Melitz model with firm-specific distortions and introduce the choice of research and development (R&D) investments. A quantitative assessment using Chinese manufacturing data shows that allowing firms to upgrade technology further reduces welfare gains from trade in this second-best environment. This is because misallocation distorts firms' R&D decisions, therefore trade liberalization encourages the growth of less productive but subsidized firms. This drives up costs for more productive yet taxed firms, resulting in a further reduction of trade gains. Even with additional R&D subsidies aimed at correcting distortions in innovation decisions, results remain unchanged. The paper emphasizes the importance of structural reforms to maximize trade gains in developing countries.

Keywords— distortions, misallocation, technology upgrade, trade liberalization, gains from trade

*Department of Economics, University of Minnesota, zeng0088@umn.edu. I would like to thank my advisors, Timothy Kehoe, Manuel Amador, and Doireann Fitzgerald for their valuable guidance and incredible support. I would also like to thank Cristina Arellano, Yan Bai, Samuel Bailey, Maria-Jose Carreras-Valle, V. V. Chari, Loukas Karabarbounis, Illenin Kondo, Entian Zhang, Xiaohan Zhang, and all the participants of the Trade workshop at the University of Minnesota and the UMN-UW Graduate Workshop for their comments and suggestions.

1 Introduction

Understanding how globalization affects aggregate productivity and welfare, as well as why its impact differs across countries, are key questions in economics. The trade literature has emphasized two channels through which trade integration can improve productivity: (1) trade integration leads to the reallocation of production factors towards more productive exporting firms, resulting in better allocation of resources *between firms* (Melitz (2003)). (2) Trade integration also leads to an increase in the rate of return to investments in new technologies, encouraging productivity improvements *within firm* (Bustos (2011)).

Nevertheless, these mechanisms rely on the assumption of an efficient economy. Many developing countries, however, are subject to prevalent policy and institutional distortions. Examples include preferential access to land and capital, taxes and subsidies, industrial policies, and more. In their influential work, Hsieh and Klenow (2009) demonstrates that these distortions result in a significant misallocation of resources across firms, leading to a decline in overall aggregate productivity. When firm-specific distortions intersect with trade liberalization, Bai, Jin, and Lu (2019) (henceforward BJL) shows that in the second-best environments, trade can induce limited welfare gains or even welfare losses, due to the worsening of resource misallocation *between firms*.

Building on BJL, this paper incorporates another channel — productivity gains within firms from technology upgrading — to analyze whether this additional channel can allow developing countries with large distortions to achieve greater welfare gains from trade liberalization. This extension is particularly motivated by China's experiences, which witnessed a surge in R&D expenditure and a growing emphasis on innovation after joining the WTO and liberalizing trade.

To investigate, I construct a two-country Melitz model with firm-specific distortions and introduce the choice of R&D investment. In this model, firms differ in productivity and their level of distortions, which I model as taxes or subsidies on firms' output (wedges). These wedges are designed to capture the wide array of policy distortions that developing countries often confront. Firms make decisions on entry, exit, exports, and R&D investments, and the R&D choice involves whether to engage in upgrading and how much effort to exert.

The presence of distortions masks the firm's true productivity. A firm may be producing in the market not due to inherent productivity advantage but because of subsidies (which I model as a smaller output wedge). With substantial subsidies, it may also be able to cover the costs of exporting and investing in technology upgrading, even if its inherent productivity is low. Conversely, firms with high productivity and output wedges (akin to 'taxes') that were able to survive and expand would be driven out as the other firms gain market share and push up costs.

As trade costs decrease, the potential profit from serving foreign markets increases. Subsidized, yet less productive firms begin to export or increase their exports, drawing more resources away from their more productive counterparts. The additional profits earned through exporting provide these firms with greater incentives to invest in R&D. Although they also choose a higher level of technology, partially mitigating overall misallocation by reducing the correlation between the output wedge and productivity, this choice results in an expanded fiscal burden. As a result, it ultimately diminishes household wealth and consumption. In other words, compared to BJL, allowing firms to invest in R&D further worsens resource misallocation, as it reinforces the adverse selection mechanism by inducing subsidized firms to upgrade technology and choose higher R&D efforts. This leads to even smaller welfare gains from trade liberalization.

Crucially, the correlation between productivity and distortions plays a pivotal role in determining the magnitude of gains from trade. When these two variables exhibit a strong and positive relationship, indicating that more productive firms face higher taxes, the overall benefits from trade diminish. This pattern is affirmed as the case in China in BJL, and is supported through the calibration of this model, establishing China as a well-suited case for examination. As documented by Hsieh and Klenow (2009), China represents an economy characterized by many distortions. Moreover, China has undergone an important trade liberalization period, which has come accompanied by a notable increase in R&D expenditure and a growing emphasis on innovation by the government.

In the quantitative analysis, I extend the model by including heterogeneity in the cost of export and innovating. To estimate the parameters, I use China manufacturing firm-level data from 2005. The model is calibrated to match key moments of the firms' participation in the export market, R&D investment, and their correlations with distortions and productivity. Then I use the estimated model to quantify the impact of trade liberalization. In particular, I calculate the welfare gains and aggregate productivity improvements when moving the economy from autarky to an open one, and compare these outcomes with those of a counterfactual efficient economy.

The result shows that distortions significantly offset the potential welfare gains from trade. While aggregate TFP improves due to two forces — firms that initially invested in R&D increasing their efforts and firms that previously did not invest in R&D initiating R&D investments — welfare becomes even smaller compared to an economy where firms lack the technology upgrading option, as in BJL. When firms can upgrade through R&D, trade liberalization results in a significant drop in aggregate prices, contributing to increased welfare gains. However, it also simultaneously generates larger misallocation. This exacerbated resource misallocation outweighs the benefits of the additional price reduction, resulting in smaller welfare gains from trade.

Another way to see how the distorted economy differs from the efficient one is by examining the specific sources contributing to the aggregate TFP improvement. Changes in aggregate TFP can be decomposed into improvements within incumbents (within-firm TFP growth) and three between-firm terms — reallocation of resources to more productive existing firms, entry of new firms, and exit of firms. For the distorted economy moving from autarky to open as in the baseline, most of the TFP improvement comes from within-firm productivity growth. Resource reallocation among incumbents yields a negative contribution since subsidized firms are selected to grow. In contrast, for an efficient economy, the decomposition shows improvements stemming primarily from resource reallocation to more productive incumbents and the exit of less productive firms, mirroring observations in advanced countries as discussed Bartelsman and Dhrymes (1998). This finding that within-firm productivity gains dominate TFP improvements in the distorted economy aligns with the empirical TFP decomposition results in China as documented by Brandt et al. (2020).

Lastly, I use the calibrated model to conduct a series of counterfactual policy experiments to see what policies can help the economy gain more from trade. In the first exercise, I reduce the variance of output wedges by 50% in the open economy. This reduction in misallocation leads to a significant increase in welfare and encourages more firms to invest in R&D and upgrade their technology. Next, I investigate whether an additional R&D support program, aimed at reducing distortions in R&D decisions, can result in higher gains. The results indicate that it only leads to a slight improvement in welfare. While it facilitates productive firms in upgrading technology, these firms still face substantial taxes on their output. As a result, the reduction in R&D costs does not generate substantial assistance. A similar logic applies when the government decides to reduce the R&D fixed costs. This underscores the importance of structural reforms. Without efforts to reduce distortions, the government's further initiatives in R&D subsidies are likely to be less effective than intended.

Related Literature. This paper contributes to several strands of literature. Firstly, it builds upon a well-established body of macroeconomic studies that examine the effects of resource misallocation, following the seminal work by Hsieh and Klenow (2009) and Restuccia and Rogerson (2008). Notable studies have explored various dimensions within this literature, such as the relationship between misallocation and finance (Midrigan and Xu (2014)), its impact on economic growth (König et al. (2022)), and many others. One significant part of this field explores the relationship between trade and misallocation. Researchers have looked into issues like firm-level distortions (BJL, Berthou et al. (2019), Bajgar (2016)), the impact of distortions on input-output structure (Caliendo et al. (2022), Baqaee and Farhi (2019)), interactions of distortions with trade policy (Bartelme et al. (2019)), see Atkin and Khandelwal (2020) for reviews of recent works.

Among these studies, this paper is most closely related to BJL. Their work examines the effects of bilateral liberalization in the presence of a firm-specific output wedge, and it builds a two-country model calibrated to the Chinese economy. Compared to them, I introduce R&D and technology improvement choices for firms. I find that this R&D option leads to even smaller gains from trade, as distortions allow the wrong firms to grow, wasting resources that could be used in production and more productive firms.

This paper also adds to the existing literature on the impact of trade on technological change. Bustos (2011) extends the work of Melitz (2003) by incorporating endogenous decisions for both export and innovation. The study predicts that the effect of tariff reductions is most significant for firms in the upper-middle range of the firm-size distribution. Lileeva and Trefler (2010) highlights the importance of heterogeneity in investment returns in understanding the joint decisions of export and innovation. Additionally, Costantini and Melitz (2008) and Aw et al. (2011) develop dynamic models of the decisions to adopt new technologies in response to trade liberalization. More recent work provides detailed discussion on process and product innovation (Atkeson and Burstein (2010), Dhingra (2013)), knowledge spillovers (Buera and Oberfield (2020), Alvarez and Lucas (2013)), technology adoption (Perla et al. (2021)), the importance of selection (Sampson (2016)), and various other aspects (see Melitz and Redding (2021) for a more comprehensive review). This paper contributes to this literature by incorporating firm-specific distortions. The presence of these distortions affects the standard selection mechanism outlined in Melitz (2003), as well as the firm's R&D effort, leading to a reduction in trade gains.

More broadly, this paper contributes to the fundamental question of the gains from trade (Arkolakis et al. (2012), Melitz and Redding (2015)). The standard welfare results in an efficient economy no longer hold in the presence of resource misallocation. This paper shows that to value how misallocation impacts the welfare and aggregate TFP, two more components are important: (1) the aggregate output-input ratio regarding domestic production, export, and R&D; (2) changes in subsidies in output relative to input in terms of trade shocks for domestic production, export, and R&D.

In exploring the benefits of trade liberalization for developing countries, Goldberg et al. (2010) underscores the significance of utilizing imported intermediate goods, while Dix-Carneiro et al. (2021) delves into the impact of imperfectly enforced regulations and informal sectors. The paper by Farrokhi and Pellegrina (2023) focuses on technology upgrading in the agriculture sector, Lagakos (2016) concentrates on the retail trade sector, and Khandelwal et al. (2013) scrutinizes the textile and clothing sector. Farrokhi et al. (2023) explores the technology adoption under distortions, with a focus on technology-specific misallocation. This paper extends this literature by examining misallocation arising from general policy distortions.

The rest of the paper is organized as follows. Section 2 lays out the model. Section 3 presents welfare analysis and analytical results under special cases from the model. Section 4 introduces the data and some suggestive evidence. Section 5 describes the calibration of the model. Section 6 presents the quantitative results and counterfactuals. Lastly, section 7 concludes the paper.

2 Model

This section presents a static model that examines the decision-making process for firms to enter the export market and upgrade their technology when firms are facing distortions in their product market. The world consists of two large economies: Home and Foreign. Countries may differ in the size of labor and distribution of firms. Labor is inelastic and immobile across countries.

Household. A representative household in each country makes decisions on the amount of final consumption (C) to maximize utility $u(C)$, and it derives income from wages and government transfers (T).

$$PC = wL + T \tag{1}$$

where P is the price of final good, w is the wage, L is the total labor force endowed.

Final Goods Producer. The final good producers are perfectly competitive. They purchase intermediate varieties from both countries and use a CES production function to combine them into the final good.

$$Q = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} + \int_{\omega \in \Omega_x^f} q(\omega)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where ω are the varieties, $q(\omega)$ is the quantity of each ω. Ω is the endogenous set of goods produced by domestic firms, and Ω_x^f is the endogenous set of goods imported from foreign firms. σ is the elasticity of substitution across varieties, and Q is the real aggregate output. The final goods producer's problem yields the price index equation and the demand function for each intermediate variety ω, where $p(\omega)$ is the price of ω in the market

$$P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} + \int_{\omega \in \Omega_x^f} p(\omega)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{3}$$

$$q(\omega) = \left(\frac{p(\omega)}{P} \right)^{-\sigma} Q \tag{4}$$

Intermediate Goods Producers. There is a mass M_e competitive fringe of potential entrants in both economies. They face uncertainty about their state and need to pay an entry sunk cost f_e to draw it from a distribution G. This state, denoted as s, consists of four components: productivity z, output wedge τ which can be a subsidy ($\tau < 1$) or a tax ($\tau > 1$) on every revenue earned, the ability to connect to foreign buyers c_x and the ability to conduct innovation c_i. After paying the entry sunk cost, the state $s = (z, \tau, c_x, c_i)$ is realized by drawing from a joint distribution G, independently across firms. These firms operate in monopolistic competition, each producing its own variety ω using labor-only technology.

To produce in the domestic market, a firm needs to pay a fixed cost of f_d in labor. It solves the following problem to maximize the domestic profit $\pi_d(s)$[1]:

$$\begin{aligned}\pi_d(s) &= \max_p \frac{pq}{\tau} - \frac{w}{z}q - wf_d \\ &= \Pi_d w z^{\sigma-1}\tau^{-\sigma} - wf_d \end{aligned} \tag{5}$$

where $\Pi_d := \frac{P^\sigma Q w^{-\sigma}}{\sigma^\sigma(\sigma-1)^{1-\sigma}}$ is taken as given by the firms. The fixed cost f_d results in a productivity threshold, below which the firm incurs negative profit while serving the domestic market.

$$\bar{z}_d(\tau) = \left[\frac{f_d}{\Pi_d}\tau^\sigma\right]^{\frac{1}{\sigma-1}} \tag{6}$$

For simplicity, I assume a firm will only enter the market if it has positive domestic profit $\pi_d(s)$. Consequently, the above threshold indicates the entry decision for firms. As seen in the equation, this cutoff varies for firms facing different levels of distortions. Low-productivity firms that would have otherwise been excluded from the market can now enter and survive if sufficiently subsidized (or if τ is small). Conversely, high-productivity firms face difficulty entering the market if they are heavily taxed.

After the firm makes the entry decision, it can then decide whether to engage in export and/or make a one-time investment in R&D simultaneously. Exports are subject to an iceberg cost $D > 1$ and a fixed cost c_x in labor. The heterogeneity of c_x therefore represents how easily the firm can connect to foreign markets. For those firms that choose export but do not upgrade their technol-

[1]Equilibrium price is $p = [\sigma/(\sigma-1)](w\tau/z)$

ogy, the additional profit gained from exporting is [2]

$$
\begin{aligned}
\pi_x(s) &= \max_{p_x} \frac{p_x q_x}{\tau} - \frac{w}{z} D q_x - w c_x \\
&= \Pi_x w D^{1-\sigma} z^{\sigma-1} \tau^{-\sigma} - w c_x
\end{aligned}
\tag{7}
$$

where $\Pi_x := \frac{P^{*\sigma} Q^* w^{-\sigma}}{\sigma^\sigma (\sigma-1)^{1-\sigma}}$, with P^* and Q^* denoting the aggregate price index and demand abroad.

R&D investment is also subject to a fixed labor cost c_i, which varies across firms. Additionally, firms can choose the intensity of their innovation efforts, denoted as α. A higher innovation intensity results in more significant productivity increases or greater technology upgrading, transforming z into $z' = z(1+\alpha)^{\frac{1}{\sigma-1}}$. The cost of choosing different innovation intensities follows:

$$
A\alpha^\beta z^\theta
$$

where β is assumed to be positive and greater than 1, reflecting greater productivity improvements are associated with higher costs. θ, on the other hand, can be positive, negative, or zero. A positive θ indicates that productive firms find it more difficult to improve their current productivity relative to their less productive counterparts. On the contrary, a negative θ suggests that productive firms have an advantage when conducting R&D; it is relatively cheaper for them when choosing the same level of α as less productive firms.

The additional profit, on top of $\pi_d(s)$, earned from technology upgrading by firms serving only the domestic market is:

$$
\pi_d^i(s) = \max_{\alpha} \left\{ \pi_d(z', \tau, c_x, c_i) - \pi_d(s) - A\alpha^\beta z^\theta w - w c_i \right\}
\tag{8}
$$

Similarly, for firms that export and conduct R&D, extra profits separate from $\pi_d(s)$ are:

$$
\pi_x^i(s) = \max_{\alpha} \left\{ \pi_d(z', \tau, c_x, c_i) + \pi_x(z', \tau, c_x, c_i) - \pi_d(s) - A\alpha^\beta z^\theta w - w c_i - w c_x \right\}
\tag{9}
$$

As emphasized by the previous literature, technology and export decisions are interdependent. Deriving the first order conditions of the above equations provides expressions for the opti-

[2] Similar to domestic only firm's problem, $p_x = [\sigma/(\sigma-1)]\,(wD\tau/z)$, and $q_x = (p_x/P^*)^{-\sigma} Q^*$

mal innovation intensity chosen by R&D non-exporters and RD exporters [3]

$$\alpha^* = \left(\frac{(\Pi_d + 1_x \Pi_x D^{1-\sigma})\tau^{-\sigma} z^{\sigma-1-\theta}}{\beta A}\right)^{\frac{1}{\beta-1}} \tag{10}$$

Exporting leads to increased profits, making it easier for firms to cover the fixed costs of R&D and variable costs of achieving greater productivity improvements. As seen in equation (10), firms that also export choose a higher α. Conversely, R&D investments give firms the opportunity to enhance productivity. This results in higher profits in both domestic and foreign markets, potentially enabling firms to cover the fixed costs of exporting and thereby entering foreign markets.

One crucial point to note is that the output distortion τ not only influences the entry decision, as shown in equation (6), but also the decisions related to R&D and exports. A highly subsidized firm (lower τ) finds it less costly to invest in α, all else being equal. Similarly, since profits are functions of τ, the thresholds for engaging in R&D and exports will be distorted as well. In next section, I will derive in further detail how these distortions impact the welfare and gains from trade.

Intermediate firms therefore make export and R&D decisions by comparing the total profit of each of the four possible choices (5), (7), (8), (9).

$$\pi(s) = \begin{cases} \pi_d(s) + \max\{0, \pi_x(s), \pi_d^i(s), \pi_x^i(s)\} & \text{if } \pi_d(s) > 0 \\ 0 & \text{otherwise} \end{cases}$$

Lastly, firms must pay the entry sunk cost f_e to obtain their productivity draw s. This leads to the free-entry condition, where the expected profit for potential entrants equals the cost f_e:

$$\int_s \pi(s) dG(s) \;=\; w f_e \tag{11}$$

[3] To see how $\alpha^*(s)$ is derived, note that $\pi_d^i(s)$ can be expressed as

$$\max_{\alpha}\left\{\Pi_d w z^{\sigma-1}\tau^{-\sigma}\alpha - A\alpha^{\beta} z^{\theta} w - w c_i\right\}$$

and similarly,

$$\pi_x^i(s) = \pi_x(s) + \max_{\alpha}\left\{(\Pi_d + \Pi_x D^{1-\sigma}) w z^{\sigma-1}\tau^{-\sigma}\alpha - A\alpha^{\beta} z^{\theta} w - w c_i\right\}$$

$\Pi_d,\ \Pi_x$ are the aggregates from Home and Foreign, which have the same expression as before, π_x is the profit earned from foreign markets without R&D innovation. Deriving first order condition regarding α will give us the equation 10.

The probability of successful entry is $\omega_e = \int_{\bar{z}_d(s)}^{\infty} g(s)dG(s)$. The ex-post distributions of state s among operational firms is $\mu(s) = g(s)/\int_{\bar{z}_d(s)}^{\infty} g(s)dG(s)$ if $z > \bar{z}_d(s)$, and 0 otherwise.

Government. The government's budget is balanced, therefore the lump-sum transfers are determined as follows

$$T = \int_{\omega \in \Omega} \left(1 - \frac{1}{\tau}\right) p(\omega)q(\omega)d\omega$$

The endogenous set of goods Ω includes all goods produced at Home selling to all destinations.

Equilibrium. With firm distribution of $s = (z, \tau, c_x, c_i)$ for Home G and Foreign G^*, labor endowment at Home L and Foreign L^*, the equilibrium is a collection of aggregate variables $\{P, P^*, w, w^*, Q, Q^*, C, C^*, T, T^*\}$, constant mass of entrants $\{M_e, M_e^*\}$ and mass of producers $\{M, M^*\}$, price and quantities of intermediate goods $\{p(s), q(s), p_x(s), q_x(s)\}$, firms' decisions $\{1_d(s), 1_x(s), 1_i(s), \alpha(s)\}$ and the labors for domestic and export production, as well as innovation $\{l_d(s), l_x(s), l_i(s)\}$ (and all the counterparts for Foreign firms), such that household, final good firm, intermediate good firms all make optimal decisions; the free entry condition (11) holds; good and labor market clearing conditions hold:

$$Q = C$$

$$M\left[\int_{\bar{z}_d} \left(l_d(s) + 1_x(s)l_x(s) + 1_i(s)l_x(s)\right)\mu(s)ds + \int_{\bar{z}_d} \left(f_d + 1_x c_x + 1_i c_i\right)\mu(s)ds + f_e\right] = L \tag{12}$$

and trade is balanced:

$$\begin{aligned} P^{*\sigma} Q^* w^{1-\sigma} M \int_{\bar{z}_d} \left(\frac{z}{\tau}\right)^{\sigma-1} 1_x(s)\Big(1 + 1_i(s)\alpha(s)\Big)\mu(s)ds \\ = \; P^{\sigma} Q w^{*1-\sigma} M^* \int_{\bar{z}_d^*} \left(\frac{z}{\tau}\right)^{\sigma-1} 1_x(s)\Big(1 + 1_i(s)\alpha(s)\Big)\mu^*(s)ds^* \end{aligned} \tag{13}$$

In equilibrium, the measure of producing firms equals the product of the measure of entrants and the probability of entering:

$$\omega_e M_e = M$$

A detailed derivation of the model is provided in Appendix A.

3 Welfare Analysis

This section presents a welfare analysis and analytical results under special cases to show how distortion can lead to a lower gains from trade, especially when R&D is taking into account. To illustrate, I consider a symmetric equilibrium with identical Home and Foreign countries.

3.1 Welfare with distortion

Welfare, denoted as W is evaluated using final consumption per capita C/L, which equals Q/L in the equilibrium[4]. Through simple algebra, Q/L can be expressed as $(PQ/L)(1/P)$. Here, PQ/L represents the revenue-based total factor productivity of the economy, denoted as $\overline{TFPR}$. Combining the aggregate price and balanced trade equations, welfare has the expression:

$$W = \frac{\sigma-1}{\sigma} M_e^{\frac{1}{\sigma-1}} \left[\int_{\bar{z}_d} \left(\frac{\overline{TFPR}}{MRPL_\tau} \cdot z \right)^{\sigma-1} (1 + 1_i(s)\alpha(s)) dG \right.$$
$$\left. + D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) \left(\frac{\overline{TFPR}}{MRPL_\tau} \cdot z \right)^{\sigma-1} (1 + 1_i(s)\alpha(s)) dG \right. \quad (14)$$

where $MRPL_\tau = w\tau$ is the firm-specific marginal revenue product of labor.

The expression demonstrates that welfare is related to weighted firm productivity, using relative distortions as weights. In an efficient case without distortion, MRPL_τ equalizes across firms and equals to $\overline{\text{TFPR}} = w$. With firm-level subsidies or taxes, welfare losses stem from: (1) resource misallocation, captured by the dispersions in $\frac{\overline{TFPR}}{MPRL_\tau}$; (2) selection mechanism, captured by $\bar{z}_d$ and firm choice over $\{1_x(s), 1_i(s)\}$. As shown in (6), subsidized firms find it easier to enter the market since they earn higher profits even though they may be less productive. Conditional on surviving, those firms also find it easy to cover the fixed costs related to export and innovation. (3) distortions in technology improvement choice $\alpha(s)$, as shown in equation (10). Subsidized firms find it cheaper to choose a higher intensity of R&D. (4) entry mechanism, as captured by M_e.

[4]Note that in this model, all the fixed costs and innovation costs are in labor terms, so the aggregate consumption directly equals to the output.

3.2 Welfare change due to trade

A reduction in iceberg costs changes the last three welfare components in equation (14): selection mechanism, technology improvement, and entry. In an efficient economy, trade liberalization generates higher export profits. For existing productivity levels, high productivity firms boost their exports, R&D engagement (1_x, 1_i), and export quantities (q_x), resulting in the expansion of these firms. Simultaneously, trade increases the competition in the domestic market, raising the productivity cutoff for entry ($\bar{z}_d$) and forcing the least productive firms to exit. Without directly changing firm-level productivity, these two forces together improve welfare and aggregate TFP through the selection mechanism. I term this the *between-firm* channel of resource reallocation. Additionally, greater profits allow more productive firms to choose a higher intensity α in R&D. This boosts the firms' productivity through what I call the *within-firm* channel.

However, with the presence of distortions, both channels can be influenced. Distortions may result in the expansion of highly subsidized firms, rather than high productivity firms, exacerbating resource misallocation, as highlighted in BJL. Additionally, it encourages the wrong firms to do innovation. Although the subsidy helps low productive firms to improve, doing so generates unnecessary fiscal burdens that ultimately reduce household consumption and welfare.

To better see this, note that the change in welfare comes from changes in the price index and income. Under free entry, aggregate firm profits are zero. Normalizing the Home wage w and labor endowment L to 1 yields household income $PC = wL + \Pi = 1 + T$. Thus, any changes in income arise solely from variations in fiscal revenue T. As in BJL, the welfare change $\Delta \log W$ from a small trade cost change can be written as

$$\Delta \log W = \Delta \log Q = -\Delta \log P + \Delta \log(PQ) = -\Delta \log P + \Delta \log(1 + T)$$

In an efficient economy without wedges, $T = 0$ and $\Delta \log W = -\Delta \log P$. Therefore, the change of T in terms of the trade cost reduction is key to see how distortions could possibly offset or even cancel out the gain from trade.

To start with, the aggregate price index P have the following expression, after combining the trade balance:

$$
\begin{aligned}
P^{1-\sigma} = \frac{\sigma}{\sigma-1} M_e \Bigg[& \int_{\bar{z}_d} z^{\sigma-1}\tau^{1-\sigma} dG && \text{(domestic output)} \\
& + D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{1-\sigma} dG && \text{(export output)} \\
& + \int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG && \text{(R\&D extra: non-exporters)} \\
& + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG \Bigg] && \text{(R\&D extra: exporters)}
\end{aligned}
\tag{15}
$$

There are four parts within the bracket. The first part comes from the domestic output[5] of all surviving firms. The second part comes from serving the foreign market for all the exporting firms. The last two are the additional outputs that come from conducting R&D. To save the notation, let's denote Λ as the value of the bracket:

$$
\begin{aligned}
\Lambda = & \int_{\bar{z}_d} z^{\sigma-1}\tau^{1-\sigma} dG + D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{1-\sigma} dG \\
& + \int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG
\end{aligned}
$$

Denote λ_1,λ_2, λ_3 be the output share of domestic, export, and additional R&D investment over the total output respectively.

$$
\begin{aligned}
\lambda_1 &= \int_{\bar{z}_d} z^{\sigma-1}\tau^{1-\sigma} dG / \Lambda \\
\lambda_2 &= D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{1-\sigma} dG / \Lambda \\
\lambda_3 &= \left(\int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG \right) / \Lambda
\end{aligned}
\tag{16}
$$

Another important equation comes from the combination of labor market clearing condition

[5]To see why the component in the bracket refers output, note that

$$
PQ = \sigma \frac{P^{\sigma} Q}{\sigma^{\sigma}(\sigma-1)^{-\sigma}} M_e \Lambda
$$

where Λ is defined below. Restructuring the equation gives the same equation as (15) and free entry condition, which have similar four components, but in terms of labor input.

$$fe = \sigma \frac{P^\sigma Q}{\sigma^\sigma (\sigma-1)^{1-\sigma}} M \Bigg[\int_{\bar{z}_d} z^{\sigma-1}\tau^{-\sigma} dG + D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{-\sigma} dG$$
$$+ \int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG \Bigg] \tag{17}$$

Similarly, define the Ξ as the value of the bracket:

$$\Xi = \int_{\bar{z}_d} z^{\sigma-1}\tau^{-\sigma} dG + D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{-\sigma} dG$$
$$+ \int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG$$

Define $S_1,\ S_2,\ S_3$ as the share of input used for domestic, export, and additional R&D.

$$S_1 = \int_{\bar{z}_d} z^{\sigma-1}\tau^{-\sigma} dG / \Xi$$
$$S_2 = D^{1-\sigma} \int_{\bar{z}_d} 1_x(s) z^{\sigma-1}\tau^{-\sigma} dG / \Xi$$
$$S_3 = \left(\int_{\bar{z}_d} (1-1_x(s)) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG + (1+D^{1-\sigma}) \int_{\bar{z}_d} 1_x(s) 1_i(s) z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG \right) / \Xi \tag{18}$$

Combining (15),(17) and the definition of six shares lead to the following proposition:

Proposition 1: The change of the distortion term $\Delta \log(1+T)$ associated with a small change in the iceberg cost has the following expression, where the size depends on (1) the aggregate output share λ_i and input share S_i of different groups of firms; (2) the change of aggregate subsidies in the output and input for domestic production, exports and R&D.

$$\begin{aligned}\Delta \log(1+T) = &\lambda_1 \Delta \log\Big(\int_{\bar{z}_d} z^{\sigma-1}\tau^{1-\sigma} dG\Big) - S_1 \Delta \log\Big(\int_{\bar{z}_d} z^{\sigma-1}\tau^{-\sigma} dG\Big)\\ &+ \lambda_2 \Delta \log\Big(\int_{\bar{z}_d \cap 1_x(s)} D^{1-\sigma} z^{\sigma-1}\tau^{1-\sigma} dG\Big) - S_2 \Delta \log\Big(\int_{\bar{z}_d \cap 1_x} D^{1-\sigma} z^{\sigma-1}\tau^{-\sigma} dG\Big)\\ &+ \lambda_3 \Delta \log\Big(\int_{\bar{z}_d \cap (1-1_x)1_i} z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG + (1+D^{1-\sigma})\int_{\bar{z}_d \cap 1_x \cap 1_i} z^{\sigma-1}\tau^{1-\sigma}\alpha(s) dG\Big)\\ &- S_3 \Delta \log\Big(\int_{\bar{z}_d \cap (1-1_x)1_i} z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG + (1+D^{1-\sigma})\int_{\bar{z}_d \cap 1_x \cap 1_i} z^{\sigma-1}\tau^{-\sigma}\alpha(s) dG\Big)\end{aligned} \tag{19}$$

Note that if firms are not allowed to improve technology, equation (19) is the same as in BJL, where only the *between-firm* channel impacting exporter selection and entry decisions is featured. However, with the choice of R&D, there is an additional component contributing to the equation, which itself combines two forces. One force operates through the *between-firm* channel by shifting $1_i(s)$ — which firms conduct R&D. The other acts via the *within-firm* channel by altering innovation intensity, α.

3.3 Special Cases

To understand how *between firm* and *within firm* channels lead to a negative distortion term $\Delta \log(1+T)$, I analyze two special cases. The first one focuses on the *within firm* channel, where it shuts down the selection mechanism by setting all fixed costs equal to 0; the second one focuses on the *between firm*, where all firms, if they decide to innovate, choose the same $\alpha = \delta$. Both cases assume homogeneous productivity and fixed cost, with only heterogeneity in output wedge τ. Further, $1/\tau$ follows Pareto distribution with parameter θ[6].

3.3.1 Within-firm channel

Consider a version of the model with zero fixed costs of production f_d, exporting f_x and R&D upgrading f_i. In this case, all firms export and upgrade technology, both in an efficient economy, or in the distorted one. Therefore, this setting removes the selection mechanism and focus only on

[6] Another important feature of this distribution assumption is that M_e is constant, therefore making the following cases easier to analysis. See Appendix B.1 and B.2 for more details.

the impact of within firm technology improvement under distortion.

Proposition 2: Consider an economy with no fixed costs, homogeneous productivity, and Pareto-distributed domestic wedge $1/\tau$ with parameter θ. For a small change in trade cost, the distortion term $\Delta \log(1+T)$ is always negative.
PROOF: see Appendix B.1.

Under the above assumptions, firm's optimal R&D intensity is:

$$\alpha(\tau) = \left[\frac{(1+D^{1-\sigma})\Pi_d \tau^{-\sigma}}{A\beta}\right]^{\frac{1}{\beta-1}}$$

where $\Pi_d = \frac{P^\sigma Q}{\sigma^\sigma(\sigma-1)^{1-\sigma}}$.

In an efficient economy, since firms are identical, they choose the same level of α. With distortions, however, subsidized firms will choose a higher intensity. Trade further enhances this as subsidized firms expand more compared to less subsidized ones, leading to an increase in total fiscal subsidies to firms and making the misallocation term $\Delta \log(1+T)$ negative.

3.3.2 Between-firm channel

Now consider the case with fixed cost $0 < f_d < f_x < f_i$. There is no heterogeneity in fixed costs. Firms have homogenous productivity, but heterogeneous wedges, follow Pareto distribution. Further assume the productivity improvement is $(1+\delta)^{\frac{1}{\sigma-1}}$, the same for all innovating firms, regardless of its state. In this setting, most taxed firms (highest τ) exit the market, less taxed firms operating domestically, least taxed or slightly subsidized firms export, and highly subsidized firms export and innovate. Therefore, this case serves as an extended version of BJL by introducing an additional stage to the selection mechanism. It also closely aligns with Bustos (2011), though firms heterogeneity is represented by output wedges rather than productivity.

Proposition 3: Consider a version of the model following the above assumptions. Under a small change in trade cost, the distortion term $\Delta \log(1+T)$ depends on the aggregate output-input ratio regarding the production of export and R&D, and their relative size.

PROOF: see Appendix B.2.

Under above assumptions, the distortion term can be written as

$$\Delta \log(1+T) = \frac{\sigma-1}{\sigma}(\theta+1)\left[(S_2-\lambda_2)+\frac{D^{1-\sigma}}{1+D^{1-\sigma}}(S_3-\lambda_3)\right]\Delta \log D$$

In the Appendix B.2, I show $S_2+S_3 \geq \lambda_2+\lambda_3$, but not necessarily with $S_2+\frac{D^{1-\sigma}}{1+D^{1-\sigma}}S_3 \geq \lambda_2+\frac{D^{1-\sigma}}{1+D^{1-\sigma}}\lambda_3$. Therefore both aggregate output and input ratios and their relative size matter. If compare this with BJL, where the above equation is always negative in BJL, technology upgrading has the potential to bring benefits to the welfare, since the distortions subsidize firms to engage in productivity improvement. But how important of this channel depends on the how many firms are impacted, and the relative size of λ_3 and S_3.

4 Data and Descriptive Evidence

This section introduces the Chinese firm-level data, and presents several suggestive evidence that supports the model.

4.1 Data

The data for Chinese firms are from the Annual Survey of Industrial Firms (ASIF), conducted by China's National Bureau of Statistics for 1998–2007. It includes all state-owned firms and private firms with more than five million RMB in revenue in the industrial sector[7]. The dataset contains the firm's basic information on the 4-digit industry, age, location, ownership, and variables of wage payments, value-added, and capital stock, as well as trading status. It records firms' R&D spending, though this information is only available after 2004. The raw data consists of over 125,858 firms in 1998 and 306,298 firms by 2007.

Table 1 presents summary statistics for the years 2005-2007, during which the R&D data is available. On average, 30% of firms are involved in exporting, and 10% exhibit positive R&D

[7]Despite the reporting threshold for private firms, the survey is representative of the whole secondary industry: When compared to the census of all firms conducted by NBS in 2004, ASIF accounted for more than 90% of both sales and output (Brandt et al. (2014))

spending. Following the approach of König et al. (2022), I focus only on the extensive margin of R&D, using it as a proxy for innovation or technology upgrading. The reason for not using the level of R&D spending is because this intensive margin is subject to a more severe measurement error. The data reveals that exporters and R&D firms are indeed larger, characterized by higher value-added and more employment. Moreover, among R&D firms, those involved in exports are even more substantial in scale.

Table 1: Summary statistics

	Number of firms	log(value add)	log(Number of employees)
All	777,702	9.03	4.69
Non-exporter	560,911	8.89	4.48
Exporter	216,791	9.39	5.23
Non-R&D	694,422	8.89	4.61
R&D	83,280	9.96	5.33
Among them:			
R&D, non-exporter	49,905	9.43	4.96
R&D, exporter	33,375	10.29	5.90

* This table shows the summary statistics for Chinese manufacturing firms for the year 2005-2007. On average, exporter firms and R&D firms are larger in value added and number of employment, firms that engage in both export and R&D are the largest in size. The unit of value added is in thousands of RMB, employment is measured in persons.

4.2 Measure of productivity and distortion

Follow Hsieh and Klenow (2009), firm-specific distortion and productivity can be measured by revenue-based total factor productivity (TFPR) and quantity-based total factor productivity (TFPQ). From their derivations, firms should have same TFPR if there is no distortion present in the economy. TFPQ, on the other hand, represents firms' true productivity z. Relates the definition with this model, TFPR corresponds to the value-added over total inputs (pq/l) and TFPQ corresponds output over total input (q/l), which follows

$$\text{TFPR} = \frac{pq}{l} = \tau\left(1 - \frac{f}{l(s)}\right), \quad \text{TFPQ} = \frac{q}{l} = z\left(1 - \frac{f}{l(s)}\right) \tag{20}$$

where $f = f_d + 1_x c_x + 1_i c_i$ is the total fixed cost paid by the firms, and $l = l_d + 1_x l_x + 1_i l_i$ is the total labor input used in production and innovation. Due to the hetergeneity of fixed costs c_i and

c_x, in efficient economy, firms make same export and R&D decision still see variations in TFPR, but the variation should be small. Under distorted economy, there will be larger dispersion.

The above equations show why distortions and productivity cannot be directly backed out from the data, as the model includes an endogenous selection (not only $1_x,\ 1_s$, but also the selection of surviving firms) and the unknown fixed costs. Similarly to BJL, these two measures back out from the data will be used to match model moments later in the calibration.

To obtain the measure of TFPQ and TFPR from the data, I follow the methodology proposed by Hsieh and Klenow (2009). σ is set to be 3. The composite inputs with capital and labor are $k_{ij}^{\gamma_i} l_{ij}^{1-\gamma_i}$ for firm j in industry i with labor share γ_i. The industry labor shares come from the U.S. NBER productivity database, which is based on the Census and the Annual Survey of Manufactures (ASM). The capital stock is calculated as the book value of fixed capital net of depreciation. Both TFPQ and TFPR are measured with their deviations from the industry mean.

4.3 Suggestive Evidence

The model generates several patterns. Firstly, value-added should be negatively correlated with the output wedge, and positively correlated with productivity. Secondly, regarding the export and innovation investment, subsidized firms and high productive firms should see higher participation in both activities and higher export profits. Lastly, in terms of R&D intensity, subsidized firms should find it cheaper to choose higher α, therefore achieve faster growth in the future.

Table 2 and 3 records the result of related regressions, where I regress the variables of interest with TFPQ, TFPR, and control for several firm characteristics such as ownership (state-owned, or foreign-owned), age, industry, province, and capital stock. All the dependent variables are taken at time $t+1$, where independent variables are at time t.

The results support the model mechanism. As shown in Table 2, columns (1)–(2) shows the pattern of value-added, the result is robust with and without controlling previous period R&D and export participation. Columns (3)-(4) confirm the distorted selection mechanism for exporting, and R&D investment enhances the mechanism. In Table 3, columns (1)-(2) confirm the distorted selection into R&D. Even though with measurement error, R&D spending shows a similar pattern.

Table 2: Chinese firm: value-added and export

	(1) log(VA)	(2) log(VA)	(3) 1(EXP)	(4) log(Exp value)
log(TFPQ)	1.77***	1.76***	0.13***	1.81***
	(0.005)	(0.005)	(0.005)	(0.070)
log(TFPR)	-1.95***	-1.95***	-0.18***	-2.30***
	(0.007)	(0.007)	(0.007)	(0.089)
1(R&D)		0.06***	0.07***	0.64***
		(0.004)	(0.006)	(0.070)
1(EXP)		0.00		
		(0.005)		
Prov,Ind FE	Y	Y	Y	Y
R-squared	0.77	0.77	0.34	0.37
obs	936,706	423,766	423,766	423,766

* This table presents suggestive evidence that supports the model mechanism. Value-added, export participation, and export value are all positively related to productivity, as indicated by TFPQ, and negatively related to the output wedge, as indicated by TFPR. The result is robust when control the R &D participation. All regressions control firm characteristics of age, capital stock, province, ownership and industry.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Lastly, columns (3)-(4) talk to the within-firm channel. Control for current productivity, more subsidized firms grow faster. Also, similar to the findings of König et al. (2022), R&D firms grow faster, though the rate is distorted by the misallocation.

5 Calibration

In this section, I estimate the quantitative effects of trade when accounting for domestic distortions. The two countries Home and Foreign, are calibrated to data corresponding to China and the U.S. The strategy is to use the observed distributions of inputs, value-added, export and R&D participation from Chinese firm-level data to estimate the underlying joint distribution of distortions and productivity in conjunction with other parameters in the model. The general process closely follows BJL, though with different choices of moments to match the model to the data.

Table 3: Chinese firm: R&D

	(1) 1(R&D)	(2) log(R&D spending)	(3) TFP growth (all)	(4) TFP growth (R&D)
log(TFPQ)	0.13***	1.01***	-0.18***	-0.16***
	(0.006)	(0.048)	(0.007)	(0.016)
log(TFPR)	-0.16***	-1.23***	-0.17***	-0.17***
	(0.007)	(0.059)	(0.010)	(0.022)
1(R&D)			0.05***	
			(0.006)	
1(EXP)	0.04***	0.27***	-0.01	0.02·
	(0.005)	(0.032)	(0.005)	(0.010)
Prov,Ind FE	Y	Y	Y	Y
R-squared	0.16	0.21	0.23	0.24
obs	609,751	609,703	314,904	37,581

[*] This table presents suggestive evidence that supports the model mechanism. R&D participation, spending, and future TFPQ growth are all positively related to productivity, as indicated by TFPQ, and negatively related to the output wedge, as indicated by TFPR. Furthermore, R&D firms grow faster than non-R&D firms. All regressions control firm characteristics of age, capital stock, province, ownership and industry.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.1 Predetermined parameters

The elasticity of substitution between varieties σ is set to be 3 as in HK. The Home labor$L$ and the entry cost f_e are normalized to 1. Foreign labor L_f is set to be 0.2 to match the relative labor force of the U.S. to China.

Next, I make several assumptions regarding the distribution G for Home and Foreign. Firstly, to better align with the data, I assume that the heterogeneity in fixed costs c_x and c_i has two components, where $c_x = \eta_x \cdot \bar{c}_x$ and $c_i = \eta_i \cdot \bar{c}_i$. Both η_x and η_i follow Bernoulli distributions, so that only p_x and p_i fractions of firms can engage in export and R&D, respectively (other firms draw a fairly large fixed cost so that it will never be optimal to participate in these activities). These restrictions are imposed due to the small correlation between export and R&D participation observed in the data. In the model, however, highly subsidized and productive firms always choose both investments, while taxed and low-productivity firms engage in neither. Without this restriction, it is challenging to achieve the same model moments as observed in the data.

In addition, I assume the firm distribution G in Home follows multivariate log-normal distribution for $(z, \tau, \bar{c}_i)$, with the mean $(0, 0, f_i)$, similar to BJL. $\bar{c}_x = f_x$ is homogeneous across firms. η_x and η_i are drawn independent from $(z, \tau, \bar{c}_i)$. In other words, firms independently draw η_x, η_i, and $(z, \tau, \bar{c}_i)$. If the firm is allowed to export (η_x=1), then it pays f_x as the fixed cost, if the firm is allowed to upgrade technology ($\eta_i = 1$), then it pays $\bar{c}_i$ fixed cost to do R&D. This give rise to the firms distribution G at Home, which is characterized by 3 standard deviations $(\sigma_z, \sigma_\tau, \sigma_{\bar{c}_i})$, 3 correlations $(\rho_{z,\tau}, \rho_{z,\bar{c}_i}, \rho_{\tau,\bar{c}_i})$, mean $(0, 0, f_i)$, 2 probability (p_x, p_i) and fixed cost f_x.

The decision to set $\bar{c}_x$ as homogeneous across firms for simplicity reason. In the data, the observed correlations between TFPR and export participation, as well as TFPQ and export participation, are both small. This suggests that the correlations between τ and c_x, as well as z and c_x is also small. Therefore keep c_x independent with (z, τ) can save computational burden. Note that the correlation between TFPR and R&D participation, as well as TFPQ and R&D participation is also small, but since it is the main interest, I keep $\bar{c}_i$ jointly distribute with (z, τ).

Lastly, Foreign is assumed to be free of distortion. It has the log-normal distribution only on the productivity, with mean μ_f calibrated internally, and same standard deviation as Home σ_z. Furthermore, the problem of Foreign intermediate firm is simplified, with no choice of innovation. The fixed cost of entry f_e, operating f_d, and export f_x, as well as iceberg cost D are assumed to be the same as Home. In the model, the Foreign country only affect Home by its aggregate, through the balanced trade condition and demand function for Home varieties. Therefore the exact actions of foreign intermediate producer is not the focus.

5.2 Parameters estimated via SMM

The remaining 16 parameters, including 10 related to Home distribution, one fixed cost f_d, 3 from R&D cost function A, β, θ, as well as iceberg cost D, and Foreign mean of productivity μ_f are estimated jointly to match 16 model moments with their data counterparts. Though every parameter matters for the general equilibrium, there are clear correspondences between certain model and data moments. Table 4 reports the estimated parameters and the most relevant moments in the data and the model.

Beginning with the distribution parameters, the variation in productivity z and distortions τ, along with their correlation $\rho_{\tau z}$, play a crucial role in aligning with the observed joint distribu-

Table 4: Parametrization and Moments

Panel A: parameters of distribution

Parameter	Value	Moment	Data	Model
Std. distortion σ_τ	0.97	Std(TFPR)	0.92	0.93
Std. productivity σ_z	1.26	Std(TFPQ)	1.23	1.23
Corr(distortion, prod) $\rho_{\tau z}$	0.74	Corr(TFPR, TFPQ)	0.89	0.83
Corr(distortion, R&D cost)$\rho_{\tau,c}$	-0.05	Corr(TFPR, R&D part)	-0.02	-0.15
Corr(prod, R&D cost) $\rho_{z,c}$	-0.10	Corr(TFPQ, R&D part)	0.09	0.09
Std. R&D cost σ_{c_i}	1.24	Frac. domestic R&D firm	0.06	0.04
Mean of R&D fixed cost f_i	0.20	Frac. exporting non-R&D firm	0.24	0.24
Prob of firm allow R&D p_i	0.24	Frac. exporting R&D firm	0.04	0.03
Prob of firm allow export p_x	0.38	Corr(TFPR, EXP part)	-0.02	-0.08
Fixed cost of exporting f_x	0.15	Corr(TFPQ, EXP part)	0.06	0.05

Panel B: parameters of fixed costs, trade, and innovation

Parameter	Value	Moment	Data	Model
Fixed cost of producing f_d	0.04	Frac. of firms surviving	0.85	0.81
Iceberg trade cost D	1.65	Import share	0.23	0.24
Mean foreign prod μ_f	1.43	GDP U.S to CHN	1.79	1.80
Innovation cost function A	20	Reg. of Col(1) Tab(3) TFPR	-0.16	-0.17
Innovation cost function β	2.98	Reg of Col(4) Tab(3) TFPQ	-0.16	-0.16
Innovation cost function θ	2.80	Reg of Col(4) Tab(3) TFPR	-0.17	-0.24

tion between TFPR and TFPQ in the data. As shown in equation (20), a firm's TFPR rises with both productivity and the wedge, while TFPQ increases with productivity but decreases with the wedge. Therefore, the standard deviations σ_z and σ_τ shape the modeled standard deviations of TFPQ and TFPR respectively. The correlation between productivity and distortions links to the correlation between TFPQ and TFPR. The calibration yields a positive $\rho_{\tau z}$, indicating that highly productive firms are taxed in China.

The heterogeneity in R&D fixed cost and the probability of firms being permitted to innovate (p_i) affects the R&D participation and subsequently impact the distribution of TFPR and TFPQ.

Specifically, the correlation of $\bar{c}_i$ with productivity z and distortion τ are matched to the correlation of R&D participation with TFPR and TFPQ. The mean and standard deviation of R&D costs (f_i and $\sigma\bar{c}_i$), along with the probability p_i, determine the fraction of firms engaged in innovation. Together with parameters related to export participation, they jointly shape the categorization of firms into different groups: those solely involved in R&D, those exclusively exporting, and those participating in both. Hence, these three parameters are linked to the proportions of firms in each group within the surviving firms.

The export-related parameters, namely the probability of firms being allowed to export (p_x) and the fixed costs of export (f_x), influence export participation in the model. In addition to affecting the share within each firm group, these also shape the correlations between export participation and TFPR, as well as TFPQ.

The share of surviving firms primarily links to the fixed cost f_d. A smaller f_d will lead to higher fraction of survivors. The share of producing firms is hence matched using the first-year firm survival rate, as suggested in BJL. Empirical data from the sample periods indicates that approximately 85% of entrants survive into the second year on average. The estimated value of f_d is small and is not significantly different from that in BJL. It's worth noting that the order of the estimated fixed costs is $f_d < f_x < f_i$, suggesting that exporting and R&D incur the higher costs. This result corresponds to the finding of literature such as Bustos (2011), though in this model, there is some degree of heterogeneity on the fixed costs of exports and R&D.

The iceberg cost (D) is calibrated to align with the aggregate import share in Home, calculated as the total exports over total sales across all firms, under the balanced trade assumption. The estimated value (1.65) is smaller than BJL (2.85) but in line with the estimate of 1.7 in Anderson and Van Wincoop (2004) and the 1.83 in Melitz and Redding (2015). μ_f, the Foreign productivity mean matches with the GDP U.S. over China.

Lastly, there are three parameters (A, β, θ) in the R&D cost function $A\alpha^{\beta}z^{\theta}$. Note that β is assumed to be greater than 1, but θ does not have any restrictions. If θ is positive, more productive firms find difficult to upgrade technology. These parameters impact the innovation intensity decision α as shown in equation (10) and the choice to engage in R&D[8]. Consequently, they shape TFP growth for innovating firms and the R&D participation decisions. Therefore, previous empirical regressions can be used to estimate the parameters' values. To do so, I simulate the model to replicate the regressions in Table 3 columns (1) and (4) after solving for equilibrium. The resulting estimates satisfy $\beta > 1$ and yield a positive θ, aligning with existing literature.

5.3 Model fit

Table 4 reports the targeted moments in the model and the data. The model matches well all the empirical targets. Specifically, it replicates well the correlation between TFPR, TFPQ, export, and innovation participation; as well as the fraction of firms conducting each activity. It also replicates the regressions well.

Furthermore, we can examine several non-targeted moments, such as TFPR and TFPQ, across four distinct groups of firms: domestic non-R&D firms, export non-R&D firms, domestic R&D firms, and export R&D firms. These moments align well with the data, as shown in Table 5.

Table 5: Non-Targeted Moments

Moment	Data	Model	Data	Model
	Domestic only		*Domestic R&D*	
St. TFPQ	1.25	1.22	1.28	1.20
St. TFPR	0.94	0.92	0.94	0.70
corr(TFPR,TFPQ)	0.91	0.89	0.86	0.85
	Export only		*Export R&D*	
St. TFPQ	1.19	1.21	1.21	1.16
St. TFPR	0.90	0.91	0.82	0.72
corr(TFPR,TFPQ)	0.88	0.88	0.78	0.79

[8] Compares to the domestic profit, if a firm has productivity higher than

$$\bar{z}_i(s) = \left(\frac{(\beta-1)^{1-1/\beta} c_i}{A^{1/\beta}\beta}\right)^{\frac{\beta-1}{\beta(\sigma-1)-\theta}} \Pi_d^{-\frac{\beta}{\beta(\sigma-1)-\theta}} \tau^{\frac{\sigma\beta}{\beta(\sigma-1)-\theta}}$$

then engage in R&D brings higher profit, hence the firm may choose to upgrade technology. We can get similar cutoffs when compares the additional profit from export, as well as both export and R&D. The cutoffs will be functions of the parameter A, θ, as well as the distortion τ

6 Counterfactual Analysis

In this section, I compare the baseline model to multiple counterfactual economies. First, I explore the gains from trade in the benchmark and compare them to the case where there are no distortions. Then I conduct several policy experiments, by moving the distorted baseline economy to an open one with half dispersion of τ, innovation subsidies from the government, and reduction in fixed cost f_i.

6.1 Role of Distortions and the interaction with R&D

In this exercise, I compute several counterfactual economies. First, I shut down trade and take the economy back to autarky by keeping all the parameters except D fixed as in the baseline. Next, I consider a counterfactual efficient economy, where there are no distortions τ, but all other parameters remain the same. Third, I move this efficient economy back to autarky. The results are recorded in Table 6.

Table 6: Comparison to an efficient economy

	Distorted		Efficient	
	closed	open	closed	open
Frac of firms upgrade	6.84%	6.91%	3.64%	3.59%
Avg intensity α	7.95%	8.07%	0.11%	0.11%
Welfare gain	-	1.24%	-	3.06%
aggregate TFP improvement	-	17.48%	-	7.78%

When moving the economy from closed to open, there are positive welfare gains under both the distorted case and the efficient case. However, the gains in the distorted economy are considerably smaller in magnitude when contrasted with those in the efficient case.

One noticeable difference lies in how firms are motivated to pursue R&D investment. In the efficient economy, only a small fraction of firms (3.64%) engage in positive R&D. The average investment intensity α across firms is a modest 0.11%, implying innovation is expensive and costly. By contrast, in the distorted economy, subsidies lower the cost of innovation for recipient firms.

This enables those firms to opt for greater investment intensity. It also raises the overall fraction of companies choosing to invest in R&D.

When interacting with trade liberalization, the efficient economy sees a minimal change in R&D decisions. In fact, the fraction of firms choosing to upgrade decreases slightly. Trade liberalization increases the potential profits from serving the foreign market, but also introduces more competition in the domestic market. These two opposing forces shape firms' profits, and thereby their innovation choices. Given the calibrated parameters, the increased competition outweighs the profit potentials, resulting in a small decrease in the share of firms pursuing R&D investment. The distorted economy sees the opposite. The presence of distortion leads to an increase in average intensity and encourages more firms to pursue technology upgrading under trade liberalization. This results in nearly double the improvement in aggregate TFP in production labor under the distorted case[9].

We can further decompose welfare to analyze the contribution of the distortion term. As shown in equation (19), there are three components within the distortion term: (1) the selection effect for domestic producers, (2) the selection effect for exporters, and (3) the combined effect of selection and productivity improvements for R&D firms. Table 7 provides the breakdown of how each of these components contributes to the overall welfare impact.

As suggested by BJL, there are two methods for calculating the decomposition. The direct method calculates λ_i and S_i in the open economy, with the three $D\log$ terms computed as the change between the open and closed economies. While easy to compute, this method can introduce inaccuracy since equation (19) is more accurate for small trade cost variations. Instead, the cumulative approach address this issue by integrating compositions from a sequence of small changes in iceberg cost. Specifically, I discretize a large number of trade costs between the benchmark $D = 1.65$ and an extremely large iceberg cost that makes the equilibrium identical to the closed equilibrium. I then sum the changes for each component under any two adjacent D values, using the λ_i and S_i from the lower D. Given the small iceberg cost changes, this cumulative method provides more accurate results.

[9] Aggregate TFP in production labor is defined as the total output produced by all the firms over the total production labor they use. Other types of the labor includes R&D labor who used to produce the productivity improvement, and labor used to pay fixed costs.

These two methods yield similar results. The presence of distortion creates overall welfare losses of 15.25% by the direct method and 15.20% by the cumulative method. Of the three components, R&D contributes the most to the losses. This suggests R&D in the distorted economy leads to further losses, as it encourages the wrong firms to grow which worsens the resource misallocation.

Table 7: Decompose of the welfare (in percentage)

	Distorted				Efficient	
	Baseline		No R&D		R&D	No R&D
Gains from trade	1.24		1.40		3.06	3.06
Distortion term decomposition	Direct	Cumulated	Direct	Cumulated		
Overall	-15.25	-15.20	-5.38	-4.97		
Domestic part (1)	-0.58	-0.62	-0.28	-0.29		
Export part (2)	-2.89	-1.67	-5.09	-4.69		
R&D part (3)	-12.78	-12.91	0	0		

Another way to see how R&D further reduces welfare gains is to compare with an economy where firms lack the technology upgrading option, paralleling BJL. Specifically, I make the average fixed cost of R&D f_i extremely large so no firms find R&D investment profitable. As Table 7 shows, this economy has 1.40% trade gains, still far below the efficient economy yet slightly higher than the baseline. Decomposing the distortions reveals selection into exporting now contributes the most losses under both calculation methods, aligning with BJL. When firms can upgrade via R&D, trade liberalization leads to a great fall in aggregate prices, raising welfare gains. However, it generates larger misallocation at the same time, increasing the distortion term. Compared to BJL with no R&D options, the exacerbated resource misallocation outweighs the benefits of the additional price reduction, which yield smaller welfare gains from trade.

One noteworthy observation is that when comparing two efficient economies — one where firms have R&D options and another without — the trade gains are nearly identical. The result is recorded in the last two columns in Table 7. This aligns with prior findings, as the high costs associated with R&D deter firms from choosing to invest in technology upgrades, even when presented with the option.

6.2 Decomposition of aggregate TFP

We can further look into firm side by decomposing the aggregate TFP. Changes in aggregate TFP can be decomposed into improvements within incumbents (within-firm TFP growth) and three between-firm terms—reallocation of resources to more productive existing firms, entry of new firms, and exit of firms.

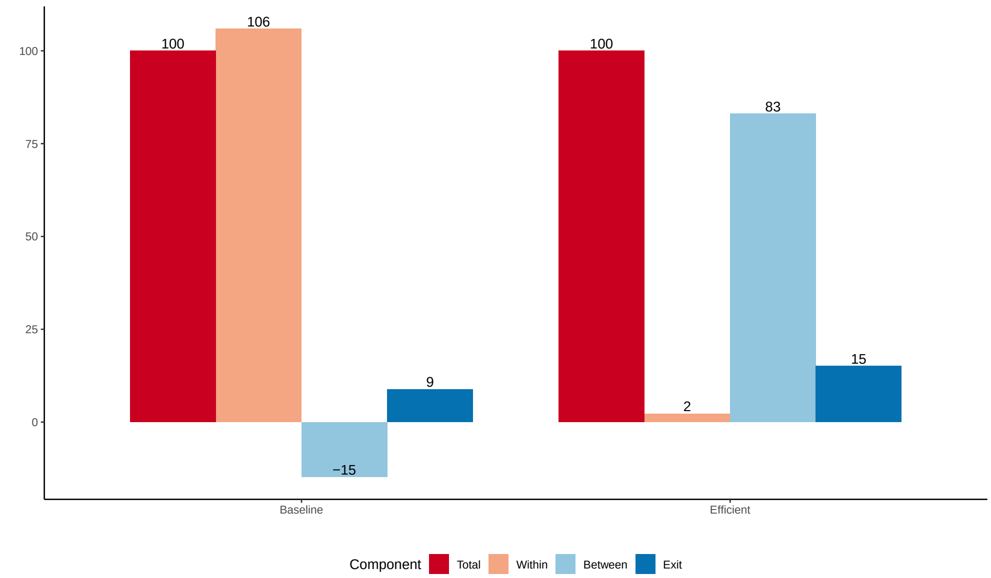
$$\Delta Z_t = \underbrace{\sum_{i \in C} \bar{s}_i \Delta z_{it}}_{\text{within firm}} + \underbrace{\sum_{i \in C} \Delta s_{it} \left[\bar{z}_i - Z_{t-1}\right]}_{\text{between incumbents}} - \underbrace{\sum_{i \in X} s_{it-1} \left[z_{it-1} - Z_{t-1}\right]}_{\text{from exiting firms}} + \underbrace{\sum_{i \in E} s_{it}(z_{it} - Z_{t-1})}_{\text{to new entrants}}$$

where Z_t is the aggregate TFP, z_{it} is firm i productivity, s_t is the output share, $\bar{z}_i, \bar{s}_i$ are the average values between two periods for the firm i. While this model compares the autarkic equilibrium with another equilibrium in an open economy, and thus cannot directly address the new entrant component, it still provides insight on how the other three elements contribute to aggregate TFP changes. Figure 1 shows the decomposition when moving an economy from autarky to trade. The left panel plots the distorted economy as in the baseline, and the right panel plots the efficient case where there is no τ, all the numbers are in percentage, and the total change is normalized to 1. Not surprisingly, most of the contribution comes from *within-firm* under distorted economy. The *between-firm* contributes negatively to the aggregate TFP, suggesting the resources do not reallocate to more productive firms. In the efficient counterfactual, *between-firm* resource reallocation is the most important source of productivity improvement, and the within-firm productivity growth contributes small. The general pattern of the decomposition under the distorted economy aligns with the empirical findings of Brandt et al. (2020) from Chinese data, although the numerical values may not match exactly. The efficient counterfactual decomposition mirrors observations in advanced countries as discussed in Bartelsman and Dhrymes (1998). This decomposition exercise further validates the model's structure.

6.3 Policy experiments

Next, I test three related policies to see which can helps the economy to gain more from trade. To do this, I move the distorted economy from autarky to each of the specified counterfactual

Figure 1: Decomposition of TFP: from autarky to the baseline



economies, with D and the remaining parameters held constant at baseline levels.

The first experiment represents the government's effort to reduce distortions at the same time of implementing trade reform and liberalization. Specifically, I reduce the dispersion of the distortions σ_τ by a half. The second experiment focuses on the government's emphasis on supporting R&D. In this scenario, the government is considering a revenue-neutral R&D subsidy program aimed at correcting distortions in innovation decisions. In particular, I set A, the parameter in the innovation cost function $A\alpha^\beta z^\theta$ to be

$$A_2 = A\tau_A(z)$$

where A has the same value as the baseline. $\tau_A(z)$ is a function that decreases with firms' productivity z[10], and the mean of τ_A is normalized to 1. This experiment helps us understand whether the government should subsidize R&D before addressing the current distortions during trade liberalization. In the last experiment, I investigate whether a reduction, for instance, 50%, in the R&D fixed cost f_i can contribute. The results are summarized in Table 8.

Among all three experiments, the first one that directly address misallocation is the most efficient. It improves the selection mechanisms for domestic production and export, and correct

[10]Specifically, I take $\tau_A(z) = z^{-1/2}$ for each of the z on the grid and re-normalize the mean across the distribution G to be 0. It turns out after solving the equilibrium, the government balance regarding R&D subsidy is small, near to zero.

Table 8: Policy experiments

	Closed	Baseline	(1) 50% σ_τ	(2) targeted R&D subsidy	(3) 50% f_i
Frac of firms upgrade	6.84%	6.91%	8.06%	7.57%	8.77%
Avg intensity α	7.95%	8.07%	2.07%	6.94%	8.72%
Welfare gains	-	1.24%	22.27%	1.29%	1.27%

the distortions in R&D decisions at the same time. As a result, more firms, especially those who are productive but heavily taxed firms, now adopt new technology. Even though they choose smaller intensity, there is still a substantial increase in the welfare and aggregate TFP.

Additional R&D subsidies lead to a slight improvement in welfare gains. It helps productive firms to upgrade technology, as reflected in the increased fraction of firms actively pursuing R&D. It reduces the average intensity at the same time, since it discourage those previously subsidized firms from expanding. Nevertheless, this policy has limited impact on welfare and aggregate TFP as the distortion in production persists. As productive firms continue to face taxation, resulting in diminished profits, the incentive to engage in R&D remains too low. Providing them with only reduction in R&D costs does not generate substantial assistance. Similar logic applies when reducing the fixed cost f_i.

The interaction of policy reforms. We can examine interactions between trade liberalization and the other reforms. Specifically, I solve for equilibriums under three single policies: (1) trade liberalization (the baseline), (2) revenue-neutral R&D subsidies, and (3) structural reform (both defined previously). I then incorporate combinations: (4) trade plus R&D subsidies (the first policy experiment in Table 8 column (3)) and (5) trade plus structural reform (the second experiment in column (4)). Finally, all three policies are applied together. The results are recorded in Table 9, where all the welfare gains is compared with the distorted economy in autarky.

As in Asturias et al. (2016), two policies are substitutes if, once a country has enacted one reform, the welfare change from enacting the other reform decreases. Similarly, two policies are complements if, once a country has enacted one reform, the welfare change from enacting the other reform increases. Suppose we start with autarky distorted economy. The trade liberalization and R&D subsidy program are subsitutes. To see this, note that trade liberalization increase the welfare by 1.24%. If the economy already has R&D subsidy program, open to trade only increase the welfare by 1.22% (from 0.06% to 1.28%). On the other hand, trade liberalization and structural reform are complements. If the economy already has structural reform, open to trade yields additional 2.5% welfare gain. This further underscores the importance of structural reform in maximizing the benefits of trade liberalization. The combined implementation of all three policies results in a welfare gain of 22.4%.

Table 9: Interactions of policy reforms

Reform 1	Reform 2	Reform 3	Welfare gains
no reform (autarky, distorted)			-
trade liberalization (baseline)			1.24%
R&D subsidy program			0.06%
structural reform			19.80%
trade liberalization	R&D subsidy program		1.28%
trade liberalization	structural reform		22.28%
trade liberalization	R&D subsidy program	structural reform	22.41%

7 Conclusion

This paper evaluates the aggregate TFP and welfare gains from trade in an economy with firm-level distortions. In addition to previous studies, this paper explores another channel in which firms can invest in R&D and enhance their current productivity. Though many studies have found that technological improvement can be another source of gains from trade, this paper shows under the distortions, allowing firms to do R&D investment can further reduce welfare gains from trade.

Misallocation not only distorts firms' decisions to export but also influences their technology choices. Consequently, trade liberalization encourages less productive yet subsidized firms to expand further, as they increase their investment in technology upgrading. This expansion raises costs for productive yet taxed firms, exacerbating resource misallocation. The results emphasize the importance of structural reform. Other policies, such as R&D subsidies aim to correct misallocation in R&D decisions, have a limited impact on the welfare gains. This suggests that in a developing country with large firm-specific distortions arising from subsidies and taxes, the government should prioritize reducing these distortions before implementing other types of reforms to maximize gains upon opening the country up.

References

Akcigit, U., H. Alp, and M. Peters (2021). Lack of selection and limits to delegation: firm dynamics in developing countries. *American Economic Review 111*(1), 231–275.

Akcigit, U., S. Baslandze, and F. Lotti (2023). Connecting to power: political connections, innovation, and firm dynamics. *Econometrica 91*(2), 529–564.

Akcigit, U. and M. Melitz (2022). International trade and innovation. In *Handbook of International Economics*, Volume 5, pp. 377–404. Elsevier.

Alvarez, Fernando E, F. J. B. and R. E. Lucas (2013). Idea flows, economic growth, and trade. Technical report, National Bureau of Economic Research.

Amiti, M. and J. Konings (2007). Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American Economic Review 97*(5), 1611–1638.

Anderson, J. E. and E. Van Wincoop (2004). Trade costs. *Journal of Economic literature 42*(3), 691–751.

Arkolakis, C., A. Costinot, and A. Rodríguez-Clare (2012). New trade models, same old gains? *American Economic Review 102*(1), 94–130.

Asker, J., A. Collard-Wexler, and J. De Loecker (2014). Dynamic inputs and resource (mis) allocation. *Journal of Political Economy 122*(5), 1013–1063.

Asturias, J., S. Hur, T. J. Kehoe, and K. J. Ruhl (2016). The interaction and sequencing of policy reforms. *Journal of Economic Dynamics and Control 72*, 45–66.

Atkeson, A. and A. T. Burstein (2010). Innovation, firm dynamics, and international trade. *Journal of Political Economy 118*(3), 433–484.

Atkin, D. and A. K. Khandelwal (2020). How distortions alter the impacts of international trade in developing countries. *Annual Review of Economics 12*, 213–238.

Aw, B. Y., M. J. Roberts, and D. Y. Xu (2011). R&D investment, exporting, and productivity dynamics. *American Economic Review 101*(4), 1312–1344.

Bai, Y., K. Jin, and D. Lu (2019). Misallocation under trade liberalization. Technical report, National Bureau of Economic Research.

Bajgar, M. (2016). Gains from trade in a distorted economy. *Working paper*.

Baqaee, D. and E. Farhi (2019). Networks, barriers. Technical report, National Bureau of Economic Research.

Bartelme, D. G., A. Costinot, D. Donaldson, and A. Rodriguez-Clare (2019). The textbook case for industrial policy: Theory meets data. Technical report, National Bureau of Economic Research.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2013). Cross-country differences in productivity: The role of allocation and selection. *American Economic Review 103*(1), 305–334.

Bartelsman, E. J. and P. J. Dhrymes (1998). Productivity dynamics: US manufacturing plants, 1972–1986. *Journal of Productivity Analysis 9*, 5–34.

Berthou, A., J. J.-H. Chung, K. Manova, and C. Sandoz Dit Bragard (2019). Trade, productivity and (mis) allocation. *Available at SSRN 3502471*.

Boehm, J. and E. Oberfield (2020). Misallocation in the market for inputs: Enforcement and the organization of production. *Quarterly Journal of Economics 135*(4), 2007–2058.

Brandt, L., J. Litwack, E. Mileva, L. Wang, Y. Zhang, and L. Zhao (2020). China's productivity slowdown and future growth potential. *The World Bank*.

Brandt, L., T. Tombe, and X. Zhu (2013). Factor market distortions across time, space and sectors in china. *Review of Economic Dynamics 16*(1), 39–58.

Brandt, L., J. Van Biesebroeck, L. Wang, and Y. Zhang (2017). Wto accession and performance of chinese manufacturing firms. *American Economic Review 107*(9), 2784–2820.

Brandt, L., J. Van Biesebroeck, and Y. Zhang (2012). Creative accounting or creative destruction? firm-level productivity growth in chinese manufacturing. *Journal of Development Economics 97*(2), 339–351.

Brandt, L., J. Van Biesebroeck, and Y. Zhang (2014). Challenges of working with the chinese NBS firm-level data. *China Economic Review 30*, 339–352.

Buera, F. J. and E. Oberfield (2020). The global diffusion of ideas. *Econometrica 88*(1), 83–114.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on argentinian firms. *American Economic Review 101*(1), 304–340.

Caliendo, L., F. Parro, and A. Tsyvinski (2022). Distortions and the structure of the world economy. *American Economic Journal: Macroeconomics 14*(4), 274–308.

Costa-Scottini, L. (2018). Firm-level distortions, trade, and international productivity differences. *Unpublished manuscript*.

Costantini, J. and M. Melitz (2008). The dynamics of firm-level adjustment to trade liberalization. *The Organization of Firms in a Global Economy 4*, 107–141.

Davidson, C., S. J. Matusz, and A. Shevchenko (2008). Globalization and firm level adjustment with imperfect labor markets. *Journal of International Economics 75*(2), 295–309.

Dhingra, S. (2013). Trading away wide brands for cheap brands. *American Economic Review 103*(6), 2554–2584.

Dix-Carneiro, R., P. K. Goldberg, C. Meghir, and G. Ulyssea (2021). Trade and informality in the presence of labor market frictions and regulations. Technical report, National Bureau of Economic Research.

Farrokhi, F., A. Lashkaripour, and H. S. Pellegrina (2023). Trade and technology adoption in distorted economies. *Unpublished manuscript*.

Farrokhi, F. and H. S. Pellegrina (2023). Trade, technology, and agricultural productivity. *Journal of Political Economy 131*(9), 2509–2555.

Fieler, A. C., M. Eslava, and D. Y. Xu (2018). Trade, quality upgrading, and input linkages: Theory and evidence from Colombia. *American Economic Review 108*(1), 109–146.

Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2010). Imported intermediate inputs and domestic product growth: Evidence from india. *Quarterly Journal of Economics 125*(4), 1727–1767.

Hsieh, C.-T. and P. J. Klenow (2009). Misallocation and manufacturing TFP in china and india. *Quarterly Journal of Economics 124*(4), 1403–1448.

Khandelwal, A. K., P. K. Schott, and S.-J. Wei (2013). Trade liberalization and embedded institutional reform: Evidence from chinese exporters. *American Economic Review 103*(6), 2169–2195.

König, M., K. Storesletten, Z. Song, and F. Zilibotti (2022). From imitation to innovation: Where is all that chinese r&D going? *Econometrica 90*(4), 1615–1654.

Lagakos, D. (2016). Explaining cross-country productivity differences in retail trade. *Journal of Political Economy 124*(2), 579–620.

Lileeva, A. and D. Trefler (2010). Improved access to foreign markets raises plant-level productivity… for some plants. *The Quarterly journal of economics 125*(3), 1051–1099.

Manova, K. (2013). Credit constraints, heterogeneous firms, and international trade. *Review of Economic Studies 80*(2), 711–744.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica 71*(6), 1695–1725.

Melitz, M. J. and S. J. Redding (2015). New trade models, new welfare implications. *American Economic Review 105*(3), 1105–1146.

Melitz, M. J. and S. J. Redding (2021). Trade and innovation. Technical report, National Bureau of Economic Research.

Midrigan, V. and D. Y. Xu (2014). Finance and misallocation: Evidence from plant-level data. *American Economic Review 104*(2), 422–458.

Mo, J., L. D. Qiu, H. Zhang, and X. Dong (2021). What you import matters for productivity growth: Experience from chinese manufacturing firms. *Journal of Development Economics 152*, 102677.

Perla, J., C. Tonetti, and M. E. Waugh (2021). Equilibrium technology diffusion, trade, and growth. *American Economic Review 111*(1), 73–128.

Restuccia, D. and R. Rogerson (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic Dynamics 11*(4), 707–720.

Sampson, T. (2016). Dynamic selection: an idea flows theory of entry, trade, and growth. *Quarterly Journal of Economics 131*(1), 315–380.

Verhoogen, E. (2021). Firm-level upgrading in developing countries. Technical report, National Bureau of Economic Research.

Wang, Z. and Z. Yu (2013). Trading partners, traded products and firm performances of china's exporterimporters: Does processing trade make a difference? *The World Economy*, 165–193.

Yeaple, S. R. (2005). A simple model of firm heterogeneity, international trade, and wages. *Journal of International Economics 65*(1), 1–20.

Appendix

A Equilibrium of the baseline model

Intermediate firms in Home take aggregate price P, P^*, w, and aggregate demand Q, Q^* as given. Based on the assumption of constant markup, firms with status $s = (z, \tau, c_x, c_i)$ set price as

$$p(s) = \frac{\sigma}{\sigma - 1}\frac{w\tau}{z'(s)}, \quad p_x(s) = \frac{\sigma}{\sigma - 1}\frac{w\tau D}{z'(s)}$$

where the technology $z'(s)$ is the policy function of optimal R&D intensity. The demand from domestic and foreign final good firms are

$$q(s) = \left(\frac{p(s)}{P}\right)^{-\sigma} Q, \quad q_x(s) = \left(\frac{p_x(s)}{P^*}\right)^{-\sigma} Q^*$$

A firm with status s first decide operate in domestic market or not, with the related profit in equation (5) as

$$\pi_d(s) = \Pi_d z^{\sigma-1}\tau^{-\sigma} - f_d$$

If the status generates positive profit, then the firm enters the market. Next, this firm decide whether to engage in export and R&D investment by comparing the potential profits regarding to export only, domestic only but upgrade technology, and export as well as upgrade technology, as shown in (7), (8), (9)

$$\begin{aligned}
\pi_x(s) &= \Pi_x D^{1-\sigma} z^{\sigma-1}\tau^{-\sigma} - c_x f_x \\
\pi_d^i(s) &= \Pi_d z^{\sigma-1}\tau^{-\sigma}\alpha_1(s) - A\alpha_1(s)^\beta z^\theta - c_i f_i \\
\pi_x^i(s) &= \Pi_x D^{1-\sigma} z^{\sigma-1}\tau^{-\sigma} + (\Pi_d + \Pi_x D^{1-\sigma}) z^{\sigma-1}\tau^{-\sigma}\alpha_2(s) - A\alpha_2(s)^\beta z^\theta - c_i f_i - c_x f_x
\end{aligned}$$

where $\Pi_d = \frac{P^\sigma Q}{\sigma^\sigma(\sigma-1)^{1-\sigma}}$, $\Pi_x = \frac{P^{*\sigma} Q^*}{\sigma^\sigma(\sigma-1)^{1-\sigma}}$ are same to all firms, optimal R&D intensities without and with exporting investment are

$$\alpha_1(s) = \left(\frac{\Pi_d \tau^{-\sigma} z^{\sigma-1-\theta}}{\beta A}\right)^{\frac{1}{\beta-1}}$$

$$\alpha_2(s) = \left(\frac{(\Pi_d + \Pi_x D^{1-\sigma})\tau^{-\sigma} z^{\sigma-1-\theta}}{\beta A}\right)^{\frac{1}{\beta-1}}$$

A firm with status s therefore has following total profit

$$\pi(s) = \pi_d(s) + \max\{0, \pi_x(s), \pi_d^i(s), \pi_x^i(s)\}$$

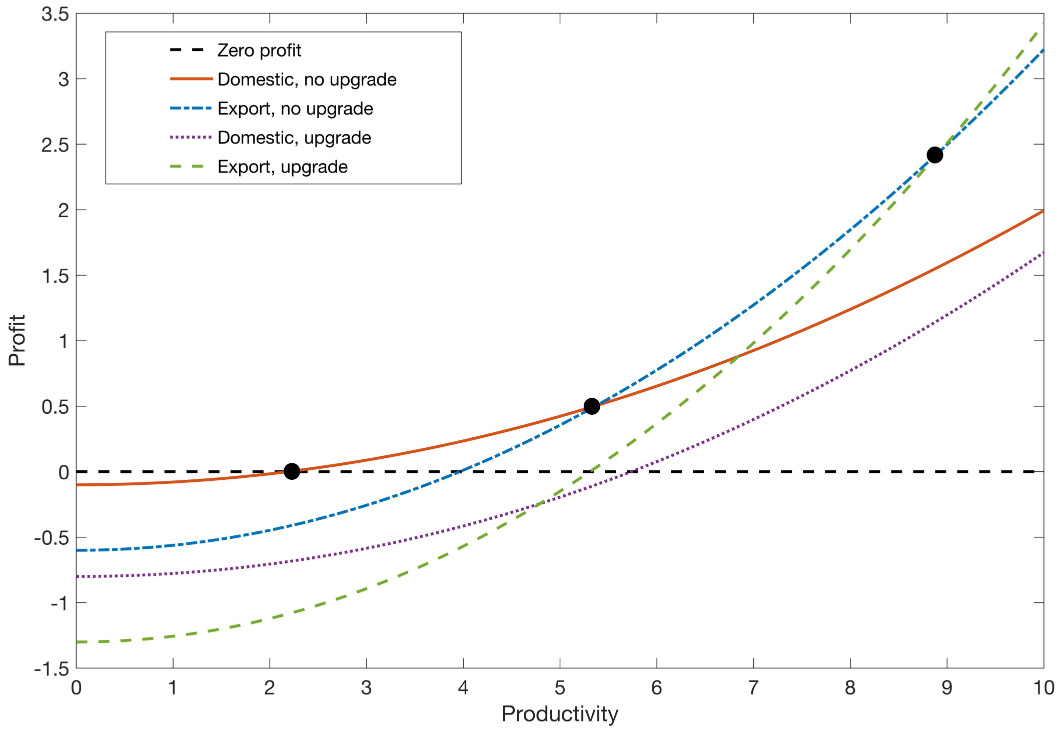
Despite of the heterogeneity in fixed costs, this model produces similar productivity cutoffs for firms. Controlling the fixed costs and output wedge τ, the lowest productivity firms exit the market, highest productivity firms engage in both exporting and R&D investments. In the middle range of productivity, depends on the shape of profit functions, three different cases could happen: (1) export only, (2) domestic only but with technology upgrading, (3) $\pi_d^i(s), \pi_x(s)$ both smaller than $\pi_d(s)$, so firms transit directly from domestic only, to export and R&D. Fig 2 shows the first case under certain value of parameters.

Total expected profit for a firm about to enter is the aggregation of profits across all possible states s, including those lead to a immediate exit. The free entry condition leads to:

$$\int_s \pi(s) dG(s) = f_e$$

Solving firm's problem by taking aggregate variables as given, we have all the policy functions regarding to price, quantity, export participation, R&D participation, R&D intensity, and labor used, for both Home and Foreign. The remaining 7 unknowns are $P, P^*, Q, Q^*, M, M^*, w^*$. By using 2 free entry conditions, 2 market clearing conditions, trade balance, and 2 aggregate price equations, we can fully solve the equilibrium.

Figure 2: Profit of a given level of τ



B Proof for Propositions

B.1 Proposition 2

With homogeneous productivity, $f_d = f_x = f_i = 0$, all firms export and engage in innovation. But since they differ in the output wedge, the optimal intensity α each firm chooses is different. This setting therefore removes selection, and only keeps the heterogeneity in within-firm innovation effort. Based on the assumption, define $h = 1/\tau$ which follows a Pareto distribution with parameter θ, the optimal intensity α for a firm with h is determined by solve the following problem

$$\max_{\alpha}\{(1 + D^{1-\sigma})\Pi_d h^{\sigma}\alpha - A\alpha^{\beta}\}$$

where $\Pi_d = \frac{P^\sigma Q}{\sigma^\sigma(\sigma-1)^{1-\sigma}}$. As before, more subsidized firm will choose higher intensity

$$\alpha(h) = \left[\frac{(1+D^{1-\sigma})\Pi_d h^\sigma)}{A\beta}\right]^{\frac{1}{\beta-1}}$$

Firm's profit

$$\pi(h) = (1-\frac{1}{\beta})(A\beta)^{\frac{1}{1-\beta}}\left((1+D^{1-\sigma})\Pi_d\right)^{\frac{\beta}{\beta-1}} h^{\frac{\theta\beta}{\beta-1}}$$

Next consider the free entry condition and labor market clearing condition. As h is Pareto distributed, the two equations can be derive as the following

$$\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma} + (1-\frac{1}{\beta})\frac{(A\beta)^{\frac{1}{1-\beta}}\,\Pi_d^{\frac{\beta}{\beta-1}}\,(1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma} = f_e$$

$$(\sigma-1)\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma} + ((\sigma-1)+\frac{1}{\beta})\frac{(A\beta)^{\frac{1}{\beta}}\,\Pi_d^{\frac{\beta}{\beta-1}}\,(1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma} + f_e = \frac{L}{M}$$

Combine these two, the key equation of the firm total mass M has the expression:

$$M = \frac{L}{\sigma}\left[\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma} + \frac{(A\beta)^{\frac{1}{1-\beta}}\,\Pi_d^{\frac{\beta}{\beta-1}}\,(1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma}\right]^{-1}$$

Now consider the distortion term in the welfare equation, which has the expression

$$\begin{aligned}
PQ &= \sigma M\left[\int(1+D^{1-\sigma})\Pi_d h^{\sigma-1}dG + (A\beta)^{\frac{1}{1-\beta}}\int(1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}\,\Pi_d^{\frac{\beta}{\beta-1}}\,h^{\frac{\beta}{\beta-1}(\sigma-1)}dG\right] \\
&= \sigma M\left[\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma+1} + \frac{(A\beta)^{\frac{1}{1-\beta}}\,\Pi_d^{\frac{\beta}{\beta-1}}\,(1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma+1}\right]
\end{aligned}$$

Since now all firms export, λ_1 and λ_2 defined in Proposition 1 or equation (19) can be combined together as λ. Similarly, combine S_1 and S_2 together, and define it as S:

$$\lambda = \frac{(1+D^{1-\sigma})\Pi_d}{(1+D^{1-\sigma})\Pi_d + \frac{\theta-\sigma+1}{\theta-\frac{\beta}{\beta-1}\sigma+1} conq \cdot \Pi_d^{\frac{\beta}{\beta-1}} (1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}$$

$$S = \frac{(1+D^{1-\sigma})\Pi_d}{(1+D^{1-\sigma})\Pi_d + \frac{\theta-\sigma}{\theta-\frac{\beta}{\beta-1}\sigma} conq \cdot \Pi_d^{\frac{\beta}{\beta-1}} (1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}$$

Note that $\lambda = 1 - \lambda_3$ and $S = 1 - S_3$, where λ_3 is the share of addtional output produced due to technology upgrading, and S_3 is the additional labor input used in production due to technology upgrading.

Then $d\log(PQ)$ with an small decrease in iceberg trade cost is

$$\begin{aligned}
d\log(PQ) =& d\log\left(\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma+1} + \frac{(A\beta)^{\frac{1}{1-\beta}} \Pi_d^{\frac{\beta}{\beta-1}} (1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma+1}\right) \\
&- d\log\left(\frac{(1+D^{1-\sigma})\Pi_d}{\theta-\sigma} + \frac{(A\beta)^{\frac{1}{1-\beta}} \Pi_d^{\frac{\beta}{\beta-1}} (1+D^{1-\sigma})^{\frac{\beta}{\beta-1}}}{\theta-\frac{\beta}{\beta-1}\sigma}\right) \\
=& \frac{1}{\beta-1}(S-\lambda) d\log\Pi_d + \frac{(\sigma-1)D^{1-\sigma}}{1+D^{1-\sigma}}\left(1-\frac{\beta}{\beta-1}\right)(S-\lambda) d\log D
\end{aligned}$$

Or equivalently

$$d\log(PQ) = -\frac{1}{\beta-1}(S_3-\lambda_3)\Big(\Delta\log(\Pi_d) + \Delta\log(1+D^{1-\sigma})\Big)$$

From the free entry condition, trade cost reduction lead to decrease in Π_d, hence $d\log\Pi_d > 0$. It is easy to see $S_3 > \lambda_3$. Therefore the misallocation term is always negative. Q.E.D.

B.2 Proposition 3

This proposition assumes (1) all firms innovate at same δ if they choose to upgrade; (2) firms only differ in the output wedge τ, and $h = \frac{1}{\tau}$ follows Pareto distribution with parameter θ; (3) $0 < f_d < f_x < f_i$. Then same as BJL and Bustos (2011), there is a clear order: firms with smallest h exit directly; as h becomes larger, firms become domestic only, then exporter, then engage in both exporter and upgrading. The cutoffs of exit, export and upgrading are

$$\bar{h}_d = \left(\frac{f_d}{\Pi_d}\right)^{\frac{1}{\sigma}}$$
$$\bar{h}_x = \left(\frac{f_x}{f_d D^{1-\sigma}}\right)^{\frac{1}{\sigma}} \bar{h}_d$$
$$\bar{h}_i = \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta}\right)^{\frac{1}{\sigma}} \bar{h}_d$$

This setting only keeps the selection, and removes the heterogeneity in within-firm innovation.

Combining the free entry condition and labor market clearing condition, equation (17) has the following expression:

$$\frac{L}{\sigma M} = \int_{\bar{h}_d} \Pi_d h^\sigma \, dG(h) + D^{1-\sigma} \int_{\bar{h}_x} \Pi_d h^\sigma \, dG(h) + (1+D^{1-\sigma})\delta \int_{\bar{h}_i} \Pi_d \, dG(h)$$

Or

$$\frac{L}{\sigma M} = \frac{f_d \left(\frac{f_d}{\Pi_d}\right)^{-\frac{\theta}{\sigma}}}{\theta - \sigma} \left(1 + \frac{f_x}{f_d}\left(\frac{f_x}{f_d D^{1-\sigma}}\right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d}\left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta}\right)^{-\frac{\theta}{\sigma}}\right)$$

At the same time, the free entry condition

$$\int_{\bar{h}_d} \Pi_d h^\sigma \, dG(h) + D^{1-\sigma} \int_{\bar{h}_x} \Pi_d h^\sigma \, dG(h) + (1+D^{1-\sigma})\delta \int_{\bar{h}_i} \Pi_d \, dG(h) - \left[f_d \int_{\bar{h}_d} dG(h) + f_x \int_{\bar{h}_x} dG(h) + f_i \int_{\bar{h}_i} dG(h)\right] = f_e$$

gives us

$$\left(\frac{f_d}{\Pi_d}\right)^{-\frac{\theta}{\sigma}} \left(1 + \frac{f_x}{f_d}\left(\frac{f_x}{f_d D^{1-\sigma}}\right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d}\left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta}\right)^{-\frac{\theta}{\sigma}}\right) = f_e \frac{(\theta-\sigma)\theta}{\sigma}$$

therefore M is a constant, and

$$\log(\left(1 + \frac{f_x}{f_d}\left(\frac{f_x}{f_d D^{1-\sigma}}\right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d}\left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta}\right)^{-\frac{\theta}{\sigma}}\right)) - \frac{\theta}{\sigma}\log(\frac{f_d}{\Pi_d}) = 0$$

The total expenditure equation (15) has the following expression under Pareto distribution:

$$PQ = \sigma M \left[\frac{f_d \left(\frac{f_d}{\Pi_d}\right)^{-\frac{\theta+1}{\sigma}}}{\theta + 1 - \sigma} \left(1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1 + D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}} \right) \right]$$

Now the definition of output share $\lambda_1,\ _2,\ \lambda_3$ and input share $S_1,\ S_2,\ S_3$ are:

$$\lambda_1 = \frac{1}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}}}$$

$$\lambda_2 = \frac{\frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}}}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}}}$$

$$\lambda_3 = \frac{\frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}}}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}}}$$

$$S_1 = \frac{1}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta}{\sigma}}}$$

$$S_2 = \frac{\frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta}{\sigma}}}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta}{\sigma}}}$$

$$S_3 = \frac{\frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta}{\sigma}}}{1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1+D^{1-\sigma})\delta} \right)^{-\frac{\theta}{\sigma}}}$$

The change of distortion term with respect to a small trade shock is therefore:

$$\begin{aligned} d\log(PQ) =& d\log(\left(1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1 + D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}} \right)) - \frac{\theta+1}{\sigma} d\log(\frac{f_d}{\Pi_d}) \\ =& d\log(\left(1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta+1}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1 + D^{1-\sigma})\delta} \right)^{-\frac{\theta+1}{\sigma}} \right)) \\ & - \frac{\theta+1}{\theta} d\log(\left(1 + \frac{f_x}{f_d} \left(\frac{f_x}{f_d D^{1-\sigma}} \right)^{-\frac{\theta}{\sigma}} + \frac{f_i}{f_d} \left(\frac{f_i}{f_d(1 + D^{1-\sigma})\delta} \right)^{-\frac{\theta}{\sigma}} \right)) \end{aligned}$$

Plug in λ_i and S_i

$$d\log(PQ) = \frac{\sigma - 1}{\sigma}(\theta + 1)\left[(S_2 - \lambda_2) + \frac{D^{1-\sigma}}{1 + D^{1-\sigma}}(S_3 - \lambda_3)\right]\Delta \log D$$

Note that we only know $\lambda_1 > S_1$, therefore whether $d\log(PQ)$ is negative or positive depends on the relative size of $\frac{\lambda_2}{S_2}$ and $\frac{\lambda_3}{S_3}$. Q.E.D

C Computational Details

For any guess of the set of parameters, I first generate the grids for z, τ, $\bar{c}_i$. These grids span $\pm$ 5 standard deviations for each variable, accompanied by two $0/1$ vectors indicating whether the firm is permitted to export and innovate. Then I produce the probability of drawing status on each grid based on the assumed distribution G. To attain equilibrium under the specified parameters, I employ the following algorithm:

(1) Define term of trade $u = \frac{P^{*\sigma}Q}{P^{\sigma}Q}$, guess u

(2) With the guess of u, find Π_d, as it is the fixed point of free entry condition. Similarly, solve Π_d^*/w^* for Foreign

(3) Use the definition of u, Π_d, Π_d^*/w^* to solve w^*, and use labor market clearing conditions to obtain total firm mass $M,\ M^*$. Plug them to balanced trade condition, and generate an update of u

(4) Iterate, until u converges.

After solving the equilibrium, I conduct a simulation by generating 10^7 points according to the established distribution, with each entry positioned on a grid. I then apply the policy functions from the preceding step to compute the moments. Next, I compare these simulated moments with the actual data, and accordingly refine the initial parameter estimates.

D Data and Additional Empirical Result

The literature addressing trade liberalization in developing countries has identified alternative channels, such as the utilization of intermediate inputs, as evidenced by Goldberg et al. (2010) for India and Amiti and Konings (2007) for Indonesia. With reduction of trade cost, firms benefit from the increased access to previously unavailable inputs, and better quality of inputs. This section seeks to test this hypothesis using Chinese data.

D.1 Additional Data

To examine how the input tariff reduction leads to increasing use of intermediate input, as well whether it promotes productivity growth and technology adoption, I incorporate two additional sets of data. The first one is the China's General Administration of Customs, providing HS 8-digit product transaction-level trade data for each firm when exporting to and importing from other countries The second one is TRAINS from United Nations Conference on Trade and Development (UNCTAD), which collects HS 6-digit product-level tariff data for each pair of trading partners.

The Chinese custom data and the manufacturing firm survey are collected separately, each assigned distinct system ID numbers. To establish a connection between them, I adopt the methodology proposed by Wang and Yu (2013). Initially, I match firms based on their Chinese name and the corresponding year. To increase the matches, I then use postal code and 7 last digit of phone numbers. Specifically, I focus on imports originating from ordinary trade and confined within the manufacturing sectors to eliminate pure assembly, given the substantial presence of processing trade in China. Moreover, to exclude trading intermediaries, firms with names containing any Chinese characters indicating "Trading Company" or "Importing and Exporting Company" are excluded from the analysis.

Regarding tariffs, they are documented at the HS 6-digit product level for each trading partner after join WTO. Consequently, the available data for China spans from 2001 to 2007. To mitigate potential endogeneity issues arising from firms' future imports and import tariff reductions, I harmonize the HS system by mapping it to the Chinese GB/T 4-digit sector code. I then calculate the average import tariff for each sector. Additionally, to prevent endogeneity concerning different trading partners, I employ the trading partner's GDP as a weight when computing the sector's average import tariff. This same process is applied to export tariffs, representing tariffs imposed by trading partners on Chinese exports.

D.2 Results

Table 10 records how input tariff reduction lead to increase use of imported input. The dependent variables in the regressions are the import value in Columns (1)-(2) and the count of different HS 6-digit products imported in Columns (3)-(4), both in log term. When regressed against the last period import tariffs, the results indicate a deviation from prior literature. Contrary to expectations, a reduction in input tariffs does not result in an increase in the value or variety of imports, even when accounting for firm fixed effects (Column (1) and (3)). When adding more controls such as last period export tariffs, firm distortion TFPR, productivity TFPQ, as well as the participation in export and R&D, and with fixed effect on sector and year, the results remain the same (Column (2) and (4)).

Table 11 shows the result of firm outcomes. The dependent variable for Columns (1)-(2) is log output, for Columns (3)-(4) is TFP growth, and for Columns (5)-(6) is R&D expenditure. I regress each dependent variable within firms and within sectors, accounting for firms' characteristics. Similar to the findings in Table (10), the reduction in import tariffs does not show a significant contribution to firm outcomes. In the study by Mo et al. (2021), the authors differentiate between capital and intermediate imports, discovering that it is capital imports that generate dynamic effects and promote future R&D specifically within the context of China. Given that capital goods imports are often considered a conduit for international technology diffusion, this paper underscores an intriguing extension by exploring another potential source of gains from trade: technology spillover and diffusion.

Table 10: Input Tariffs and Firm Imports

	(1)	(2)	(3)	(4)
	log(Import Value)	log(Import Value)	log(Import Variety)	log(Import Variety)
Import tariff	0.003	-0.005	0.001	0.004$^{\cdot}$
	(0.003)	(0.006)	(0.001)	(0.002)
Export tariff		-2.00***		-0.024***
		(0.016)		(0.005)
log(TFPQ)		1.81***		0.62***
		(0.034)		(0.011)
log(TFPR)		-2.20***		-0.80***
		(0.047)		(0.015)
1(R&D)		0.28***		-0.017
		(0.054)		(0.017)
1(EXP)		-0.69***		0.063***
		(0.047)		(0.015)
Firm FE	Y	N	Y	N
Prov,Ind FE	N	Y	N	Y
Year FE	Y	Y	Y	Y
R-squared	0.90	0.30	0.90	0.33
obs	62,737	17,713	62,737	17,713

Table 11: Input Tariffs and Firm Outcomes

	(1) Output	(2) Output	(3) TFP growth	(4) TFP growth	(5) R&D	(6) R&D
Import tariff	0.002***	0.000	-0.001	-0.002*	0.005*	0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)
Export tariff	0.002*	-0.020***	-0.005*	0.005***	0.002	-0.007***
	(0.001)	(0.001)	(0.003)	(0.002)	(0.004)	(0.002)
log(TFPQ)		1.700***		-0.071***		0.619***
		(0.003)		(0.004)		(0.005)
log(TFPR)		-1.886***		-0.052***		-0.736***
		(0.002)		(0.006)		(0.007)
1(R&D)		0.142***		0.030***		3.554***
		(0.004)		(0.008)		(0.009)
1(EXP)		0.020***		-0.018***		0.163***
		(0.003)		(0.006)		(0.007)
Firm FE	Y	N	Y	N	Y	N
Prov,Ind FE	N	Y	N	Y	N	Y
Year FE	Y	Y	Y	Y	Y	Y
R-squared	0.93	0.72	0.32	0.03	0.81	0.44
obs	783,471	358,455	493,372	147,563	515,599	358,426