China’s Export Surge and the New Margins of Trade∗

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Abstract

This paper builds a multi-sector spatial general equilibrium model featuring heterogeneous firms’ and workers’ location choice, to quantify how three fundamental policy reforms affected China’s export growth over 1990 to 2005: changes in China’s import tariffs, changes in tariffs facing China’s exports in foreign countries, and changes in barriers on internal migration within China. The model allows firms to choose where to locate, whether to export, and the export regime (processing or ordinary), and features firm heterogeneity in productivity along each of these dimensions. Theoretically, we decompose the aggregate elasticity of trade with respect to trade costs into multiple margins of firm adjustment, and show that each margin has an analytic expression, thereby nesting the intensive and extensive margins in Chaney (2008)’s influential application of Melitz (2003).

Empirically, we combine multiple data sources to estimate the model parameters that determine each margin of adjustment. We then quantify the role of each policy in determining China’s export surge and decompose the impact into different margins of adjustment. We find the reductions in China’s import tariffs account for 12.9%, reductions in foreign tariffs on China’s export account for 8.1%, and reductions in barriers to internal labor mobility in China account for 7.8%. The remainder is accounted for by reform-induced TFP growth. We also find firms’ location switches are important in explaining China’s export surge: in the absence of firms’ relocation, the portion of China’s export increase explained by three combined policy drops from 29% to 19%.

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1 Introduction

From 1980 to 2005, the share of “Made in China” in global trade grew from 0.8% to 13%, and to 18% among rich destinations. What has caused China’s extraordinary export surge? One related body of work highlights the importance of productivity growth, while others target trade liberalization, firm entry, and the associated productivity impact.1 A few emphasize the importance of China’s processing exports. As economic reforms have significantly reduced the barriers of capitals, goods and factors movement in China, the interaction of policy with the endogenous responses of firms, workers, and consumers may be important contributions to China’s export surge. However, quantifying the sources of China’s export surge while taking into account policy associated market adjustments is challenging: as the economic incentive changes, firms’ decision of where to locate and whether to export, as well as workers’ decision of where to live and work, might change and closely interact.

Although the literature has identified factors that contributed to China’s post-1990 export boom, to the best of our knowledge, no quantitative evidence on the relative contribution of factors causing China’s export surge exists. To fill this gap in the literature, we build a multi-sector spatial general equilibrium model featuring heterogeneous firms’ and workers’ endogenous location choice, to quantify China’s export surge between 1990 and 2005 due to three policy changes: changes in China’s import tariffs, changes in tariffs facing China’s exports in foreign countries, and changes in barriers on internal migration within China. The model allows firms to choose where to locate, whether to export, and the export regime (processing or ordinary), and features firm heterogeneity in productivity along each of these dimensions. Theoretically, we decompose the aggregate trade elasticity to changes in trade costs into multiple margins of firm adjustment. Empirically, we merge detailed transactions-level with firm-level data to estimate the key variables that determine each margin, and combine multiple data sources to quantify the role of each policy in determining China’s export surge and decompose the impact into the different margins of adjustment.

Our model embeds four margins of firm adjustment that jointly shape the aggregate trade response to changes in economic conditions. We show each margin has an analytic expression. Importantly, the analytic results allow us to structurally identify each margin of firm adjustment. The first two are the standard intensive and extensive margins studied in Chaney (2008). The third margin is firms’ location switching in responses to economic condition changes, referred to the location margin. We find that the location margin is prominent when import tariffs fall in explaining the national-level export growth, whereas the migration-induced location margin is important in explaining the export surge of coastal provinces. The fourth margin that is important for China’s case is firms’ switching between processing and ordinary export

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regimes, refers to as the export-regime margin. We find firms’ switches from processing to ordinary production are prominent for the cases of import tariff reduction, whereas switching from ordinary to process is pronounced when tariffs on China’s exports fall.

Several mechanisms are key in determining the interaction between policy and firm’s adjustment. First, China’s progressive import tariff-cut incentivizes foreign establishments in China to expand, whereas migration-induced firms’ location switches favor coastal provinces where the share of migrants in manufacturing employment is the highest. Second, since ordinary export production is subject to nominal import tariff, whereas the imported intermediate materials are duty-free in processing export production, China’s import tariff reduction operates in favor of ordinary exporters and promotes switching to the ordinary export regime.\(^2\) In contrast, the reductions in tariffs on China’s exports favors processing exporters which are more export-oriented.\(^3\) Finally, despite the domestic value added is higher in ordinary production than in processing production,\(^4\) we find reductions in migration barriers promote processing exports slightly more than ordinary exports. The dominating fact is that processing-oriented industries, such as Computer, Electronic and Optical Equipment, employ migrant workers much more intensively than less-processing-oriented industries.

Our decomposition results depend crucially on the functional form of our model-implied import demand systems — the equations that govern how aggregate trade flows are affected by trade or production costs. We show that the isomorphisms of the import demand systems hold in a much broader class of models (including ours) than the class of models that recent literature has recognized, namely the models that have Constant Elasticity of Substitution (CES) import demand systems.\(^5\) Therefore, the quantitative results of our paper are robust to a wide class of trade models that have different assumptions on market structure, technology, or preferences. The broad class of models that we analyze nest several important ones developed in recent quantitative trade literature. These include the multivariate Pareto generalization of Melitz-Chaney (Arkolakis, Ramondo, Rodriguez-Clare and Yeaple, 2018) (ARRY hereafter), the multivariate Fréchet generalization of Eaton-Kortum as the subclass of the generalized extreme value (GEV) import demand system (Lind and Ramondo, 2018),\(^6\) and the Armington model with nested-CES preferences (Feenstra, Luck, Obstfeld and Russ, 2018).

We measure the changes in import and export tariffs between 1990 and 2005 from the data, and jointly estimate labor supply elasticity and changes in migration frictions (identified as destination-sector fix-effects) by relating changes in migration shares of each destination-sector

\(^2\)This channel has been recently studied in Brandt and Morrow (2017).
\(^3\)While 100% of processing output are sold abroad, only 10.7% output of ordinary production are sold overseas.
\(^4\)See Koopman et al. (2012) and Kee and Tang (2016) who find that the domestic value added in ordinary exports are at least twice as large as that in processing exports.
\(^5\)The isomorphism of models with CES system has been studied in the context of international trade (see Arkolakis, Costinot and Rodríguez-Clare, 2012; Allen, Arkolakis and Takahashi, 2017), and urban economics in terms of commuting flows (see Monte, Redding and Rossi-Hansberg, 2015; Tsivanidis, 2018).
\(^6\)The Eaton-Kortum generalization with a cross-nested CES correlation function has been the empirical workhorse of the generalized extreme value (GEV) import demand system. See Section 6 of Lind and Ramondo (2018) for multiple applications.
pair between 1990 and 2005 to changes in wages, bilateral distance and other determinants. To address workers’ non-random location and sector choices, we instrument the endogenous province-sector wage changes using our model predicted changes of wage component that is associated with China’s export tariff changes between 1990 and 2005. Our key identification assumption is that changes in tariffs on China’s exports levied by foreign countries affect China’s internal migration flows only through its impact on wages, but is uncorrelated with other unobserved factors that affect internal migration.

We merge Annual Surveys of Industrial Firms (ASIF), China’s Customs Transactions Database, and Regional Input-Output Table to estimate China’s provincial imports and exports, inter-provincial trade flows, the value added and the expenditure share on intermediate inputs separately for processing and ordinary production. We also draw multiple population Censuses to measure sectoral employment and wages in China’s provinces and in foreign countries, and measure bilateral trade flows between foreign countries based on STAN Bilateral Trade Database. Despite the fact that our model implies a non-standard gravity equation, the model can be solved in relative changes using “exact hat algebra” (Dekle, Eaton and Kortum, 2008). We account for China’s export surge due to import tariff reduction, export tariff reduction, and changes in internal migration costs and decompose each policy impact into the different margins of adjustment - through the lens of our model that has 29 sectors, 2 export regimes (processing and ordinary), 30 Chinese provinces, and 32 foreign countries.

We find the three policies combined (tariffs in imports, tariffs on exports, internal migration barriers) account for 28.8% of China’s export growth, with the reduction in China’s import tariffs explaining 12.9%, changes in foreign tariffs on China’s exports explaining 8.1%, and reductions in barriers to internal labor mobility in China accounting for 7.8%. The substantial remainder of China’s export growth is accounted for by reform-induced TFP growth. We also find firm location switches are important in explaining China’s export surge: in the absence of firms being able to relocate, the portion of China’s export increase explained by three combined policy drops to 18.8%. Moreover, each policy has differential impact on processing and ordinary exports: the impact of import tariff reduction operates primarily by boosting ordinary exports, whereas the reduction in barriers to internal migration and the reductions in foreign tariffs on China’s exports both favor processing exports.

Section 2 relates this paper to previous literature; Section 3 presents policy changes and facts to motivate our analysis; Section 4 presents our model, and Section 5 decomposes the aggregate trade elasticity into multiple margins. Section 6 discusses model solution, the data sources, our measures of policy shocks, and the estimation of model’s parameters. Section 7 presents the quantitative results. Section 8 concludes.

7Literature which constructs model-based instrumental variables using general equilibrium model include Allen, Arkolakis and Takahashi (2014), Monte, Redding and Rossi-Hansberg (2015), and Adao, Arkolakis and Esposito (2018). Our approach is based on Allen et al. (2014).

8Lind and Ramondo (2018) show the Hat Algebra Approach work in a more general case of Generalized Extreme Value (GEV) import demand system.
2 Literature

The China Shock  China’s spectacular productivity and export growth have drawn enormous research interest. A large body of work has emerged to analyze the global welfare consequences on the rise of China (see Autor, Dorn and Hanson, 2016, for a review). Although the literature has identified several factors that contributed to China’s post-1990 export boom, literature still lacks an accounting of the relative contribution of these factors. We examine the relative contribution of multiple policy changes and their interaction with firm’s adjustment in a unified framework. Our results confirm the major role of China’s TFP growth, and highlight the role of policy-induced firms’ relocation in contributing to China’s export surge.

China’s Processing Trade  The special feature of China’s export surge is its large share of processing exports, and the differential policy treatment faced between processing and ordinary exporters (Branstetter and Lardy, 2006). In this aspect, our paper is related to the literature on China’s ordinary and processing trade (for example, Yu, 2015; Kee and Tang, 2016; Manova and Yu, 2016; Dai, Maitra and Yu, 2016). Our paper is the closest to Brandt and Morrow (2017) and Brandt, Li and Morrow (2018). Differing from the first paper which analyzes firms’ choice of export regime in a partial equilibrium approach, our general equilibrium approach allows the reductions in import tariffs to affect processing exporters through input-output linkages and equilibrium wage adjustments. The second paper builds ordinary and processing trade into a multi-sector Ricardian model of Eaton-Kortum to study the welfare impact if allowing processing producers to sell outputs domestically. Although the micro-foundation in the second paper differs systematically from ours, we show the import demand systems are isomorphic in a broad class of models with non-CES import demand systems (nest ours and theirs). The unique advantage of our model with endogenous firms’ location choice is its ability to structurally identify and quantify policy impact by multiple margins of firm adjustments. Our findings on import tariff-induced firm switching from processing to ordinary corroborate the finding in Brandt and Morrow (2017), while our findings on policy-induced location margin of trade, and migration-induced firms’ switching to processing are new in the literature.

Firm and Worker Mobility in Spatial Equilibrium  This paper also relates to studies on the role of factor mobility in determining the aggregate economic outcomes. In terms of firm mobility, Suárez Serrato and Zidar (2016) and Fajgelbaum, Morales, Serrato and Zidar (2018) model firms’ location choice using i.i.d Gumbel productivity component and assume zero fixed operating costs. However, their work do not allow firms’ selection to export, or do not

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9See Di Giovanni et al. (2014), Hsieh and Ossa (2016), Bai et al. (2017), among others.


11Both papers refer processing and ordinary trade as the organization of trade.

12When fixed costs is zero, every firm has a positive profit to serve neighboring markets under monopolistic
provide analytic expression for each margin of trade. Regarding worker mobility, our approach — guided by the analytic expression of elasticity decomposition we derived — allows us to disentangle the direct effect of worker mobility (the main effect) from the indirect effect of migration-induced firm relocation (the interactive effect) on aggregate economic outcome through the lens of our general equilibrium model. This feature is silent in related literature that analyzes worker mobility (e.g., Enrico, 2011; Diamond, 2016; Bryan and Morten, 2017).

Although it is well-known that China’s internal migration is the backbone of manufacturing employment (Li, Li, Wu and Xiong, 2012), we are the first to quantify their impact on export surge. The focus of our paper therefore, differs from a few recent papers that analyze China’s internal migration and trade using spatial general equilibrium models (e.g., Tombe and Zhu, 2015; Fan, 2015), 13 or Imbert, Seror, Zhang and Zylberberg (2016) who explore firms’ adjustment in response to internal migration. 14 To build our argument, we measure the provincial employment of migrants at the dis-aggregated sectoral levels. 15 We also document an important and novel fact: industries that are more processing-oriented employ migrant workers more intensively than less processing-oriented industries.

**Quantitative Trade Model** This paper relates to the literature of quantitative models in trade and economic geography, and particularly close to the growing literature that study the non-CES import demand system (Adao, Costinot and Donaldson, 2017). 16 We extend the approach in ARRY to incorporate firms’ sorting across processing and ordinary regimes in China, multiple sectors, frictions to internal labor mobility, input-output linkages, and construct a multivariate Pareto distribution with rich correlation structure, all of which are necessary to quantify China’s export surge. We provide a new way to derive the equilibrium conditions of the model in Section 4.2, derive analytic expression for each margin of trade in Section 5. The analytic expression of elasticity decomposition not only provides a transparency comparison of the class of ARRY model to standard Melitz-Chaney, 17 but also shows how this class of models can be used to structurally disentangle the aggregate trade elasticity into multiple margins of trade, including the new margins. Finally, our results on the isomorphic import demand systems connects several important pieces of innovation in the recent trade literature, such as ARRY, Lind and Ramondo (2018), Feenstra et al. (2018), among others.

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13 Tombe and Zhu (2015) quantify the impact of China’s distortions in labor and goods markets on aggregate productivity. Fan (2015) analyzes the impact of trade on regional inequality and skill premium, and how does the impact depend on China’s internal labor market frictions. Also see Zi (2016) and Ma and Tang (2016).
14 These papers do not contain the firm relocation channel.
15 Previous studies have only measured the spatial movement of China’s internal migrants, not at detailed sector level.
16 Adao, Costinot and Donaldson (2017) study a general setting where the factor demand system which is invertible. Also see papers with specific function form of non-CES import demand system, Brooks et al. (2014), Lashkari and Mestieri (2016), Feenstra et al. (2018), Bas et al. (2017).
17 We show after the mass of firm in each location is endogenously determined, the equilibrium productivity distribution follows a univariate Pareto, and therefore our model virtually collapses to a standard Melitz-Chaney model. This property is not explored in ARRY.
3 Background

This section introduces the three types of policy changes which we analyze in this paper and also presents facts to motivate our quantitative model.

3.1 Tariff Reduction

Between 1990 and 2005, the tariffs that China’s exports faced in foreign countries decreased considerably as China gain Most-Favored-Nation (MFN) status following China’s WTO accession. The tariffs fell more pronounced to countries such as India, Brazil, Thailand. The decline of nominal import tariffs was even more progressive in this period: the average import tariffs had declined from over 40 percent to less than 10 percent. As shown in Figure 11, there was substantial heterogeneity in import tariff cuts across industries. Some industries experienced a tariff cut of more than 50 percentage points, including Textiles, Leather and Footwear, Food Product, Beverages and Tobacco. Other industries such as Basic Metals, faced small tariff changes.

In fact, China’s openness to global markets expanded faster than the reduction in nominal tariffs appears, which had to do with the emergence of China’s export processing industry. Since 1987, processing firms have enjoyed the duty-free privileges of imported intermediate materials, but they are not allowed to sell output domestically. In contrast, ordinary producers face nominal import tariffs, but can sell their products domestically.

We incorporate in our model endogenous sorting of firms into processing and ordinary regimes. This choice of regimes not only captures China’s differential tariff treatment, but also allows us to quantify firm endogenous switch of firms between two regimes when there are policy changes. We refer to this type of firm switch as the export-regime margin of trade.

3.2 Migrants’ Employment and Manufacturing Exports

We relate migrants’ manufacturing employment to provincial exports. The left Panel of Figure 1 plots provincial migrants’ employment share in broad manufacture sectors in 2005 against provincial export to output ratio. It shows that provinces where migrants contribute larger portions of manufacturing employment were more export-oriented and accounted for higher shares of national exports (reflected by the circle size). Two noteworthy provinces are Guangdong and Shanghai where migrants accounted for 55.6% and 40.1% of provincial manufactur-

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\(^{18}\) Export processing is the process that firm imports raw materials or intermediate inputs from abroad and exports the value-added final goods (Feenstra and Hanson, 2005).

\(^{19}\) The duty-free privileges are reflected in the gap between nominal import tariff and the share of import revenue in import values: tariff revenue accounted for only 8-10% of import values in 1990, in contrast to the 44% of the average statutory import tariff rate (Naughton, 1996).

\(^{20}\) To sell output to domestic market, processing firms have to be approved by provincial commerce and Customs authorities, and pay back the exempted taxes plus interest payments (Dai et al., 2016).
ing employment respectively. Appendix D provides time-series evidence to show that cross-sectional relationship in 2005 was primarily established during 1990-2005 (the period that we analyze).

Figure 1: Migrants’ Manufacturing Employment Share against Provincial Export/Output Ratio (left); Sector Migrants’ Employment Share against the Share of Processing Export in Guangdong Province (right)

Notes: We measure provincial manufacturing exports using China’s Customs Transactions database for 2005. We measure China’s internal migration using China micro-population census 2005 and define migrants as the geographic mis-match between the province of Hukou registration and the province of residence: people whose Hukou are not registered in the province where they are currently working. The circle size of the left panel measures provincial export volume. The circle size of the right panel reflects provincial processing export volume in each sector.

Trade and migration interact. On the one hand, the reductions in migration barriers caused workers to migrate to coastal provinces. The manufacturing wages fell in destination provinces resulted from the massive internal migration (Imbert et al., 2016),\(^{21}\). Wage reductions promoted export growth. On the other hand, the export surge boosted the labor demand in coastal provinces and attracts migrants. These interacted forces motivate our general equilibrium approach with frictions in workers’ sector and location mobility.

The right panel shows that in Guangdong province, migrants’ employment share was much higher in processing-oriented manufacturing industries — such as Computer, electronic and optical equipment – than industries that were less concentrated in processing exports. The circle size of the right panel reflects provincial processing export volume in each sector. Both fitted lines from export-volume-weighted weighted linear regression (in blue) and the unweighted linear regression (in green) confirm the strong positive correlation. Appendix C shows that the positive correlation also existed in other major exporting provinces.

\(^{21}\)Imbert et al. (2016) construct an instrumental variable using exogenous world agricultural commodities prices and estimate a wage elasticity to migration in China is about -0.9.
3.3 The Special Economic Zones and Provincial Export Growth

Figure 2 displays provincial average annual growth rate between 1990 and 2005 in real terms. As is evident, coastal provinces experienced a faster export growth, with the most rapid increases (in darker green) appearing in Yangtze River Delta economic zones (Shanghai, Jiangsu, and Zhejiang Provinces). Guangdong Province experienced the largest increase in export volumes between 1990 and 2005, although its percentage increase was slightly smaller than those in Yangtze River Delta zones.\(^{22}\)

Coastal provinces’ faster export growth was not only due to their proximity to foreign markets, but had more to do with their special policy privileges which were part of China’s export-oriented development strategy. Between 1980 and 1984, the central government of established four Special Economic Zones (SEZs) (in black dots). Three were located in Guangdong and one in Fujian province.\(^{23}\) Granted by the central government, these SEZs offer foreign and domestic investors special tax and business incentives, as well as large freedom in international trade activity (Leong, 2007).\(^{24}\) In 1984, the government approved 14 National Economic and Technological Development Zones (ETDZs) (in red dots) to further open China to the world. All of these ETDZs were located along coastal provinces.\(^{25}\) These ETDZs offered investors similar economic incentives as SEZs but with higher corporate taxes (Leong, 2013). In 1992, an additional 18 national ETDZs (in pink dots) were introduced, and 11 were coastal cities.\(^{26}\)

Special economic policies of Coastal provinces and their geographic advantages have created dramatic incentives to attract investments and new establishments. Motivated by these facts, we allow firms to endogenously switch locations in response to tariff or migration shock, referred to as the location margin of trade.

\(^{22}\)The export activity in Guangdong has taken off in the 1980s.

\(^{23}\)These SEZs are Shenzhen, Zhuhai, and Shantou in Guangdong province and Xiamen in Fujian province.

\(^{24}\)Foreign and domestic trade and investment can be made without the authorization of central government.

\(^{25}\)The 14 ETDZs are Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Minhang, Hongqiao, Caohaijing, Ningbo, Fuzhou, Guangzhou, Zhanjiang.

\(^{26}\)To date, there are 54 national level ETDZs, 34 of which are eastern coastal regions. The other 21 ETDZs are mostly locate the Middle West regions and were established after the 2000s, following as part of China’s Western Development Strategy.
4 A Spatial Equilibrium Model with Firm Location Choice

We introduce a multi-sector spatial equilibrium model with heterogenous firms’ and workers’ location choice. The world has a fixed mass of firms producing differentiated products in each sector. Firms decide which country to produce, and whether to export; if locating in China, firms’ options are the combination of province and export regime (processing or ordinary). Workers are immobile across countries, but are mobile within country. In China, workers’ are imperfectly mobile across provinces and sectors, but are perfectly mobile across processing and ordinary units. In foreign country, workers are perfectly mobile across sectors.

Our setting differs from the recent quantitative model of firm imperfectly mobility (e.g., ARRY, Suárez Serrato and Zidar, 2016; Fajgelbaum et al., 2018) along several dimensions. First, we incorporate firm sorting over processing and ordinary regime to distinguish China’s differential tariff treatments, and also add multiple sectors to capture sector heterogeneity in facing policy changes. Second, we allow a rich correlation structure of firms’ productivity to relax the independent irrelevant alternative (IIA) property. Third, our model relaxes the zero fixed cost assumption made in Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2018), while allowing non-negative fixed operating costs. Firms, therefore, can endogenously select to export (the extensive margin). Finally, we show the equilibrium productivity distribution (after firms sort globally) follows a uni-variate Pareto distribution.

4.1 Final Goods Producers

The world has many “units” in which production can take place, and between which goods can be traded. We index these production units by $u$ and $r$. We treat each foreign country as a single unit, index by $j$ or $n$, and treat China’s production units are combinations of province, $l$, and export regimes, $m$. We index China by $i$.

In each production unit $u$ and sector $s$, a final good producer using Dixit-Stiglitz production function to produce (non-tradable) final goods by combining a quantity $q_{r,n,s}(\omega)$ of intermediate goods sourcing from $r$

$$Q_{u,s} = \left( \sum_r \int q_{r,u,s}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1.$$  

The summation adds up intermediate goods sourced from all foreign countries, and processing and ordinary production of all China’s provinces. The integral adds over all types of

\[\text{footnote}{\textbf{27}}
\text{The two referred papers assume zero fixed costs, and hence, every firm has a positive profit to serve every destination.}\]

\[\text{footnote}{\textbf{28}}
\text{We find the (cost-adjusted) equilibrium productivity distribution, after firms sort globally, follows a uni-variate Pareto distribution, where the Pareto scale parameter characterized by an endogenous equilibrium object, namely firms’ market access to consumers, that captures the consequence of firms’ sorting. This result, which was not explored by ARRY, implies that our model collapses to a standard Melitz-Chaney model and motivates our elasticity decomposition results presented in Section 5.}\]
varieties produced by firms in \( r \). \( \sigma \) is the elasticity of substitution across varieties.

The final goods can be either consumed by households or used as the raw materials to produce intermediate goods. \( u \)'s optimal demand of intermediate goods produced by \( r \) in sector \( s \) is

\[
q_{r,u,s}(\omega) = \left[ p_{r,u,s}(\omega) \right]^{-\sigma} E_{u,s} P_{u,s}^{\sigma-1},
\]

where \( E_{u,s} \) is \( u \)'s total expenditure on \( s \), and the price index in \( u \) and \( s \) is

\[
P_{u,s} = \left( \sum_r \int p_{r,u,s}(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}.
\]

### 4.2 Intermediate Goods Producers

In the world, there is a total mass \( M_s \) of potential intermediate good producers (firms) in each sector \( s \). Firms can produce in any production units of the world, which include each foreign country as a single unit, and province-regime combination as the production units in China.

#### 4.2.1 Production Technology

In production unit \( r \), firms that have productivity \( \phi_{r,s} \), employ \( L_{r,s} \) efficiency units of labor and \( Q_{r,s,k} \) units of raw materials (final goods) from sector \( k \) to produce a quantity \( q_{r,s} \) of output, according to the following production function

\[
q_{r,s} = \phi_{r,s} L_{r,s}^{\lambda_{r,s}} \prod_k Q_{r,s,k}^{\lambda_{r,s}^{k}},
\]

where \( \lambda_{r,s}^{L} \) is the share of value added of labor, and \( \lambda_{r,s}^{k} \) is the share of the expenditure on raw materials from sector \( k \). When \( r \) referring to China, we allow \( \lambda_{r,s}^{L} \) and \( \lambda_{r,s}^{k} \) to differ between China’s processing and ordinary production. We assume the cost shares add to one, \( \lambda_{r,s}^{L} + \sum_k \lambda_{r,s}^{k} = 1 \).

The implied unit cost of the input bundle is

\[
c_{r,s} = \left( \frac{w_{r,s}}{\lambda_{r,s}^{L}} \right) \prod_k \left( \frac{P_{r,k}}{\lambda_{r,s}^{k}} \right)^{\lambda_{r,s}^{k}}. \tag{29}
\]

In each sector, every intermediate goods producer (firm) draw a vector of productivities, \( \vec{\phi}_{r,s} = \{ \phi_{l(m),s}, \phi_{j,s} \} \) across China’s provinces and regimes, and across foreign countries from a multivariate Pareto distribution below:

\[
F(\vec{\phi}_{l(m),s}, \phi_{j,s}) = 1 - \left[ \sum_l \left( \sum_m A_{l(m),s} \phi_{l(m),s}^{-\frac{\theta}{1-\gamma}} \right)^{\frac{1-\rho}{1-\gamma}} + \sum_{j \in S} A_{j,s} \phi_{j,s}^{-\frac{\theta}{1-\gamma}} \right]^{1-\gamma}, \tag{3}
\]

\(^{29}\)The unit cost of input bundle is common to all firms in province \( l \) and export regime \( m \).
where $S$ denotes the collection of foreign countries. The support of the distribution is defined on $\phi_{l(m),s} > \left[ \sum_l \left( \sum_m A_{l(m),s} \right) ^{\frac{1-\rho}{\sigma}} + \sum_{j \in S} A_{j,s} \right] ^{1-\gamma}$, for all $l$ and $m$.\textsuperscript{30} We assume $\theta > \sigma - 1$.\textsuperscript{31} A larger $\theta$ corresponds to a smaller productivity dispersion. We assume $\theta$ is the same across countries and sectors.\textsuperscript{32} $\rho$ captures the productivity correlation between processing and ordinary regimes,\textsuperscript{33} and $\gamma$ captures the productivity correlation between locations. Each correlation parameter takes value between 0 and 1, with a value close to 1 indicating perfect productivity correlation, and a value close to 0 indicating weak correlation.

The CDF in (3) assumes the productivity correlation between any pair of China’s provinces is the same as the correlation between China’s province and foreign country. In Appendix A.8, we present a more general model to allow difference in these two productivity correlations.

In addition, we assume agglomeration economies in China by assuming $A_{l(m),s} = \bar{A}_{l(m),s} L^\alpha_{l(m),s}$, with $\alpha$ capturing the agglomeration externalities.

4.2.2 Firm’s Problem

 Tradable intermediate goods are subject to two types of variable costs: iceberg-trade costs and \textit{ad valorem} tariff, both of which are export-mode specific. In particularly, we set processing import tariffs to be zero, while applying nominal import tariffs to ordinary production. Also because the output produced by processing firms are not allowed to sell domestically, we set infinite iceberg-trade costs from processing production to any combination of province and regime in China.

Firms solve a sequential optimization problem. In the first stage, for each destination market $n$, firms choose to where to locate by minimizing the unit costs to produce at and export to $n$. In the second stage, given location and regime choices, firms decide whether to export to destination $n$ and if export, then they set price to maximize profits. We now solve firm’s optimization problem by backward induction.

Optimal Price: under monopolistic competition, firms choose the optimal price to maximize the profit if they were to produce from $r$ and decide to export to destination $n$,

$$\pi(\phi_{r,s}) = \max_{p_{r,n,s}} \left\{ p_{r,n,s} q_{r,n,s} - q_{r,n,s} c_{r,s} - c_{n,s} f_{r,n,s} \right\},$$

subject to constrain in equation (1). $\tau_{r,n,s} = 1 + t_{r,n,s}$ is the export tariff levied by foreign country $n$ on $r$. Firms that export to $n$ need to cover a fixed cost in unit of input bundles of destination $n$, denoted as $c_{n,s} f_{r,n,s} > 0$.\textsuperscript{34} For firms that have productivity $\phi_{r,s}$, they set optimal price with a

\textsuperscript{30}Arkolakis, Rodríguez-Clare and Su (2016) provides a detail discussion of the multivariate Pareto distribution.

\textsuperscript{31}This ensures the average productivity is finite.

\textsuperscript{32}See Spearot (2016) who allows the Pareto share parameter to be country-industry specific.

\textsuperscript{33}We assume $\rho$ is the same across provinces. In a more general case, $\rho$ can be specific to province $l$.

\textsuperscript{34}$f_{r,n,s}$ is the fixed cost in units of input bundles at destination $n$. Although our model remains tractable by
markup \( \sigma \sigma^{-1} \) over marginal cost of selling to country \( n \)

\[
p_{r,n,s} = \frac{\sigma}{\sigma - 1} \frac{c_{r,s} d_{r,n,s}}{\phi_{r,s}}
\]

(4)

**Export Decision:** Firms would only export from \( r \) to destination \( n \) if the profit is positive. Given the optimal demand in (1) and the optimal price in (4), the zero-profit productivity cutoff above which firm would export from \( r \) to destination \( n \) is

\[
\phi^*_{r,n,s} = \frac{\sigma}{\sigma - 1} c_{r,s} d_{r,n,s} \frac{\pi^{-1}}{\tau_{r,n,s}} \frac{1}{E_{n,s}}
\]

(5)

In related papers that study firms’ location choice, Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2018) assume \( f_{n,s} = 0 \). We allow positive fixed costs, \( f_{n,s} > 0 \), and hence, a strict positive zero-profit productivity cutoffs, \( \phi^*_{r,n,s} > 0 \) to capture endogenous firms’ switches of export decision (the extensive margin of trade) in response to economic condition changes.\(^{36}\)

Another feature to note from equation (5) is that by modeling revenue tariff, the zero-profit productivity cutoffs is more responsive to tariff changes than changes in iceberg costs.\(^{37}\)

**Firm’s Location and Regime Choice:** We define a cost-adjusted productivity, which is also the inverse of unit cost of production of serving to destination \( n \), as follows

\[
\tilde{\phi}_{r,n,s} = \frac{\phi_{r,n,s}}{c_{r,s} d_{r,n,s} \tau_{r,n,s}}.
\]

(6)

The corresponding cost-adjusted zero-profit productivity cut-off becomes

\[
\tilde{\phi}^*_{r,n,s} = \frac{\sigma}{\sigma - 1} \left( \tau_{r,n,s} \right) \frac{\pi^{-1}}{E_{n,s}} \left( \frac{\sigma c_{n,s} f_{n,s}}{E_{n,s}} \right) \frac{\pi^{-1}}{P_{n,s}}.
\]

(7)

It is worth mentioning that given a destination \( n \), the cost-adjusted zero-profit productivity cut-off is only specific to country due to the tariff, and is invariant across \( l \) and \( m \) in China.

A firm that draws productivity vector \( \tilde{\phi}_{r,s} = \{ \tilde{\phi}_{l(m),s}, \tilde{\phi}_{j,s} \} \) the production unit with the highest cost-adjusted productivity to serve destination \( n \). Thus, firms solves the following problem

\[
Y = \text{argmax}_r \left\{ \tilde{\phi}_{r,n,s} \right\},
\]

again \( r \) includes the combination of China’s province and regime \( (l(m)) \), and foreign country.

\(^{35}\)Chen and Moore (2010) find evidence suggesting that the productivity cut-off of French multinational firm is higher in host countries with less attractive characteristics.

\(^{36}\)In Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2018), there is no firm select to export since every firm makes positive profit to serve every market under monopolistic competition.

\(^{37}\)This feature has been emphasized in Caliendo, Feenstra, Romalis and Taylor (2015).
Y is a discrete random variable denoting firms’ location and regime choices. We omit subscript \( n \) and \( s \), but we are aware of \( Y \) is destination- and sector-specific.

4.2.3 Firm Sorting and Equilibrium Productivity Distribution

Definition. \((Equilibrium\ Productivity\ Z)\) Let \( Z \) be a continuous random variable such that

\[
Z = \max_r \left\{ \widetilde{\phi}_{r,n,s} \right\}.
\]

According to the maximization problem regarding firms’ location and regime choices, \( Z \) is the (cost-adjusted) productivity of all Chinese firms in equilibrium (after sorting into locations and regimes). Again, we omit subscript \( n \) and \( s \), but we are aware of \( Z \) is also specific to each destination and sector. Assuming \( \phi^*_{r,n,s} > \left[ \sum_l \left( \sum_m A_{l(m),s} \right)^{\frac{1-\rho}{\theta}} + \sum_j A_{j,s} \right]^{1-\gamma} \), which ensures the productivity cut-off is not too low that some firms from \( l(m) \) will decide not to serve market \( n \), we have the following Lemma.

Lemma. \((The\ Joint\ Distribution\ of\ Y\ and\ Z)\) The joint probability density function of \( Y \) and \( Z \) is

\[
P(Y = \{l, m\} \& Z = z) = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}} \times \frac{\Psi_{l,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}} \times \left( \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right)^{1-\gamma} \theta z^{-\theta-1},
\]

\[
P(Y = \{j\} \& Z = z) = \frac{\psi_{j,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}} \times \left( \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right)^{1-\gamma} \theta z^{-\theta-1},
\]

where \( \psi_{l(m),n,s} = A_{l(m),s} \left( c_{l(m),s} d_{l(m),n,s} \tau_{l,n,s} \right)^{-1-\rho} \), \( \psi_{j,n,s} = A_{j,s} \left( c_{j,s} d_{j,n,s} \tau_{j,n,s} \right)^{-1-\gamma} \), and

\[
\Psi_{l,n,s} = \left[ \sum_m \psi_{l(m),n,s} \right]^{1-\rho}.
\]

\( \tau_{l,n,s} \) and \( \tau_{j,n,s} \) are tariffs facing China’s and country \( j \)’s exports in country \( n \), respectively. Appendix A.1 provides the proof. Based on Lemma, we obtain the following Proposition.

Proposition 1. \((The\ Marginal\ Density\ of\ Y\ and\ Z)\)

(a) \( Z \) follows a univariate Pareto distribution with the following probability density function

\[
P(Z = z) = \left( \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right)^{1-\gamma} \theta z^{-\theta-1}.
\]

(b) The probability density function of \( Y \) is

\[
P(Y = \{l, m\}) = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}} \times \frac{\Psi_{l,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}}.
\]

\[
P(Y = \{j\}) = \frac{\psi_{j,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}}.
\]
See Appendix A.2 for proof. Part (a) of Proposition 1 states that in each sector, the equilibrium (cost-adjusted) productivity distribution after firms’ optimally choose location and regime globally, follows a univariate Pareto distribution with shape parameter $\theta$, and scale parameter $\left(\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}\right)^{\frac{1}{\gamma+\theta}}$. The scale parameter reflects the market access of all firms’ access to serve to destination market $n$.\(^{38}\)

Part (b) shows that firms’ choice probability depends on the average productivity level ($A_{l(m),s}$), the production costs ($c_{l(m),s}$), iceberg trade costs ($d_{l(m),n,s}$), and export tariffs ($\tau_{i,n,s}$), mirroring the factors which firms take into account when choose location.

Part (c) states that firms’ choice and the equilibrium productivity distribution are independent. One implication is that $P(Y = \{l,m\})$ reflects not only the location probability among exporting firms, but also the location probability among all firms, since independence property implies $P(Y = \{l,m\}) = P(Y = \{l,m\} | Z > \tilde{\phi}_{l(m),n,s})$. Another implication regards the firms’ equilibrium productivity distribution conditional on each production unit. Denote $P(Z = z | Y = \{l,m\})$ as the equilibrium productivity distribution in China’s province $l$ and regime $m$, and $P(Z = z | Y = \{j\})$ as the productivity distribution in foreign country $j$. We have the Corollary below.

**Corollary. (Equilibrium Productivity Distribution)** For all $l(m)$ and $j$, $P(Z = z | Y = \{l,m\})$ and $P(Z = z | Y = \{j\})$ have Pareto density defined in (8).

The result follows directly from Proposition 1: since $Y$ and $Z$ are independent, the conditional probability equals unconditional probability. The univariate Pareto productivity for each production unit $r$, ex-post firms’ sorting, implies that our model collapses to a standard Melitz-Chaney model. The aggregate trade share and price index can be derived similar as in Melitz-Chaney model, except the following two differences. First, we need to keep track the endogenous firm mass defined in equation (9) and (10); and second, the Pareto scale parameter of each country is characterized by an endogenous equilibrium object that captures the consequence of firms’ sorting, namely firms’ market access to consumers.

### 4.3 Aggregate Trade Shares and Prices

The share of country $n$’s expenditure in sector $s$ that spent on goods produced by province $l$ and regime $m$ is

$$\Pi_{l(m),n,s} = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}} \times \frac{\Psi_{l,n,s} \tau_{i,n,s}^{\theta} \tau_{j,n,s}^{\theta}}{\sum_l \Psi_{l,n,s} \tau_{i,n,s}^{\theta} + \sum_{j \in S} \psi_{j,n,s} \tau_{j,n,s}^{\theta}}. \tag{11}$$

\(^{38}\)Equivalently, the scale parameter can be interpreted as consumers’ in country $m$’s market access goods produced in China.
See Appendix A.5 for derivation. Analogously, the share of country $n$’s expenditure in sector $s$ that spent on goods produced by foreign country $j$ is

$$\Pi_{j,n,s} = \frac{\psi_{j,n,s} \tau_{j,n,s}^\vartheta}{\sum_l \Psi_{l,n,s} \tau_{l,n,s}^\vartheta + \sum_{j \in S} \psi_{j,n,s} \tau_{j,n,s}^\vartheta}.$$  \hspace{1cm} (12)

again, $\psi_{l(m),n,s} = A_{l(m),s} \left( c_{l(m),s} d_{l(m),n,s} \tau_{i,n,s} \right)^{-\frac{\vartheta}{\sigma-1}}$, $\psi_{j,n,s} = A_{j,s} \left( c_{j,s} d_{j,n,s} \tau_{j,n,s} \right)^{-\frac{\vartheta}{\sigma-1}}$, and

$$\Psi_{l,n,s} = \left( \sum_m \psi_{l(m),n,s} \right)^{\frac{1-\vartheta}{\sigma-1}}.$$  \hspace{1cm} \(\vartheta = \frac{\sigma-1-\vartheta}{\sigma-1}\) captures the additional trade response to changes in export tariff. Equation (11) specifies the key factors that determine trade shares in equilibrium. These factors $A_{l(m),s}$, iceberg trade costs $d_{l(m),n,s}$, export tariffs $\tau_{i,n,s}$, and the cost of the input bundle $c_{l(m),s}$. Our empirical analysis decomposes China’s export surge due to changes in $c_{l(m),s}$ that are associated with internal migration and import tariff changes, and also analyze the impact of changes in export tariff, while attributing the residual of export increases to $A_{l(m),s}$ and $d_{l(m),n,s}$.

Another noteworthy point is that as a macro-level consequence of modelling revenue tariffs, the changes in export tariff has an additional impact on aggregate trade, comparing to iceberg trade costs $d_{l(m),n,s}$ or changes in cost of input bundle $c_{l(m),s}$.\footnote{In equation (11), export tariff has a symmetric effect on trade share as $d_{l(m),n,s}$ does, and also has an additional effect through the term $\tau_{j,n,s}^\vartheta$.}

Although our quantitative results depend crucially on the import demand system given in equation (11), we show in Proposition 2 that equation (11) is a generic prediction of a wide class of theoretical trade models. Therefore, our quantitative results on export impact of each policy is robust to a wide class of theoretical models that have different assumptions on market structure, technology, or preference.

**Proposition 2. (The Isomorphisms of Import Demand System)** There exists a version of Ricardian Eaton-Kortum model or a version of Armington model that can generate the isomorphic import demand system as the one in equation (11).

Appendix A.3 provides the proof. There are two important differences from which our results depart from those analyzed in the literature (e.g., Arkolakis et al., 2012; Allen et al., 2017). First, the isomorphic results studied in the literature are based on CES import demand system, whereas we analyze a broader class of nested-CES models. Second, the isomorphism studied in the literature are general equilibrium results, whereas ours is a partial equilibrium result that only applies to the import demand system. Without making further assumptions, our result is silent to link the general equilibrium welfare implications across different models.

We provide a simple representation of trade share formula between production units. The
share of $u$’s expenditure in sector $s$ that spent on goods produced by $r$ is

$$\Pi_{r,u,s} = \frac{M_{r,s} \tau_{r,u,s}}{\sum_{r'} M_{r',s} \tau_{r',u,s}}.$$  \hspace{1cm} (13)

When $r$ refers to a province-regime combination in China, $M_{r,s} = M_s \times P(Y = \{l,m\})$; when $r$ refers to a foreign country $j$, $M_{r,s} = M_s \times P(Y = \{j\})$. Appendix A.6 shows how we obtain the simple representation of trade share from (11) and (12).

We also have the aggregate price index in $r$ and sector $s$ is

$$P_{n,s} = \left[ \Theta M_s \left( \frac{E_{n,s}}{C_{n,s}} \right)^{\vartheta} \left( \sum_{l} \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right)^{-\gamma} \left( \left[ \sum_{l} \Psi_{l,n,s} \tau_{l,n,s}^{\vartheta} + \sum_{j \in S} \psi_{j,n,s} \tau_{j,n,s}^{\vartheta} \right] \right) \right]^{\frac{1}{\vartheta}}.$$  \hspace{1cm} (14)

again $\Theta = \sigma^{1-\vartheta} \left( \frac{\vartheta}{\vartheta - \vartheta + 1} \right) \left( \frac{\sigma}{\sigma - 1} \right)^{-\theta}$, and $\vartheta = \frac{\sigma}{\sigma - 1}$.

### 4.4 Workers’ Preference and the Labor Markets

Workers consume final goods of all sectors, and their utility function from their consumption baskets is determined by Cobb-Douglas preferences,

$$U = \prod_s C_{s}^{\beta_s}, \quad \text{where} \quad \sum_s \beta_s = 1,$$  \hspace{1cm} (15)

with $0 < \beta_s < 1$ denoted as the expenditure share on the final good produced by sector $s$.

**China’s Labor Markets:** Chinese workers are grouped based on their provinces of Hukou registration, and we index group by $g$. We model workers’ province and sector sorting using a Fréchet-Roy model with frictions to the labor market. Within each province and sector, workers are perfectly mobile between processing and ordinary. Specifically, a worker choose a province to live and a sector to work by maximizing

$$V_{l,s} \times \zeta_{g,l,s} \times a_{g,l,s},$$

where $V_{l,s} = \frac{w_{l,s}}{P_l}$, which is the real wage per efficiency unit in $l$ and $s$. $w_{l,s}$ is the wage per efficiency unit of labor in province $l$ and sector $s$, and $P_l$ is the aggregate price index in province $l$.\(^{40}\)

$\zeta_{g,l,s}$ is migration frictions which is a proportional loss of real income.\(^{41}\) In Appendix C.2, we show there is a large degree of heterogeneity in migrants’ sector sorting across different destination provinces.\(^{42}\) The differences in migrants’ sector sorting suggest the barriers that

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\(^{40}\)Since workers only consume the final goods in the ordinary production unit, $P_l$ is computed as $P_l = \prod_i \left( P_{l(o),i}/\beta_s \right)^{\vartheta}_s$.

\(^{41}\)The assumption that migration costs perform as proportional adjustment to real consumption is commonly exploited in the literature; for example, see Borjas (1987), Chiquiar and Hanson (2005), Galle et al. (2015) and Caliendo et al. (2016). One interpretation is that migrants may enjoy fewer working/leisure hours because of more time spent on the way (Bryan and Morten, 2017).

\(^{42}\)In provinces such as Guangdong, Zhejiang, migrants are disproportionately employed in manufacturing sectors, whereas in Shanghai, Beijing, migrants are disproportionately employed in hotel & restaurant service,
migrants face to work in a given sector may differ across provinces, which can be due to
the differences in local government’s Hukou policies that allow migrants to work in certain
sectors. We accommodate these facts by allowing migration friction as a combination of group-
destination-sector, $\zeta_{g,l,s}$.

$a_{g,l,s}$ is the efficiency units of labor for a worker, and is drawn independently across $l$ and
$s$ from a Fréchet distribution with CDF $G(a) = \exp (-a_{g,l,s}^\kappa)$. $\kappa$ captures the dispersion of
productivity draws, with a larger $\kappa$ corresponding to a smaller degree of heterogeneity in pro-
ductivities across workers. The Fréchet productivity implies the fraction of group $g$ workers
that work in province $l$ and sector $s$ has the close-form as:

$$\Lambda_{g,l,s} = \frac{\zeta_{g,l,s}^\kappa V_{l,s}^\kappa}{\sum_{n,k} \zeta_{g,n,k}^\kappa V_{n,k}^\kappa}.$$  \hspace{1cm} (16)

$\kappa$ governs the labor supply elasticity with respect to real wages. Conditional on migration
choices, the average level of efficiency units that group $g$ workers supply to sector $s$ in province
$l$ is given by:

$$\mathbb{E}[a_{g,l,s}| \text{choose } l, s] = \Gamma \left( 1 - \frac{1}{\kappa} \right) \Lambda_{g,l,s}^{-\frac{1}{\kappa}}.$$

In line with the Roy model, a higher migration fraction $\Lambda_{g,l,s}$ is associated with lower average
efficiency units of workers.

**Foreign Labor Markets:** Each foreign country $n$ has a fixed population $L_n$. We consider a
single labor market in each foreign country, and labor is perfectly mobile across sectors. $w_n$
denotes the wage unit in country $n$.

### 4.5 Market Clearing Conditions

we assume that the profits are expended by managers on input bundles in the production process.\(^{43}\) The final goods market clear condition is

$$E_{r,s} = \beta_s I_r + \sum_k \lambda_{r,k}^s \left( (1 - \eta) \sum_u \frac{\Pi_{r,u,k} E_{u,k}}{1 + t_{r,u,k}} + \eta \sum_u \frac{\Pi_{u,r,k} E_{r,k}}{1 + t_{u,r,k}} \right)$$ \hspace{1cm} (17)

where $E_{r,s}$ is the total expenditure on the final good in region $r$ and sector $s$. Our model
implies that the total fixed costs of marketing spent by firms are a fixed proportion $\eta = \frac{\theta - \sigma + 1}{\sigma \theta}$
of net-of-tariff trade flows. Equation (17) means that the value of the final good produced in
unit $r$ and sector $s$ equals the consumption plus the amount used as raw materials to produce
intermediate goods.\(^{44}\)

\(^{43}\) As an alternative, we also experiment with the assumption that that profits are spent by managers on con-
sumption goods according to equation (15), which gives quantitatively similar results.
\(^{44}\) Since the final good is produced only using intermediate goods (either produced domestically or imported),
unit $r$’s value of final goods equals the its total expenditure on intermediate goods, $E_{r,s} = P_{r,s} Q_{r,s}$. 

18
The first term on the right-hand side of equation (17) is the amount of final goods consumed by workers and local governments, which equals the product between sector expenditure share $\beta_s$ and the income in $r$, $I_r$. The latter equals the labor income plus the tariff collected by unit $r$, $T_r = \sum_s \sum_u \frac{t_{u,r,s}}{1+t_{u,r,s}} \Pi_{u,r,s} E_{r,s}$. When $r$ refers to a foreign country $n$, the total labor income is $w_n L_n$, and therefore $I_n = w_n L_n + T_n$.\footnote{Since Chinese workers only consume the final goods in the ordinary production unit, when $r$ refers to a China’s ordinary production unit $l(o)$, we derive $I_l(o) = \sum_l \sum_s w_{l,s} L_{g,l,s} + T_l(o)$, where $L_{g,l,s} = \Gamma (1 - \frac{1}{2}) L_g \gamma^{1-\frac{1}{2}} g_{l,s}$ is the amount of efficiency units that group $g$ workers supply to province $l$ and sector $s$. When $r$ refers to a China’s (duty-free) processing production unit $l(p)$, $I_l(p)$ equals zero.}

The second term sums up the amount of final goods used as raw materials to produce intermediate goods in each sector $k$. $\sum_u \frac{\Pi_{u,k} E_{u,k}}{1+t_{u,k}}$ represents the total production of intermediate goods in unit $r$ and sector $s$, of which a proportion $1-\eta$ (variable costs plus profits) is spent on costs of input bundles (labor and raw materials) in the origin. $\eta \sum_u \frac{\Pi_{u,k} E_{u,k}}{1+t_{u,k}}$ is the total costs of marketing spent by global firms selling goods to unit $r$ and sector $s$, which was assumed to be spent on the input bundle in the destination. Cobb-Douglas production function indicates that a fraction $\lambda_{r,k}$ of input costs in unit $r$ and sector $k$ is spent on the final good (raw materials) from sector $s$. Aggregating across sectors, $\sum_k \lambda_{r,k} \left( (1-\eta) \sum_u \frac{\Pi_{u,k} E_{u,k}}{1+t_{u,k}} + \eta \sum_u \frac{\Pi_{u,k} E_{u,k}}{1+t_{u,k}} \right)$ amount of final goods in sector $s$ is used as raw materials.

As workers are perfectly mobile between processing and ordinary producers in each China’s province and sector, the labor markets are cleared for each China’s province $l$ and sector $s$.

$$\sum_m \lambda_{m,s}^L \left( (1-\eta) \sum_u \frac{\Pi_{l(m),u,s} E_{u,s}}{1+t_{l(m),u,s}} + \eta \sum_u \frac{\Pi_{u,l(m),s} E_{l(m),s}}{1+t_{u,l(m),s}} \right) = \sum_g w_{l,s} L_{g,l,s}. \quad (18)$$

The left-hand side represents firms’ expenditures on labor, including both ordinary and processing producers. It sums up the product between the share of labor costs $\lambda_{m,s}^L$ and the total costs on input bundles (labor and raw materials) in sector $s$ across trade regimes. The right-hand side is the total labor income in $l$ and $s$ earned by workers from all labor groups.

For foreign country $n$, we assumed a single labor market for each country, for which the market clearing condition is:

$$\sum_s \lambda_{n,s}^L \left( (1-\eta) \sum_u \frac{\Pi_{n,u,k} E_{u,k}}{1+t_{n,u,k}} + \eta \sum_u \frac{\Pi_{u,n,k} E_{n,k}}{1+t_{u,n,k}} \right) = w_n L_n. \quad (19)$$

In summary, given model fundamentals $\{A_{r,s}, f_{n,s}, L_g, L_n, M_{l,s}, d_{r,u,s}, \tau_{r,u,s}, \zeta_{g,l,s}\}$ and parameters $\{\theta, \rho, \gamma, \kappa, \sigma, \alpha, \beta_s, \lambda_{r,s}^L, \lambda_{r,s}^k\}$, $\{\Pi_{l(m),u,s}, \Pi_{n,u,k}, P_{r,s}, \Lambda_{g,l,s}, E_{r,s}, w_{l,s}, w_n\}$ satisfy all equilibrium conditions (11)–(14) and (16)–(19).
5 Decomposing the Aggregate Trade Elasticity

Our model allows four margins through which the aggregate trade flows response to changes in economic conditions. These margins are the intensive and extensive margin, location margin and export-regime margin. This section derives the analytic expression to link the key parameters and variables that determine each margin of trade. The decomposition results presented here provide the empirical guide to structurally disentangle different margins of trade.

Without loss of generality, we, again, develop our argument by considering exports from \( l(m) \) in China to foreign destination \( n \).\(^{46}\) Recall the aggregate trade flows from \( l(m) \) to \( n \) in sector \( s \) is

\[
X_{l(m),n,s} = M_s \cdot P(Y = \{l, m\}) \left[ \int_{\phi^*}^{+\infty} x_{l(m),n,s}(\phi) \cdot P(Z = \phi \mid Y = \{l, m\}) \, d\phi \right] \tag{20}
\]

where \( \phi \) is used as a shorthand for \( \tilde{\phi}_{l(m),n,s} \). \( x_{l(m),n,s}(\phi) \) denotes the sales from \( l(m) \) to \( n \) in sector \( s \) for firms that have productivity level \( \tilde{\phi} \).\(^{47}\)

Our gravity equation (20) resembles the one in Melitz model, except that we have the endogenous mass of firms \( P(Y = \{l, m\}) \) that choose to produce in \( l \) and \( m \) to serve \( n \), defined in equation (9).\(^{48}\) Recall \( P(Z = \phi \mid Y = \{l, m\}) \) follows a Pareto distribution given in (8). Substituting \( \tilde{\phi} \) by \( \phi \) based on equation (6), we rewrite (20) as

\[
X_{l(m),n,s} = M_s R \left[ \int_{\phi^*}^{+\infty} x_{l(m),n,s}(\phi) \, dG(\phi) \right],
\]

where \( G(\phi) = 1 - \phi^{-\theta} \) and

\[
R = P(Y = \{l, m\}) \left( c_{l(m),s}d_{l(m),n,s} \right)^\theta \left( \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right)^{1-\gamma}
\]

\(^{46}\)The results for other cases such as internal trade or trade between foreign countries can be derived analogously.

\(^{47}\)\( x_{l(m),n,s}(\phi) \) equals the product between \( q_{l(m),n,s} \) as in equation (1) and \( p_{l(m),n,s} \) as in equation (4). We write it as

\[
x_{l(m),n,s}(\phi) = \left( \frac{\sigma}{\sigma - 1}\tau_{l,n,s} \right)^{1-\sigma} \left( \frac{\phi}{\phi_{l,m,n,s}} \right)^{\sigma - 1} E_{n,s} P_{n,s}^{\sigma - 1}. \tag{21}
\]

\(^{48}\)A subtle difference is that the integral is defined on the cost-adjusted productivity.
To decompose trade elasticity to each margin, we apply Leibniz rule to have

\[
\frac{\partial X_{l,m,n,s}}{\partial d_{l,m,n,s}} = M_s R \int_{\phi^*}^{+\infty} \frac{\partial x_{l,m,n,s}(\phi)}{\partial d_{l,m,n,s}} dG(\phi) - M_s R x_{l,m,n,s}(\phi^*) \frac{\partial \phi^*}{\partial d_{l,m,n,s}} + \frac{\partial R}{\partial d_{l,m,n,s}} M_s \left[ \int_{\phi^*}^{+\infty} x_{l,m,n,s}(\phi) dG(\phi) \right]
\]

### Intensive Margin

\[\int_{\phi^*}^{+\infty} \frac{\partial x_{l,m,n,s}(\phi)}{\partial d_{l,m,n,s}} dG(\phi)\]

### Extensive Margin

\[\frac{\partial R}{\partial d_{l,m,n,s}} M_s \left[ \int_{\phi^*}^{+\infty} x_{l,m,n,s}(\phi) dG(\phi) \right]\]

### Export-regime and Location Margin

\[\frac{\partial \phi^*}{\partial d_{l,m,n,s}} + \frac{\partial R}{\partial d_{l,m,n,s}} M_s \left[ \int_{\phi^*}^{+\infty} x_{l,m,n,s}(\phi) dG(\phi) \right]\]

The interpretation of each margin is closely related to the sequential order of firms’ optimization, in which firms first choose a production unit to produce, and after that firms choose whether to export and set the price to maximize profits. The first two terms reflect the post intensive margin and the extensive margin of firm adjustments, respectively, after firms choose the optimal location and regime to produce. The last term reflects the composite of export-regime margin and location margins, and each contains two forces.

First, the derivative of the term \(P(Y = \{l, m\}) (\xi_{l,m} d_{l,m,n,s})^\theta\) with respect to \(d_{l,m,n,s}\) reflects the export effects due to the changes in the mass of firms that choose \(l\) and \(m\), excluding the associated intensive and extensive margin changes which has been counted by the first two terms.\(^4\) Second, the derivative of the term \((\sum_l \psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s})^{1-\gamma}\) with respect to \(d_{l,m,n,s}\) capturing the effect on exports due to changes in firms’ access to serve to consumers in country \(n\). In our decomposition exercise, we pool these two forces together without separately analyzing each.

We break down export-regime and location margin, and decompose the aggregate trade elasticity \(-\frac{X_{l,m,n,s}}{d_{l,m,n,s}}\) to four margins as follows

\[
\sigma - 1 + \theta - \sigma + 1 + \frac{\theta \gamma}{1 - \gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l,m,s}}{M_{l,s}} + \frac{\theta \rho}{1 - \rho} \left( 1 - \frac{M_{l,m,s}}{M_s} \right)
\]

See Appendix A.4 for the detailed derivation. \(\frac{M_{l,m,s}}{M_{l,s}} = \frac{\psi_{l,m,s}}{\sum_m \psi_{l,m,s}}\) is the conditional probability for firms that export from province \(l\) to destination \(n\), the fraction that are in regime \(m\); \(\frac{M_{l,s}}{M_s} = \frac{\psi_{l,n,s}}{\sum_l \psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}}\) is the number of firms that export from \(l\) to \(n\) as a share of all national firms that export to \(n\).

The first two terms in (22) are exactly the ones studied in Chaney (2008). When trade costs fall, export would grow because the local exporting firms would export more (intensive

\(^4\)In particular, the derivative of the term \(P(Y = \{l, m\})\) with respect to \(d_{l,m,n,s}\) captures the changes in the mass of firms that choose \(l\) and \(m\) inclusive the intensive and extensive margins that are associated with the change of firms’ mass. The derivative to the term \((\xi_{l,m} d_{l,m,n,s})^\theta\) captures the associated intensive and extensive margin changes due to firm mass changes.
margin), and more local firms select to export (extensive margin).

The third term captures the location margin, which depends positively on 1) the productivity correlation across locations, \( \rho \); 2) the share of firms that are not producing in province \( l \), \( 1 - \frac{M_{l,s}}{M_{s}} \), reflecting the mass of firms that are subject to switch to province \( l \); and 3) the likelihood that outside firm would choose regime \( m \) in province \( l \), captured by \( \frac{M_{l(m),s}}{M_{l,s}} \).

The last term captures the export-regime margin, which depends positively on 1) the productivity correlation between processing and ordinary regimes, \( \gamma \); and 2) the fraction of local firms that produce in alternative regime, \( 1 - \frac{M_{l(m),s}}{M_{l,s}} \) which reflects the mass of local firms that are subject to switch to regime \( m \).

**Linking to Migration and Import Tariff Shocks:** Our counterfactual experiments which involve internal migration shock or import tariff reduction, would affect firms’ cost of production, \( c_{l(m),s} \). Since \( c_{l(m),s} \) and \( d_{l(m),n,s} \) are symmetric in our gravity equation, the elasticity decomposition results in equation (22) apply to analyze these two shocks. Since export tariff has an asymmetric effect from iceberg costs, our decomposition results can not be applied to analyze changes in export tariffs.

**Relation to Chaney (2008):** Our model predicts a larger trade elasticity in response to changes in trade costs than that in Melitz-Chaney Model with exogenous entry. Particularly, a stronger firm-level productivity similarity across regimes (or across locations), leads to a larger aggregate trade elasticity as firms’ switching across regimes (or locations) is more responsive to policy changes. Equation (22) also implies that there are two special cases in which our model predicts the same trade elasticity as in Melitz-Chaney model with exogenous firm entry. The first is if we exogenously assign firms to each province and regime, i.e., \( \Pi_{m|l} = 1 \) and \( \Pi_{l} = 1 \). Second, productivities are perfectly uncorrelated across regimes and locations, i.e., \( \rho = 0 \) and \( \gamma = 0 \). In this case, firm-level productivity correlation is too weak, and the case is equivalent to the one where firms’ location and export-regime are randomly chosen.

### 6 Quantitative Analysis

China’s exports increased by a factor of 10.5 in real terms between 1990 and 2005, which implies an annualized increase of 16.9%. We decompose this observed export increases to four sources including: 1) changes in the labor costs \( c_{l(m),s} \) due to internal migration; 2) changes in the costs of intermediate inputs due to import tariff changes; 3) changes in export tariff; and 4) the composite of changes in TFP \( \bar{A}_{m,s} \), iceberg trade costs \( d_{l(m),n,s} \), which we match to the residual of the observed export increases. In this section, we discuss our solution method, the data source, our measurement of three types of policy shocks, and the estimation of model parameters.
6.1 Solution Method

Our solution method is slightly different from the conventional “Exact Hat Algebra” approach used in the literature, which takes the model to the initial year (in our case, year 1990), and introduces policy shocks in terms of the proportional increases of model fundamentals.\(^{50}\) Instead, we match our model to the ending year of our study (in our case, year 2005), while measuring the inverse proportional changes of model fundamentals. The reason is that Chinese data are of higher quality and more reliable in later years for measuring inter-provincial migration and trade, and provincial imports and exports to foreign countries.

Denote the proportional change for the variable \(x\) as \(\hat{x} = \frac{x'}{x}\), where \(x'\) represents variables in counterfactual status, and \(x\) refers to variables in the observed equilibrium. The proportional changes in trade shares between trade units \(r\) and \(u\) can be written as

\[
\hat{\Pi}_{r,u,s} = \frac{\hat{M}_{r,s} \hat{\alpha}_{r,u,s}}{\sum_{r'} \hat{M}_{r',s} \hat{\alpha}_{r',u,s} \Pi_{r,u,s}}. \tag{23}
\]

where \(\hat{M}_{r,s} = \hat{P}(Y = \{l, m\})\) when \(r\) refers to a province-regime combination in China, where

\[
\hat{P}(Y = \{l, m\} | Y = \{l\}) = \frac{\hat{\psi}_{l,(m),n,s}}{\sum_m \hat{\psi}_{l,(m),n,s} \frac{M_{(m),s}}{M_s}}, \quad \hat{P}(Y = \{l\}) = \frac{\hat{\psi}_{l,n,s}}{\sum_l \hat{\psi}_{l,n,s} \frac{M_{l,s}}{M_s}} + \sum_j \hat{\psi}_{j,n,s} \frac{M_{j,s}}{M_s}
\]

Analogously, when \(r\) refers to a foreign country \(j\), where

\[
\hat{M}_{r,s} = \hat{P}(Y = \{j\}) = \frac{\hat{\psi}_{j,n,s}}{\sum_l \hat{\psi}_{l,n,s} \frac{M_{l,s}}{M_s} + \sum_j \hat{\psi}_{j,n,s} \frac{M_{j,s}}{M_s}}
\]

where \(\hat{\psi}_{l,(m),n,s} = \hat{A}_{l,(m),s} \left(\hat{c}_{l,(m),s} \hat{d}_{l,n,s} \hat{r}_{l,n,s}\right)^{-\frac{\theta}{\gamma}}\), \(\hat{\psi}_{j,n,s} = \hat{A}_{j,s} \left(\hat{c}_{j,s} \hat{d}_{j,n,s} \hat{r}_{j,n,s}\right)^{-\frac{\theta}{\gamma}}\), and

\[
\hat{\psi}_{l,n,s} = \left[\sum_m \hat{\psi}_{l,(m),n,s} \frac{M_{(m),s}}{M_s}\right]^{-\frac{1}{\gamma}}. \tag{51}
\]

We also have the proportional changes in aggregate price index is

\[
\hat{P}_{r,s} = \left[\frac{\hat{c}_{r,s} \hat{f}_{r,s}}{\hat{E}_{r,s}}\right]^{-\frac{\theta}{\gamma}} \left[\sum_l \hat{\psi}_{l,n,s} \frac{M_{l,s}}{M_s} \hat{r}_{l,n,s} \Pi_{l,n,s} + \sum_j \hat{\psi}_{j,n,s} \frac{M_{j,s}}{M_s} \hat{r}_{j,n,s} \Pi_{j,n,s}\right]^{-\frac{1}{\gamma}}. \tag{24}
\]

The proportional changes of migration flows is

\[
\hat{\lambda}_{g,l,s} = \frac{\hat{\lambda}_{l,s}}{\sum_{l',s'} \zeta_{g,l,s} \hat{V}_{l',s'} \lambda_{g,l,s}}, \tag{25}
\]

\(^{50}\)Papers that use the initial year as the base year include, Caliendo and Parro (2015), Burstein et al. (2015), and Lee (2016), among others.

\(^{51}\)The proportional change in unit costs is given by \(\hat{c}_{l,(m),s} = \hat{u}_{l,(m),s} \Pi_k \hat{P}_{l,(m),k}\). \(\hat{A}_{l,(m),s} = \hat{A}_{l,(m),s} \hat{L}_{l,(m),s}\) contains both changes in fundamental productivity \(A_{m,s}\) and agglomeration effects that are induced through \(L_{l,(m),s}\).
The final-good market clearing conditions can be written in proportional changes as

\[
E_{r,s} \hat{E}_{r,s} = \beta_s \hat{L}_r + \sum_k \lambda^L_{n,k} \left( 1 - \eta \right) \sum_u \frac{\Pi_{r,u,k} E_{u,k} \hat{\Pi}_{r,u,k} \hat{E}_{u,k}}{\tau_{r,u,k} \hat{\tau}_{r,u,k}} + \eta \sum_u \frac{\Pi_{u,r,k} E_{r,k} \hat{\Pi}_{u,r,k} \hat{E}_{r,k}}{\tau_{u,r,k} \hat{\tau}_{u,r,k}}
\]

(26)

where \( \hat{\tau}_{r,u,k} = \frac{1+\tau_{r,u,k}}{1-\tau_{r,u,k}} \).

The labor market equilibrium for China can be written in proportional changes as:

\[
\sum_m \lambda^L_{m,s} \left( 1 - \eta \right) \sum_u \frac{\Pi_l(m),u,s E_{u,s} \hat{\Pi}_l(m),u,s \hat{E}_{u,s}}{\tau_l(m),u,s \hat{\tau}_l(m),u,s} + \eta \sum_u \frac{\Pi_u(l(m),s) E_{l(m),s} \hat{\Pi}_u(l(m),s) \hat{E}_{l(m),s}}{\tau_u(l(m),s) \hat{\tau}_u(l(m),s)} = \sum_g w_{l,s} \hat{w}_{l,s} L_{g,l,s} \hat{L}_{g,l,s}
\]

(27)

And the labor market equilibrium for foreign countries is written similarly as:

\[
\sum_s \lambda^L_{n,s} \left( 1 - \eta \right) \sum_u \frac{\Pi_{n,u,k} E_{u,k} \hat{\Pi}_{n,u,k} \hat{E}_{u,k}}{\tau_{n,u,k} \hat{\tau}_{n,u,k}} + \eta \sum_u \frac{\Pi_{u,n,k} E_{n,k} \hat{\Pi}_{u,n,k} \hat{E}_{n,k}}{\tau_{u,n,k} \hat{\tau}_{u,n,k}} = w_n \hat{w}_n L_n \hat{L}_n.
\]

(28)

Given parameters values of \( \{ \theta, \rho, \gamma, \kappa, \sigma, \alpha, \beta_s, \lambda^L_{r,s}, \lambda^k_{r,s} \} \), we measure China’s import and export tariff changes \( (\hat{\tau}_{r,s}) \), and changes in migration frictions, \( (\hat{\zeta}_{g,l,s}) \). Then we introduce the shock into the model, one at each time, while setting \( \hat{A}_{r,s} = \hat{f}_{n,s} = \hat{M}_s = \hat{\alpha}_{r,u,s} = \hat{L}_g = \hat{L}_n = 1 \). We solve \( \{ \hat{\Pi}_l(m),u,s, \hat{\Pi}_{n,u,k}, \hat{P}_s, \hat{\Lambda}_{g,l,s}, \hat{E}_{r,s}, \hat{w}_{l,s}, \hat{w}_n \} \) from the system of equation (23) – (28). For all counterfactual exercises, we assume that the US GDP is the numeraire and trade is balanced.\(^{52}\)

Our counterfactual exercises require data on: the expenditure share on imports \( \{ \Pi_{r,u,s} \} \); firms’ location probability \( (\frac{M_l(m),s}{M_s}) \); the inter-provincial migration rates \( \{ \Lambda_{g,l,s} \} \); sectoral output \( \{ X_{r,s} \} \); labor income \( \{ w_{l,s} L_{g,l,s} \} \) in China, and in foreign country \( \{ w_n L_n \} \); consumption shares of each sectoral goods, \( \{ \beta_s \} \); the share of value added \( \lambda^L_{m,s} \) and intermediate inputs \( \{ \lambda^k_{m,s} \} \) by processing and non-processing trade in each sector for China; and the share of value added \( \lambda^L_{n,s} \) and intermediate inputs \( \{ \lambda^k_{n,s} \} \) in each sector for foreign countries. We provide a short summary of the data sources we used. Appendix B provides a detailed description on the measurement of each variables, industry aggregation, as well as the industry cross-walk used to match datasets.

### 6.2 Data

We calibrate our model to 29 sectors, 30 Chinese provinces, 31 foreign countries and a constructed rest of the world.\(^{53}\) Our 29 sector categories are aggregated based on 2-digit Intern-

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\(^{52}\)Instead of assuming balanced trade, an alternative approach is to assume the aggregate trade deficit as a fixed share of the world GDP (Caliendo, Dvorkin and Parro, 2015).

\(^{53}\)We exclude Tibet from our analysis due to the lack of data on Tibet’s inter-provincial migration and trade. Our choice of the 31 countries is fully driven by the availability of both bilateral trade flow data and labor market data. The 31 foreign countries considered in our analysis are: Argentina, Australia, Austria, Brazil, Cambodia, Canada, Chile, Denmark, France, Finland, Germany, Greece, Hongkong, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Malaysia, Mexico, Norway, Philippines, Portugal, Singapore, South Africa, Spain, Sweden, Taiwan, Thailand, Turkey, UK, US, and Vietnam.
national Standard Industrial Classification industry code (ISIC Rev 3), including 16 tradable sectors and 13 non-tradable sectors; see Appendix Table 6 for details. For China, we also distinguish trade regimes by processing and non-processing.

**Provincial Import and Export by Types:** We use China Customs Transactions Database in 2005 to measure trade flows between China’s provinces and foreign countries by processing and ordinary regimes. China Customs Transactions Database has very dis-aggregated information on firms’ monthly import and export transaction. The data also has information on whether a firm is engaging in processing export activity. In this paper, we classify firms that only performed processing exports as processing exporters and all other firms as ordinary firms. Using the variable on firms’ address, we aggregate firms’ transaction-level import and export volumes to provincial level by sectors and by processing and ordinary exports. Finally, we cluster the 8-digit HS code to our 29 sector aggregations using the industry cross-walk between HS and ISIC code.\(^5^4\)

**Provincial Gross Output by Types:** We combine China’s regional input-output table in year 2007 (the closest available year to 2005) and China’s Customs Transactions Database in 2005 to estimate the gross output by processing and ordinary production by each province and sector.\(^5^5\) Using the concordance in Dean and Lovely (2010), we match the 2-digit China’s Standard industrial classification code (CSIC) used in China’s regional input-output table with the 2-digit ISIC code. After that we cluster sectors to our 29 aggregations. We deflate output and trade flows to year 2005 using the growth rates of China’s sectoral output between 2005 to 2007. Since processing production are not allowed to sell domestically, we use the total processing exports obtained from China’s Customs Transactions Database to measure the gross output, and set domestic processing sales as zero. We obtain province-sector gross output from industry input-output tables, and subtract it by the overall processing exports (which also equals processing output) to measure of the gross output in ordinary production.

**Inter-province Trade Flows by Types:** We proceed as follows. First, we obtain inter-provincial trade flows by sectors (without distinguish processing or ordinary production) from regional input-output table. Since processing firms can not sell domestically, data from regional input-output table reflects the domestic sales from ordinary producers. The question remains how to distribute the domestic sales to those purchased by processing and ordinary producers at each province. Second, we obtain the national-level share of domestic sales purchased by processing producers. To achieve this, we impute each province’s total purchase of domestic intermediate material by taking the difference between the value of intermediate inputs that each provincial processing producers purchased (we calculated as the product between provincial processing output and input-output coefficient) and their imported intermediate in-

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\(^{54}\) China Customs Transactions Database reports product based on the 8-digit Harmonized System (HS) industry code.

\(^{55}\) China’s regional input-output table in year 2007 is obtained from Liu, Chen, Tang, Liu, Han and Li (2012) and established by Key Laboratory of Regional Sustainable Development Modelling, China Academy of Sciences.
puts (measured from China Customs Transactions Database). Third, we assume the national-level share obtained previously applies constantly to each province. This allows us to separate inter-provincial trade into those purchased by ordinary and processing producers.

**The Distribution of Firms:** Our counterfactual exercise also requires measure for each sector $s$, how the fixed mass $M_s$ of global firms are distributed across foreign countries, China’s provinces and export-regime. We normalize $M_s = 1$ for each sector, and pin down the firm’s choice probability based on equilibrium conditions on firms’ choice probability and trade share given in (9) - (12). See Appendix B for details.

**Trade Flows Between Foreign Countries:** We measure bilateral trade flows between foreign countries using STAN Bilateral Trade Database, where the values are reported in thousands of U.S. dollars at current prices. We measure sectoral gross output of each foreign country using OECD input-output databases. We measure imports from the rest of the world by subtracting the import from each country that we considered from the total import volume from the world.\footnote{Similarly, we measure exports to the rest of the world by subtracting the export to each country that we considered from the total export volume to the world.} Since both dataset has 2-digit ISIC industry code available, we collapse the 2-digit ISIC code to our 29 industry aggregation, and use these data to calculate the import expenditure share and sectoral output.

**Labor Market Variables:** We use China’s Population Survey 2005 to measure China’s internal migration flow, wages, and sectoral employment. We define China’s internal migration as those who work in a province other than the place of their Hukou registration. The set of migrant population we measure reflects the effect of China’s Hukou reform on “floating population”, and is slightly differing from previous literature.\footnote{Tombe and Zhu (2015) consider both inter-provincial migrants and rural-urban migrants during 2000-2005; they define rural-urban migrants as the sector mismatch between the Hukou and the actual employment. Fan (2015) examines pre-2000 internal migrants who are defined as the mismatch between workers’ the place of residence and the place of birth. Zi (2016) also measures internal migration induced by Hukou reform based on a 5-year migration intensity.} This provides us with a total of 30 China’s worker groups. For each group, we calculate the number of workers living in each Chinese provinces and working in each of our 29 sector aggregation. After that, we estimate sectoral-migration rates for each group. We consider one aggregate labor group for each foreign country, and extract data from IPUMS–International and Luxembourg income study (LIS) to measure employment and wages.

### 6.3 Measuring Policy Shocks

We measure three sets of policy shocks from the data, and examine what would happen to China’s export in 2005 had each of these three policies were unchanged since 1990. The policy shocks that we measure are 1) the inverse changes in migration frictions, 2) the inverse changes in China’s import tariff rates, and 3) the inverse changes in China’s export tariff. We
measure tariff changes as the observed changes in *ad-valorem* tariff rates, using the weighted average effective applied rates at 2-digit ISIC industry level available at United Nations Statistical Division-Trade Analysis and Information System (TRAINS). The effective tariff rates take into account Most-Favored-Nation (MFN) tariffs and Preferential tariffs. For all counterfactual exercises, we hold the tariff structure for the rest of the world to the levels in 2005, i.e., \( \hat{t}_{i,n,s} = 1 \) if neither \( i \) nor \( n \) includes China. Therefore our accounting exercises account for China’s export growth conditional on the realized world tariff structure changes.

**Estimating Migration Friction Changes:** We impose two assumptions to estimate the changes in policy related migration barriers. First, we assume migration frictions of working in any sectors of the home province remain constant over time. Second, we impose the multiplicative separable assumption on \( \zeta_{g,l,s} \) such that \( \zeta_{g,l,s} = \zeta_{g,l} \times \zeta_{l,s} \).

The term \( \zeta_{g,l} \) captures non-policy related migration costs (e.g., geographic and transportation costs, culture assimilation) that are specific to origin-destination pairs. The term \( \zeta_{l,s} \) is our policy related parameter, which captures destination- and sector-specific policy barriers to migration, and is independent across origin provinces. The separability assume that provincial Hukou restriction can be reduced more in some sectors than other sectors, but the extent of reduction is the same across migrants’ province of Hukou origin.

Taking the logarithm on proportional changes of migration rate in equation (26), and normalize by home-stay rate, we have the estimating equation as

\[
\log \left( \frac{\hat{\Lambda}_{g,l,s}}{\hat{\Lambda}_{g,l}} \right) = \log(\text{distance}) + \alpha_{l,s} + \kappa \cdot \log \left( \frac{\hat{V}_{l,s}}{\hat{V}_{l,g}} \right) + \epsilon_{g,l,s}. \tag{29}
\]

\( \hat{\zeta}_{g,l} \) captures changes in non-policy related bilateral migration frictions for group \( g \) to migrate to \( m \). We assume \( \hat{\zeta}_{g,l} \) is symmetric between origins and destinations, and approximate it as a function of \( \log(\text{distance}) \). We measure changes in provincial-sector real wages \( \hat{V}_{m,s} \) from the data. We measure the dependent variable (changes in destination-sector migration shares relative to home-province-sector shares) between 1990-2005 using China’s Population Census 1990 and China’s Population Survey 2005.\(^59\) The independent variables include \( \log(\text{distance}) \).

\(^{58}\)To obtain the estimating equation, we first take the logarithm of proportional changes in region-sector migration shares to have

\[
\log \left( \frac{\hat{\Lambda}_{g,l,s}}{\hat{\Lambda}_{g,l}} \right) = \log(\text{distance}) + \frac{\alpha_{l,s}}{\alpha_{l,s}} + \frac{\kappa}{\kappa} \log \left( \frac{\hat{V}_{l,s}}{\hat{V}_{l,g}} \right) + \epsilon_{g,l,s},
\]

\( \alpha_{l,s} \) can only be identified up to scale, since any arbitrary sector-specific shift in migration rates could be explained either by changes in labor group productivity at that sector, or by changes in migration frictions at that sector, making these two stories observationally equivalent in the data. We normalize the above equation by the migration share of home-stayers, to obtain estimating equation (29).

\(^{59}\)Since the variable on the province of Hukou registration is unavailable in China’s Population Census 1990, we measure province-sector migration rates based on a 5-year migration intensity measurement: the mismatch of residential province between 5 years ago and the survey year.
between origins and destinations, destination-sector fixed-effects, and destination-sector wage changes obtained from China Labor Statistical Yearbook.

In equation (29), $\varepsilon_{g,l,s}$ captures unobserved factors that affect changes in migration rates, but is not specified in our structural model. The endogeneity issue arises as $\varepsilon_{g,l,s}$ is in general correlated with $\log \frac{\hat{V}_{m,s}}{\hat{V}_{mg,s}}$. For example, if faster developed coastal provinces also experienced negative amenity shocks, such as congestion or pollution which discouraged migration incentives for some labor groups, then the Ordinary Least Square (OLS) regression would underestimate $\kappa$. We rely on the general equilibrium structure of our model to construct a model-based instrument, following Allen, Arkolakis and Takahashi (2017).

Specifically, we introduce China’s export tariff changes between 1990 and 2005 into our model, and use the model-implied relative changes in wage rates as as instruments for $\log \frac{\hat{V}_{m,s}}{\hat{V}_{mg,s}}$. Our key identification assumption is that changes in China’s export tariff levied by foreign countries is uncorrelated with unobserved factors that affect internal migration, but affect China’s internal migration flow only through its impact on wages. Our instrument tends to be relevant, since provinces which are more affected by export tariff reduction are those that experiences faster economic growth. After obtaining estimates of $\alpha_{l,s}$, we recover the proportional changes in migration costs as $\hat{\zeta}_{l,s} = \exp\{\alpha_{l,s}\}$.

Figure 13 in Appendix shows the inverse provincial changes in migration frictions, for all sectors on Panel (a) and for manufacturing on Panel (b), respectively. We compute the former as an average across sectors weighted by migrant employment in 2005. The darker color stands for a value of $\hat{\tau}_{m,s}$ closer to zero, indicating a larger proportional change in migration friction. Unsurprisingly, coastal provinces, especially Guangdong Province, experienced the largest decrease in migration barriers in both maps. The estimated $\hat{\tau}_{l,s}$ at broad manufacturing sectors are in the range of $[0.20, 0.35]$ in coastal provinces and Beijing.

**Estimating Import and Export Tariff Changes:** We obtain China’s nominal import tariff rates by sector, as well as export tariff rates levied by each country in 1990 and 2005, from UNCTAD trade analysis and information system (TRAINS). TRAINS data generally suffer from missing values, particular on China’s tariff data in the year 1990. Whenever the data is missing, we also see Adao, Arkolakis and Esposito (2018) and Allen and Donaldson (2018) for constructing model-based instrumental variables. Constructing the instrument requires knowing the value of $\kappa$. We choose the commonly estimated value of $\kappa = 2$ in the literature (e.g. Burstein et al., 2015). We shall note this particular choice of $\kappa$ to generate model-implied instruments for wage changes will not affect the consistency of our estimates of $\kappa$ by using equation (29).

We also verify that counterfactual wage changes are correlated with real wage changes between 1990 to 2005 for destination-sector pairs by use of the first-stage regression. We set $\hat{\tau}_{l,s} = 1$ for those cells that have a limited number of observations, as we dropped group-destination-sector pairs with the number of observations smaller than 30.

It is important to note that previous empirical studies which evaluate the impact of tariff changes have mostly constructed changes in input and output tariffs as a function of changes in import and export tariffs; see Amiti and Konings (2007), Topalova and Khandelwal (2011), and Yu (2015). Our production function incorporates input-output linkages, which allows us to conveniently evaluate the counterfactual changes of import and export tariffs which are directly observed from the data, but also take into account sectoral differences in their input-output structure.
use the data in the nearest year available to supplement the missing value.64

The UNCTAD trade analysis and information system (TRAiNS) provides tariff data by 4-digit HS industry code, including a total of 1200–1300 industries. We map the HS code to 2-digit ISIC code according to the concordance provided by WITS. We calculate the bilateral tariff rates in each of our 29-industry aggregation by taking trade-value weighted average of tariff rates across 4-digit HS industry within each aggregated industry.

After that, we compute the inverse proportional changes in China’s import and export tariffs between 1990 and 2005. We then apply the estimated changes of export tariffs to both processing or non-processing exports, and apply estimated changes of import tariff to only non-processing trade. We set the import tariff as unchanged for processing trade, because China’s processing firms have enjoyed the duty-free since 1987.

6.4 Parameter Values

Estimation of $\kappa$: Table 1 reports estimation results for equation (29). We report the OLS results based on a full sample which is formed by non-zero pairwise origin-destination-sector combinations, in Column (1A), the 2SLS results on the full sample in Column (3A), and the 2SLS results which we weight each destination-origin-sector pair by the group population size in 2005 in Column (5A). All coefficients are positive and significant: on average a higher real wage attracts more migration. The OLS results seems to underestimate $\kappa$, as it is smaller than the 2SLS estimates. We choose our preferred estimates as $\kappa = 2.87$. We also repeat the OLS and 2SLS estimation on a subset of observations with destination provinces restricted to 5 coastal provinces and Beijing, in Column (2A) for the OLS, Column (4A) for the 2SLS on the full sample, and Column (6A) for the 2SLS on the weighted sample. Among our 2SLS estimates, the coefficient in Column (4) and (6) are larger than that in Column (3) and (5), respectively, suggesting migration to more developed provinces are likely to be more responsive to changes in economic conditions.65

Estimates of $\lambda^L_{m,s}$, $\lambda^k_{m,s}$: Following Yu (2015) and Dai et al. (2016), we match the Annual Survey of Industrial Firms (ASIF) 2005 with China’s Customs Transactions Database 2005 based on variables such as firm name, telephone number and zip code, and use the matched data to estimate value added and cost share of intermediate inputs by processing and ordinary production by sectors in China.66

We assume value added and cost share of intermediate inputs to be identical across provinces.

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64Around the year 1990, most of our China tariff value is from the year 1992 due to the data availability.

65In unreported regressions, we also control actual destination relative to origin population changes (instrumented by model-implied changes) when estimating equation (29). This aims to capture possible congestion effects. However, we do not find any significant effects of population changes on migration flows.

66The firm identification code differ systematically between these two dataset, and can not be used to merge observations.
### Table 1: Estimation results on $\kappa$ in Changes

<table>
<thead>
<tr>
<th></th>
<th>OLS (1A)</th>
<th>OLS (2A)</th>
<th>IV (3A)</th>
<th>IV (4A)</th>
<th>IV, Weighted Sample (5A)</th>
<th>IV, Weighted Sample (6A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimation based on Equation (29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\log \frac{V_{m,s}}{V_{mg,s}}$</td>
<td>0.519***</td>
<td>0.666***</td>
<td>2.871***</td>
<td>4.352***</td>
<td>3.047***</td>
<td>4.303***</td>
</tr>
<tr>
<td></td>
<td>(0.131)</td>
<td>(0.180)</td>
<td>(0.362)</td>
<td>(0.701)</td>
<td>(0.562)</td>
<td>(0.672)</td>
</tr>
<tr>
<td>Destination</td>
<td>All</td>
<td>Coastal</td>
<td>All</td>
<td>Coastal</td>
<td>All</td>
<td>Coastal</td>
</tr>
<tr>
<td>F-stat First Stage</td>
<td>15.99</td>
<td>41.04</td>
<td>19.03</td>
<td>44.07</td>
<td>19.03</td>
<td>44.07</td>
</tr>
<tr>
<td>Num. of Obs.</td>
<td>2,876</td>
<td>1,061</td>
<td>2,876</td>
<td>1,061</td>
<td>2,876</td>
<td>1,061</td>
</tr>
</tbody>
</table>

Notes: Standard errors are clustered at the destination-sector level. Estimation is based on observations formed by non-zero pairwise combinations of origins of province, destination provinces, and sectors $(30 \times 30 \times 14)$. Column (3) to (6) weight each destination-origin-sector pair by the population size of each group $g$ in 2005. Column (1) and (2) is based on the unweighted sample. We cluster our 16 detailed manufacturing industries as a single broad manufacturing industry. The dependent variable is measured as the ratio of provincial-sector migration rates between 1990 and 2005. The odd number columns are based on a sample includes all 30 provinces as migration destinations; the even number columns are based on a sample includes 5 coastal provinces (Guangdong, Shanghai, Zhejiang, Jiangsu, Fujian) and Beijing as migration destinations.

Again, we treat firms that only performed processing exports as processing exporters and all other firms as ordinary firms, and aggregate value-added and sales by these two types of firms and ISIC industries to compute the value-added shares by processing and ordinary in each sector. Finally, for each sector, we re-scale the value added share such that the export-weighted average of value added share in each sector matches the one calculated from China’s industrial input-output tables, and the ratio of value added shares between processing and ordinary is based on Annual Survey of Industrial Firms (ASIF) and Customs Transactions Database.

**Other Parameter Values:** There are 8 sets of parameter values which are required to solve the model. We display the parameter values used in our benchmark model and their sources in table 2. By convention, we set elasticity of substitution across varieties $\sigma$ to be 4.\(^{67}\) We set the trade elasticity $\vartheta$ to be 4.5 in our benchmark following Simonovska and Waugh (2014).

We measure value added and cost share to intermediate inputs from OECD input-output tables. The OECD database provides input-output tables for 48 countries for the years 1995, 2000, and 2005, and contains information for 37 ISIC Rev. 3 industries. We collapse the 37 ISIC industries to our 29 aggregation following Table 6. After that, we calculate $\lambda_{n,s}^k$ as the

\(^{67}\)See Head and Mayer (2014), Broda and Weinstein (2006), and Arkolakis et al. (2018), among others.
ratio of intermediate inputs from sector $k$ to total output in sector $s$ for each country, then take the average over all countries. We calculate the value added share as $\lambda_{n,s}^L = 1 - \sum_k \lambda_{n,s}^k$. We calculate $\beta_s$, the share of world income spent on goods $s$ as the ratio of the total consumption spending on sector $s$ across all countries and provinces to the world total income.

**Table 2: Parameter Values in Benchmark Model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>Elasticity of substitution across varieties</td>
<td>Head and Mayer (2014)</td>
<td>4</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Trade elasticity</td>
<td>Simonovska and Waugh (2014)</td>
<td>4.5</td>
</tr>
<tr>
<td>$\lambda_{m,s}^L$</td>
<td>Value added share (China)</td>
<td>ASIF, Customs, China I/O Table</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{m,s}^k$</td>
<td>Intermediate input share (China)</td>
<td>ASIF, Customs, China I/O Table</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{n,s}^L$</td>
<td>Value added share (foreign)</td>
<td>OECD I/O Table</td>
<td></td>
</tr>
<tr>
<td>$\lambda_{n,s}^k$</td>
<td>Intermediate input share (foreign)</td>
<td>OECD I/O Table</td>
<td></td>
</tr>
<tr>
<td>$\beta_s$</td>
<td>Industry consumption share</td>
<td>OECD I/O Table</td>
<td></td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Productivity correlation across locations</td>
<td>ARRY</td>
<td>0.55</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Productivity correlation across regimes</td>
<td>Brandt et al. (2018)</td>
<td>0.71</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Agglomeration elasticity</td>
<td>Combes and Gobillon (2015)</td>
<td></td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Labor supply elasticity</td>
<td>IV estimation</td>
<td>2.87</td>
</tr>
</tbody>
</table>

We set $\rho = 0.55$ following ARRY and $\gamma = 0.71$ obtained in Brandt et al. (2018), and $\alpha$ takes value such that the implied agglomeration elasticity equals 0.05 as suggested in Combes and Gobillon (2015).

7 Quantitative Results

We first show the extent to which each policy promoted China’s export surge between 1990 and 2005. After that, we decompose the impact of policies into different margins of trade. Finally, we present quantitative results on how each policy affected the number of China’s exporting firms.

7.1 The Policy Impact on Exports

We introduce the three measured policy change (tariffs on imports, tariffs on exports, internal migration barriers) to our model one at a time and attribute the residual of observed export growth to changes in $\bar{A}_{m,s}$ and $d_{l(m),n,s}$. We set parameter values using Table 2.

**Aggregate export impact:** Panel A of Table 3 shows the export impact of each shock in terms of annual growth rates in percentage points. The last column shows the average annual growth rate between 1990-2005. On the national level, the reduction in migration barriers led to a 1.31
p.p. annual export growth and accounted for \( \frac{1.31}{16.9} \approx 7.8\% \) of the entire export growth. The reduction in import tariffs caused an average of 2.18 p.p. annual export growth and accounted for \( \frac{2.18}{16.9} \approx 12.9\% \) of the entire export growth. The changes in export tariffs resulted in a 1.37 p.p. increase in annual export growth and accounted for \( \frac{1.37}{16.9} \approx 8.1\% \) of the entire export growth. \( \frac{12.0}{16.9} \approx 71.2\% \) of China’s export surge was explained by changes in \( A_{l(m),s} \) and \( d_{l(m),n,s} \).

Table 3: Export Impact of Policies, In terms of Percentage Points of Annual Growth Rate

<table>
<thead>
<tr>
<th></th>
<th>Migration</th>
<th>Import Tariff</th>
<th>Export Tariff</th>
<th>Residual</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: China’s Export Increases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>1.31</td>
<td>2.19</td>
<td>1.37</td>
<td>12.0</td>
<td>16.9</td>
</tr>
<tr>
<td><strong>Panel B: Provincial Export Increases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guangdong</td>
<td>4.32</td>
<td>2.16</td>
<td>1.70</td>
<td>9.52</td>
<td>17.7</td>
</tr>
<tr>
<td>Shanghai</td>
<td>2.35</td>
<td>1.89</td>
<td>1.21</td>
<td>13.1</td>
<td>18.5</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>0.38</td>
<td>1.81</td>
<td>1.51</td>
<td>18.4</td>
<td>22.1</td>
</tr>
</tbody>
</table>

Notes: In each counterfactual, we obtain the proportional changes of export denoted \( \frac{\text{export volume observed in 2005}}{\text{export volume in counterfactual}} \). We then calculate each value of column 2-4 as \( (\text{export volume observed in 2005} - 1) \times 100 \).

Panel B of Table 3 reports the results for China’s three major exporting provinces, Guangdong, Shanghai, and Jiangsu. These three provinces combined account for about 70 percent of China’s overall exports in 2005. The reduction in migration barriers led to the most notable export increases in Guangdong and Shanghai, causing an increase of 4.32 p.p. in annual export growth in Guangdong and of 2.35 p.p. in Shanghai. They explain \( \frac{4.32}{17.7} \approx 24.4\% \) and \( \frac{2.35}{18.5} \approx 12.7\% \) of the entire export increases between 1990 and 2005 for these two provinces respectively. These results are consistent with the fact documented in Section 3 that a large fraction of manufacturing employment in Guangdong and Shanghai were supplied by internal migrants in 2005.

Although the reductions in import and export tariffs were both applied uniformly across provinces, the impact of tariff reduction vary systematically across provinces. The variation was primarily driven by cross-province differences in the composition of process and ordinary exports, as well as differences in provincial industrial specialization.\(^{68}\) We find the impact of the changes in import tariffs and export tariffs was slightly larger in Guangdong province, where these changes caused an average of 2.16 + 1.70 = 3.86 p.p. annual export increase. In Shanghai and Jiangsu Province, the changes in import and export tariffs led to an increase of 1.89 + 1.21 = 3.10 and 1.81 + 1.51 = 3.32 p.p. annual export growth respectively.

**Processing and ordinary exports:** We break down China’s export increases by processing and ordinary regimes and display the results in Table 4. We highlight three findings below.

---

\(^{68}\)We set the cost share of intermediate inputs to be identical across provinces.
First, the changes in migration barriers had a larger impact on processing exports than on ordinary exports at the national level. The reductions in migration barriers reduction caused a 1.50 p.p. annual increase of processing exports, in comparing to 1.10 p.p. annual growth of ordinary exports. Although the domestic value added was higher in ordinary than in processing production, (Kee and Tang, 2016), the larger impact on processing exports was primarily driven by the fact that migrants’ employment shares were much larger in processing-oriented industries than in industries that were less concentrated in processing exports. At provincial level, we find the reductions in migration barriers had a larger impact on processing than ordinary exports in Guangdong. In Shanghai, we find the impact on ordinary exports was slightly larger than that on processing exports.

Table 4: Export Impact of Policies by Processing and Ordinary Trade, in Percentage Points of Annual Growth Rate

<table>
<thead>
<tr>
<th></th>
<th>Processing Trade Share in 2005</th>
<th>Migration</th>
<th>Import Tariff</th>
<th>Export Tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ordinary</td>
<td>Processing</td>
<td>Ordinary</td>
</tr>
<tr>
<td>China</td>
<td>56.5%</td>
<td>1.10</td>
<td>1.50</td>
<td>2.81</td>
</tr>
<tr>
<td>Panel A: China’s Export Increases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guangdong</td>
<td>72.0%</td>
<td>3.42</td>
<td>4.75</td>
<td>3.09</td>
</tr>
<tr>
<td>Shanghai</td>
<td>59.9%</td>
<td>2.82</td>
<td>2.07</td>
<td>3.13</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>65.9%</td>
<td>0.47</td>
<td>0.34</td>
<td>2.55</td>
</tr>
<tr>
<td>Panel B: Provincial Export Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: the value in percentage point increase is calculated by following the same way as described in the notes of Table 3.

Second, import tariff reductions had a larger impact on ordinary exports than on processing exports at both the national and the provincial levels. This is because the imported materials for ordinary production faced the reductions in nominal tariffs, whereas imported materials for processing exporters were duty-free and unaffected by these reductions in nominal tariffs. On the national level, import tariff reduction caused a 2.81 p.p. annual growth in ordinary exports. Differing from the partial equilibrium approach in Brandt and Morrow (2017), our general equilibrium approach also predicts a 1.71 p.p. annual growth in processing exports caused by reductions in import tariffs. This difference was due to the input-output linkages and equilibrium wage changes in response to import tariff reductions (similar as in Ossa, 2014).

Third, the impact of export tariff reduction operates mostly through promoting processing exports. On the national level, export tariff reductions caused a 1.70 p.p. annual growth of processing exports, in comparing to 1.00 p.p. growth in ordinary exports. We find similar patterns among coastal provinces. The results is driven by the fact that processing producers were much export-oriented than ordinary producers.
7.2 Policy Impact by Different Margins of Trade

We next break down the impact of each policy into four margins. Besides the intensive margin and the extensive margin studied in Chaney (2008), we introduce two new margins of trade: the export-regime margin and the location margin.

Table 5: The Impact on National-level Exports by Different Margins of Trade, in Percentage Points

<table>
<thead>
<tr>
<th>Policy Shock</th>
<th>Intensive Margin $\theta = 3, \gamma = 0, \rho = 0$</th>
<th>Intensive &amp; Extensive Margin $\theta = 4.5, \gamma = 0, \rho = 0$</th>
<th>Intensive, Extensive &amp; Regime Margin $\theta = 4.5, \rho = 0.71, \gamma = 0$</th>
<th>Benchmark Model with Four Margins $\theta = 4.5, \rho = 0.71, \gamma = 0.55$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration Shock</td>
<td>0.77</td>
<td>1.01</td>
<td>0.97</td>
<td>1.31</td>
</tr>
<tr>
<td>Import Tariff</td>
<td>0.90</td>
<td>1.32</td>
<td>1.29</td>
<td>2.19</td>
</tr>
<tr>
<td>Export Tariff</td>
<td>0.67</td>
<td>0.91</td>
<td>0.92</td>
<td>1.37</td>
</tr>
<tr>
<td>Combined Policies</td>
<td>2.34</td>
<td>3.24</td>
<td>3.18</td>
<td>4.87</td>
</tr>
</tbody>
</table>

Notes: the value in percentage point increase is calculated by following the same way as described in the notes of Table 3. Each value in last row adds up the values of the first three rows along its column.

We introduce three different sets of parameters for $\theta$, $\gamma$, and $\rho$ to isolate the effect of these margins of trade, while setting all other parameter values in the same way as in Table 2. We calibrate all the versions of our model to year 2005. We first set $\theta \equiv \sigma - 1 = 3$, $\gamma = 0$, and $\rho = 0$ and introduce each shock one at a time. This exercise examines the impact of policies on exports due to the intensive margin of trade. We then use the second set of parameters of $\theta = 4.5$, $\gamma = 0$ and $\rho = 0$ and introduce shocks one at a time. This exercise is used to quantify the intensive and extensive margins of trade. Note that the results from this exercise are equivalent to the ones predicted by a multi-sector Melitz-Chaney model with exogenous entry. Comparing the results under the second set of parameters ($\theta = 4.5$) with the results under the first set of parameters ($\theta = 3.0$), we isolate the extensive margin of trade. We then implement the third set of parameters $\theta = 4.5$, $\rho = 0.71$, and $\gamma = 0$. By changing $\rho$ to 0.71 from 0, we isolate the effect of the export-regime margin. Finally, comparing the results of the third set of counterfactuals with our baseline results shown in Table 3, we isolate the impact on exports due to the location margin.

\footnote{We would ideally set the value of trade elasticity as 3 which is equal to the value of $\sigma - 1$. However, this violates the model restriction of $\theta > \sigma - 1$, which ensures that the integral of sales distribution is finite. We simulate the model by setting the aggregate trade elasticity as 3.1.}
Figure 3: Export Impact of Policy by Different Margins of Trade, in Percentage Points

Notes: The intensive margin is obtained from Column (1) of Table 5. The extensive margin is obtained from the difference between Column (2) and (1); the Export-regime margin is obtained from the difference between Column (3) and (2), and the location margin is obtained from the difference between Column (4) and (3).

For each set of parameters, Table 5 reports the impact of each policy on exports in terms of percentage point annual growth. The first three rows report the impact of the migration shock, import tariff reductions, and export tariff reductions, respectively. The last row reports the combined impact of all three policies, which simply adds values along the corresponding column. A noteworthy result is that comparing column (3) with column (4), the location margin of the three policies combined triggered a $4.87 - 3.18 \approx 1.69$ p.p. annual increase of China’s exports and accounted for $\frac{1.69}{16.9} \approx 10\%$ of the overall national export growth. In other words, when there were no firm relocation, the combined contribution of the three policies to China’s export growth dropped from 28.8% to 18.8%. We present provincial-level results in Appendix table 9.

Next, in Figure 3, we decompose the impact of each policy on exports by four margins of
trade. On the national level, presented in the upper left Panel, the intensive margin of trade (in blue) had the most pronounced impact on export increases across all the policy changes and margins. Across all three policies, the location margin (in red) had the strongest for the case of import tariff changes and caused a 0.90 p.p. annual increase of China’s exports. Migration-induced location margin of trade was the smallest across all three policies, causing a 0.35 p.p. annual increase of national export. The small impact of migration-induced location margin on the national-level exports suggests a strong offsetting effect due to firms’ relocation across provinces.\(^70\)

At provincial level, we find strong effects of the migration-induced location margin in Guangdong, causing a 1.69 p.p. annual export growth. The result is consistent with the large migrants’ manufacturing employment share documented in section 3. The effect of the migration-induced location margin of trade was also substantial in Shanghai, leading to a 0.50 p.p. annual export growth. However, we find small effects of the migration-induced location margin in Jiangsu Province. As for import tariff reductions, the effects of the location margin were substantial all of Guangdong, Shanghai and Jiangsu Provinces, causing 0.92, 0.74 and 0.73 p.p. annual export growth respectively.

7.3 Changes in Firms’ Location Choices

We further explore the extent to which would each policy affected the mass of exporting firms that were located in China’s coastal provinces. Figure 4 plots the histogram of \( \hat{P}(Y = \{l, m\}) \), the changes in firm’s probability of choosing China’s province and export regime to serve each foreign destination \( n \) in sector \( s \). We plot the impact of migration shock in green, the impact of reductions in import tariffs in blue, and the impact of reductions in export tariffs in red. Panel (a) and (b) show firms’ likelihood of choosing ordinary and processing regimes in Guangdong respectively, where Panel (c) and (d) are for ordinary and processing regimes in Shanghai respectively. Each panel has a vertical black dash line indicating \( \hat{P}(Y = \{l, m\}) = 1 \).

One evident feature is that most areas of the histogram are located to the right of the vertical line, indicating that policy changes have attracted more exporting firms into China. The impact of each policy on firm’s location choice mirrors the corresponding policy impact on exports previously presented in Table 4 and Figure 3. We highlight some findings below.

\(^{70}\)We found provinces that experienced a relative small migration inflow or migration outflow suffer a net out-flow of firms.
Changes in Choice Probability

(a) Guangdong Ordinary Exporters
(b) Guangdong Processing Exporters
(c) Shanghai Ordinary Exporters
(d) Shanghai Processing Exporters

Figure 4: The Histogram of Changes in Firms’ Probability to Choose China’s Province and Export-regime, $\hat{P}(Y = \{l, m\})$

Notes: The histogram is plotted across all foreign destinations $n$, sectors $s$ where the export volume is greater than 30 million US dollars. For the case of export tariff, there are destination-sector pairs where $\hat{P}(Y = \{l, m\})$ takes large value (with probability density smaller than 0.05). We truncate the distribution where $\hat{P}(Y = \{l, m\})$ takes value smaller than 3.

First, in both Guangdong and Shanghai, import tariff reductions had a stronger impact of attracting ordinary firms than processing firms, as the blue bars are more skewed to the right in panel (a) and (c) in comparing to those in panel (b) and (d), respectively. Second, the reductions in migration barriers substantially attracted firms to relocate to Guangdong province, and the impact was stronger on processing exporters than on ordinary exporters. Import tariff reductions appeared important in attracting ordinary firms to be located in Shanghai. Finally, export tariff changes had relative small impact of attracting firms to relocate to Guangdong and Shanghai.
8 Conclusion

This paper quantifies how three fundamental policy reforms affected China’s exports over 1990 to 2005, and decompose the impact into different margins of adjustment. Although the literature has identified many factors that contributed to China’s post-1990 boom in manufacturing exports, the literature still lacks an accounting of the relative contribution of these factors. We fill this gap. For the nation as a whole, we find the three policy combined explains around 29% of China’s export surge, with the remainder accounted for by reform-induced TFP growth. We also find firms’ location switch are important in explaining China’s export surge: in the absence of firms’ relocation, the portion of China’s export increase explained by three combined policy drops from 29% to 19%.

In terms of methodology, we view our trade elasticity decomposition provide a guide of using quantitative models to disentangle different margins of firms’ adjustments in response to economic condition changes. Our decomposition results can be applied to address several other questions, for example, the role of firms’ relocation in determine the welfare impact of tax policy or building transportation infrastructure.
References


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Ma, L. and Tang, Y. (2016), ‘Geography, trade, and internal migration in china’.


A Proofs

A.1 Proof of Lemma

For notation simplicity, we omit $n$ and $s$ in the proof, and denote $\xi = cd\tau$.

\[ P(\tilde{\phi}_{l(m)} \leq x_{l(m)}, \tilde{\phi}_j \leq x_j, \forall l, m, j) = P(\phi_{l(m)} \leq \xi_{l(m)} x_{l(m)}, \phi_j \leq \xi_j x_j, \forall l, m, j) \]

\[ = 1 - \left[ \sum_l \left( \sum_m A_{l(m)} \xi_{l(m)}^{1-\theta} x_{l(m)}^{1-\theta} \right)^{\frac{1-\rho}{1-\theta}} + \sum_{j \in S} A_{j,s} \xi_j^{\theta} x_j^{\theta} \right]^{1-\gamma} \]

The first equality holds since by definition, $\tilde{\phi} = \frac{\phi}{\xi}$. The derivative of the CDF with respect to an arbitrary element $x_{k(o)}$ is

\[ P\left( \tilde{\phi}_1 \leq x_1, \ldots, \tilde{\phi}_{k(o)} = x_{k(o)}, \ldots, \tilde{\phi}_N \leq x_N \right) = \frac{\partial P\left( \tilde{\phi}_1 \leq x_1, \ldots, \tilde{\phi}_{k(o)} = x_{k(o)}, \ldots, \tilde{\phi}_N \leq x_N \right)}{\partial x_{k(o)}} \]

using our multivariate Pareto CDF function, this derivative further equals

\[ \theta \left[ \sum_l \left( \sum_m A_{l(m)} \xi_{l(m)}^{1-\theta} x_{l(m)}^{1-\theta} + \sum_{j \in S} A_{j,s} \xi_j^{\theta} x_j^{\theta} \right)^{\frac{1-\rho}{1-\theta}} \right]^{-\gamma} \left( \sum_m A_{l(m)} \xi_{l(m)}^{1-\theta} x_{l(m)}^{1-\theta} \right)^{\frac{1-\rho}{1-\theta} - 1} \frac{A_{k(o)} \xi_{k(o)}^{\theta} x_{k(o)}^{\theta}}{x_{k(o)}}. \] (30)

Evaluating the derivative of CDF at a common productivity level $z$ gives the joint probability for firms to choose $k$ and $n$ at that productivity level, which equals

\[ P\left( Y = \{k, o\} \& Z = z \right) = P\left( \tilde{\phi}_1 \leq z, \ldots, \tilde{\phi}_{k(o)} = z, \ldots, \tilde{\phi}_{l(m)} \leq z \right) \]

\[ = \frac{\psi_{k(o), n, s}}{\sum_m \psi_{k(m), n, s}} \times \Psi_{k(n), s} \times \left[ \sum_l \Psi_{l, n, s} + \sum_{j \in S} \psi_{j, n, s} \right]^{-\gamma} \theta z^{-\theta - 1}. \]

The second equality holds by plugging $z$ into formula (30). Where $\psi_{k(o)}$ is the shorthand for

\[ \psi_{k(o), n, s} = A_{k(o), s} \left( c_{k(o), s} d_{k, n, s} \tau_{k, n, s} \right)^{-\frac{\phi}{1-\rho}}, \quad \psi_{j, n, s} = A_{j,s} \left( e_{j, s} d_{j, n, s} \tau_{j, n, s} \right)^{-\frac{\phi}{1-\rho}}. \]

and $\Psi_{k(n), s} = \left[ \sum_m \psi_{k(m), n, s} \right]^{\frac{1-\rho}{1-\theta}}$.

Analogously, the derivative of the CDF with respect to an arbitrary element $x_j$ is

\[ \theta \left[ \sum_l \left( \sum_m A_{l(m)} \xi_{l(m)}^{1-\theta} x_{l(m)}^{1-\theta} + \sum_{j \in S} A_{j,s} \xi_j^{\theta} x_j^{\theta} \right)^{\frac{1-\rho}{1-\theta}} \right]^{-\gamma} \frac{A_{j,s} \xi_j^{\theta} x_j^{\theta}}{x_j}. \]
Evaluating the derivative of CDF at a common productivity level $z$ to have

$$P(Y = \{j\} \& Z = z) = \psi_{j,n,s} \times \left[ \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right]^{-\gamma} \theta z^{-\theta-1}.$$

### A.2 Proof of Proposition 1

The probability density function of equilibrium productivity is

$$P(Z = z) = \sum_{l,m} P(Y = \{k, o\} \& Z = z) + \sum_j P(Y = \{j\} \& Z = z)$$

$$= \left[ \sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s} \right]^{-\gamma} \theta z^{-\theta-1}.$$

By the definition of conditional probability,

$$P(Y = \{l, m\}) = \frac{P(Y = \{l, m\} \& Z = z)}{P(Z = z)} = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}} \times \frac{\Psi_{l,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}}.$$

In addition,

$$P(Y = \{l\}) = \sum_m P(Y = \{l, m\}) = \frac{\Psi_{l,n,s}}{\sum_l \Psi_{l,n,s} + \sum_{j \in S} \psi_{j,n,s}}.$$

and by conditional probability again,

$$P(Y = \{m\}) = \frac{P(Y = \{l, m\})}{P(Y = \{l\})} = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}}.$$

$Y$ and $Z$ are independent, as the product of each margin density $P(Y = \{l, m\})$ and $P(Z = z)$ equals the joint density.
A.3 Proof of Proposition 2

A.3.1 The Eaton-Kortum Model With Cross-Nested Correlation Function

Consider a multi-region, multi-sector Eaton-Kortum model where intermediate goods are produced under perfect competition using constant return to scale Cobb-Douglas technology with input-output linkage as in equation (2). For each sector \( s \), we assume the productivity vector \( \vec{\phi}(m) \) is drawn from a multivariate Fréchet distribution across China’s provinces and regimes, and the productivity \( \phi_{j,s} \) is drawn independently from a univariate Fréchet across foreign countries. The joint productivity distribution over all production units has the following CDF

\[
F^{EK}(\vec{\phi}(m),s,\vec{\phi}(n),s) = \exp \left\{ - \left[ \sum_l \left( \sum_m A^{EK}_{l(m),s} \phi_l(m) \right)^{1-\rho^{EK}} \right] - \sum_j A^{EK}_{j,s} \phi_{j,s}^{1-\gamma^{EK}} \right\}^{1-\gamma^{EK}}, \tag{31}
\]

\( \rho^{EK} \) captures the productivity correlation between processing and ordinary regimes, and \( \gamma^{EK} \) captures the productivity correlation between Chinese provinces. In addition, we allow external economies of scale such that \( A^{EK}_{l(m),s} = \bar{A}^{EK}_{l(m),s} L^{EK}_{l(m),s} \).

The share of country \( n \)’s expenditure in sector \( s \) that spent on goods produced by province \( l \) and regime \( m \), is

\[
\Pi^{EK}_{l(m),n,s} = \frac{\psi^{EK}_{l(m),n,s} \times \Psi^{EK}_{l,n,s}}{\sum_m \psi^{EK}_{l(m),n,s} \times \left[ \sum_l \psi^{EK}_{l,n,s} \right] + \sum_j \psi^{EK}_{j,n,s}} \times \left[ \sum_l \psi^{EK}_{l,n,s} \right] + \sum_j \psi^{EK}_{j,n,s} \tag{32}
\]

where \( \psi^{EK}_{l(m),n,s} = A^{EK}_{l(m),s} \left(c^{EK}_{l(m),s} d^{EK}_{l(m),n,s}\right)^{-\rho^{EK}} \), and \( \Psi^{EK}_{l,n,s} = \left[ \sum_m \psi^{EK}_{l(m),n,s} \right]^{1-\gamma^{EK}} \). The import demand system given in equation (32) is isomorphic to (11) under the following parameter restrictions

\[
\tau_{i,n,s} = 1, \quad \forall i, n, s.
\]

\[
\theta = \theta^{EK},
\]

\[
\rho = \rho^{EK},
\]

\[
\gamma = \gamma^{EK},
\]

\[
\lambda^{L}_{m,s} = \lambda^{EK,L}_{m,s}, \quad \forall m, s,
\]

\[
\lambda^{k}_{m,s} = \lambda^{EK,k}_{m,s}, \quad \forall m, k, s,
\]

\[
\lambda^{L}_{j,s} = \lambda^{EK,L}_{j,s}, \quad \forall j, s,
\]

\[
\lambda^{k}_{j,s} = \lambda^{EK,k}_{j,s}, \quad \forall m, k, s,
\]

\[
A^{Ek}_{l(m),s} = A^{EK}_{l(m),s}, \quad \forall l, m, s,
\]

\[
A^{EK}_{j,s} = A^{EK}_{j,s}, \quad \forall j,
\]

\[
d^{Ek}_{l(m),n,s} = d^{EK}_{l(m),n,s}, \quad \forall l, m, s
\]

\[
d^{EK}_{j,s} = d^{EK}_{j,s}, \quad \forall j.
\]

Below we derive the expenditure share by applying the proposition 2 in Lind and Ramondo

\[^{71}\text{For foreign country } j, \psi^{EK}_{j,n,s} = A^{EK}_{j,s} \left(c^{EK}_{j,s} d^{EK}_{j,n,s}\right)^{-\rho^{EK}} \]
(2018). Note that the correlation function of the multivariate Fréchet distribution in (31) is

\[ G(\bar{x}_{l(m)}, \bar{x}_j) = \left[ \sum_l \left( \sum_m x_{l(m)}^{- \frac{1}{\rho}} \right)^{\frac{1-\rho}{1-\gamma}} + \sum_j x_j^{- \frac{\theta}{1-\gamma}} \right]^{1-\gamma}, \]

and recall that

\[ \text{Prob}[\text{choose } l(m)] = x_{l(m)} \frac{\partial G(\bar{x}_{l(m)}, \bar{x}_j)}{\partial x_{l(m)}} \bigg/ G(\bar{x}_{l(m)}, \bar{x}_j). \]

The derive of \( G(\bar{x}_{l(m)}, \bar{x}_j) \) with respect to element \( x_{l(m)} \) is

\[
\frac{\partial G(\bar{x}_{l(m)}, \bar{x}_j)}{\partial x_{l(m)}} = (1 - \gamma) \left[ \sum_l \left( \sum_m x_{l(m)}^{- \frac{1}{\rho}} \right)^{\frac{1-\rho}{1-\gamma}} + \sum_j x_j^{- \frac{\theta}{1-\gamma}} \right]^{\frac{1}{1-\gamma} - 1} \frac{1}{1 - \rho} \frac{1}{x_{l(m)}} \frac{1}{x_{l(m)}} \\
= \frac{\sum_l x_{l(m)}^{- \frac{1}{\rho}}}{\sum_m x_{l(m)}^{1-\frac{1}{\rho}}} \frac{\left( \sum_m x_{l(m)}^{- \frac{1}{\rho}} \right)^{\frac{1-\rho}{1-\gamma}} + \sum_j x_j^{- \frac{\theta}{1-\gamma}}}{1} \left[ \sum_l \left( \sum_m x_{l(m)}^{- \frac{1}{\rho}} \right)^{\frac{1-\rho}{1-\gamma}} + \sum_j x_j^{- \frac{\theta}{1-\gamma}} \right]^{1-\gamma} \frac{1}{x_{l(m)}}.
\]

Substituting \( x_{l(m)} \) by \( \left( A_{l(m),s}^{EK} \right)^{1-\rho_{EK}} \left( \sum_{l,m} c_{l(m),s}^{EK} d_{l(m),n,s}^{EK} \right)^{-\rho_{EK}} \), and substituting \( x_j \) by \( \left( A_{j,s}^{EK} \right)^{1-\rho_{EK}} \left( \sum_{j,n,s} c_{j,s}^{EK} d_{j,n,s}^{EK} \right)^{-\rho_{EK}} \) to have the share of country \( n \)'s expenditure in sector \( s \) that spent on goods produced by province \( l \) and regime \( m \), follows in equation (32).

### A.3.2 The Armington Model with Nested-CES Preference

Consider a multi-region, multi-sector Armington model where the upper-tier utility function is Cobb–Douglas as in (15), and the lower-tier is defined as below

\[ C_{n,s} = \left[ \sum_j C_{j,n,s}^{\eta} + \sum_l \left( \sum_m C_{l(m),n,s}^{\nu} \right)^{\frac{\nu-1}{\eta}} \right]^{\frac{\eta-1}{\eta}}, \]

where \( \eta \) and \( \nu \) capture the elasticity of substitution across goods within each nest. Again we index \( j \) for foreign country, and \( l(m) \) for China’s province and regime. Assuming the goods markets are perfectly competitive, and are produced using Cobb-Douglas production technology with input-output linkage as in (2). The prices are

\[ p_{AT}^{AT} = \frac{c_{l(m),s}^{AT} d_{l(m),n,s}^{AT}}{A_{l(m),s}^{AT}}, \quad p_{j,n,s}^{AT} = \frac{c_{j,s}^{AT} d_{j,n,s}^{AT}}{A_{j,s}^{AT}}, \]

\(^{72}\)See the proposition 2 of Lind and Ramondo (2018), or for more general case see Theorem 1 of McFadden (1978).
we allow external economies of scale $A_{(m),s} = \bar{A}_{(m),s} L_{(m),s}^{\nu}$. The share of country n’s expenditure in sector s that spent on goods produced by province l and regime m, is

$$\Pi_{l(m),n,s}^{\ ATF} = \frac{\psi_{l(m),n,s}^{\ ATF}}{\sum_{m} \psi_{l(m),n,s}^{\ ATF}} \times \frac{\sum_{l} \Psi_{l,n,s}^{\ ATF}}{\sum_{l} \Psi_{l,n,s}^{\ ATF} + \sum_{j} \psi_{j,n,s}^{\ ATF}}, (33)$$

where $\psi_{l(m),n,s}^{\ ATF} = \left(\frac{\bar{A}_{l(m),s}}{\bar{A}_{l(m),s}}\right)^{\nu-1} \left(c_{l(m),n,s}^{\ ATF} \frac{\bar{A}_{l(m),s}}{\bar{A}_{l(m),s}}\right)^{1-\nu}$, and $\Psi_{l,n,s}^{\ ATF} = \left[\sum_{m} \psi_{l(m),n,s}^{\ ATF}\right]^{\frac{1-\nu}{\nu}}$. For foreign country j, $\psi_{j,n,s}^{\ ATF} = \left(\frac{\bar{A}_{j,s}}{\bar{A}_{j,s}}\right)^{\nu-1} \left(c_{j,s}^{\ ATF} \frac{\bar{A}_{j,s}}{\bar{A}_{j,s}}\right)^{1-\nu}$. The import demand system given in equation (33) is isomorphic to (11) under the following parameter restrictions

$$\tau_{i,n,s} = 1, \forall i, n, s.$$ 

$$\frac{\theta}{1 - \rho} = \nu - 1,$$

$$\frac{\theta}{1 - \gamma} = \eta - 1,$$

$$\lambda_{m,s}^{L} = \lambda_{m,s}^{AT,L}, \forall m, s, \quad \lambda_{m,s}^{k} = \lambda_{m,s}^{AT,k}, \forall m, k, s,$$

$$\lambda_{j,s}^{L} = \lambda_{j,s}^{AT,L}, \forall j, s, \quad \lambda_{j,s}^{k} = \lambda_{j,s}^{AT,k}, \forall m, k, s,$$

$A_{l(m),s} = \left(\frac{\bar{A}_{l(m),s}}{\bar{A}_{l(m),s}}\right)^{\nu-1}, \forall l, m, s, \quad A_{j,s} = \left(\frac{\bar{A}_{j,s}}{\bar{A}_{j,s}}\right)^{\eta-1}, \forall j,$

$d_{l(m),n,s} = d_{l(m),n,s}^{AT}, \forall l, m, s \quad d_{j,n,s} = d_{j,n,s}^{AT}, \forall j,$

Below we drive equation (33). Based on the CES preference, the expenditure share and price are

$$E_{l(m),n,s} = p_{l(m),n,s}^{1-\nu} E_{l,n,s} P_{l,n,s}^{\nu-1}, \quad P_{l,n,s} = \left[\sum_{m} p_{l(m),n,s}^{1-\nu}\right]^{\frac{1}{\nu}};$$

$$E_{l,n,s} = p_{l,n,s}^{1-\eta} E_{n,s} P_{n,s}^{\eta-1}, \quad P_{n,s} = \left[\sum_{l} p_{l,n,s}^{1-\eta} + \sum_{j} p_{j,n,s}^{1-\eta}\right]^{\frac{1}{\eta}};$$

The implied expenditure share can be rewritten as

$$\frac{E_{l(m),n,s}}{E_{l,n,s}} = \frac{p_{l(m),n,s}^{1-\nu}}{\sum_{m} p_{l(m),n,s}^{1-\nu}},$$

$$\frac{E_{l,n,s}}{E_{l,n,s}} = \frac{\sum_{l} \left(\sum_{m} p_{l(m),n,s}^{1-\nu}\right)^{\frac{1-\eta}{\nu-\eta}}}{\sum_{l} \left(\sum_{m} p_{l(m),n,s}^{1-\nu}\right)^{\frac{1-\eta}{\nu-\eta}}} + \sum_{j} p_{j,n,s}^{1-\eta}.$$ 

Multiplying the above shares and substitute price to obtain equation (33).
A.4 Decomposing Margins of Trade Elasticity

Recall the derivative of trade flows to trade costs has three terms as follows

\[
\frac{\partial X_{l(m),n,s}}{\partial d_{l(m),n,s}} = -M_s R \int_{\phi^*}^{+\infty} \frac{\partial x_{l(m),n,s}(\phi)}{\partial d_{l(m),n,s}} dG(\phi) + M_s R x_{l(m),n,s}(\phi^*) dG(\phi^*) \frac{\partial \phi^*}{\partial d_{l(m),n,s}}
\]

\[\text{Intensive Margin}\]

\[\frac{\partial R}{\partial d_{l(m),n,s}} M_s \int_{\phi^*}^{+\infty} x_{l(m),n,s}(\phi) dG(\phi) \]

\[\text{Extensive Margin and Export-regime Margin}\]

1) The Intensive Margin of Trade Elasticity: recall \(x_{l(m),n,s}(\phi)\) the sale from \(l(m)\) to \(n\) in sector \(s\), for firms which has productivity \(\phi\), and is equal to

\[x_{l(m),n,s}(\phi) = \left(\frac{\sigma}{\sigma - 1} \frac{c_{l(m),s} d_{l(m),n,s}}{\phi_{l(m),n,s}}\right)^{1-\sigma} E_{n,s} P^{\sigma-1}_{n,s} \]

The first term can be rewritten as

\[M_s R \int_{\phi^*}^{+\infty} \frac{\partial x_{l(m),n,s}(\phi)}{\partial d_{l(m),n,s}} dG(\phi) = \frac{1 - \sigma}{d_{l(m),n,s}} M_s R \left[ \int_{\phi^*}^{+\infty} x_{l(m),n,s}(\phi) dG(\phi) \right] d_{l(m),n,s} X_{l(m),n,s} \]

Then the intensive margin of trade elasticity is

\[-M_s R \int_{\phi^*}^{+\infty} \frac{\partial x_{l(m),n,s}(\phi)}{\partial d_{l(m),n,s}} dG(\phi) / \frac{\partial x_{l(m),n,s}(\phi)}{\partial d_{l(m),n,s}} = \frac{1 - \sigma}{d_{l(m),n,s}} M_s R \left[ \int_{\phi^*}^{+\infty} x_{l(m),n,s}(\phi) dG(\phi) \right] / \frac{d_{l(m),n,s}}{X_{l(m),n,s}} = 1 - \sigma.
\]

2) The Extensive Margin of Trade Elasticity: The second term can be rewritten as

\[M_s R x_{l(m),n,s}(\phi^*) dG(\phi^*) \frac{\partial \phi^*}{\partial d_{l(m),n,s}} = M_s R x_{l(m),n,s}(\phi^*) \phi^* dG(\phi^*) \frac{1}{d_{l(m),n,s}} \]

\[= \theta M_s R \left(\frac{\sigma}{\sigma - 1} \frac{c_{l(m),s} d_{l(m),n,s}}{\phi_{l(m),n,s}}\right)^{1-\sigma} E_{n,s} P^{\sigma-1}_{n,s} (\phi^*)^{\sigma-1-\theta} \frac{1}{d_{l(m),n,s}}.
\]

The first equality holds since \(\frac{\partial \phi^*}{\partial d_{l(m),n,s}} = \frac{\phi^*}{d_{l(m),n,s}}\). Then the extensive margin of trade elasticity is
Recall $R$ can be written as

$$R = \frac{M_{l,m,s}}{M_{l,s}} \frac{M_{l,s}}{M_s} \left[ \sum_l \psi_{l,n,s} + \sum_j \psi_{j,n,s} \right]^{1-\gamma} \left( c_{l(m),s} d_{l(m),n,s} \right)^\theta.$$ 

where $\frac{M_{l,m,s}}{M_{l,s}} = \frac{\psi_{l(m),n,s}}{\sum_m \psi_{l(m),n,s}}$ is the share of firms that engage in regime $m$, conditional on those that export to $n$ and locate in province $l'; \frac{M_{l,s}}{M_s} = \frac{\psi_{l,n,s}}{\sum_l \psi_{l,n,s} + \sum_j \psi_{j,n,s}}$ is the share of firms that locate in province $l$, conditional on those that export to $n$. According to the chain rule, that $\frac{\partial R}{\partial d_{l(m),n,s}}$ is the summation of four terms. We derive each elasticity term next.

The derivative to the first term can be derived as

$$\frac{\partial M_{l(m),s}}{\partial d_{l(m),n,s}} = -\frac{\theta}{1-\rho} \frac{1}{\sum_l \psi_{l(m),n,s} d_{l(m),n,s}} \left[ \sum_m \psi_{l(m),n,s} \right]^{-\frac{\theta}{(1-\rho)}} \left( \frac{M_{l(m),s}}{M_{l,s}} \right) \left( \frac{M_{l,s}}{M_s} \right).$$

where $\psi_{l(m),n,s} = A_{l(m),s} \left( c_{l(m),s} d_{l(m),n,s} \right)^{-\frac{\theta}{1-\rho}}$. The implied elasticity is

$$\frac{\partial \psi_{l(m),n,s}}{\partial d_{l(m),n,s}} = -\frac{\theta}{1-\rho} \frac{1}{\frac{M_{l(m),s}}{M_{l,s}} \frac{M_{l,s}}{M_s}} = \frac{\theta}{1-\rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right). \quad (34)$$
The derivative to the second term can be derived as
\[
\frac{\partial M_{l,s}}{\partial d_l(m),n,s} = -\frac{\theta}{1-\gamma} \left[ \sum_m \psi_l(m),n,s \right]^{\frac{1}{1-\gamma} - 1} \frac{\psi_l(m),n,s}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right] + \frac{\theta}{1-\gamma} \psi_l,n,s \left[ \sum_m \psi_l(m),n,s \right]^{\frac{1}{1-\gamma} - 1} \frac{\psi_l(m),n,s}{d_l(m),n,s}
\]
\[
= -\frac{\theta}{1-\gamma} \frac{1}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s - \Psi_l,n,s \right] \left[ \sum_m \psi_l(m),n,s \right]^{\frac{1}{1-\gamma} - 1} \frac{\psi_l(m),n,s}{d_l(m),n,s}
\]
\[
= -\frac{\theta}{1-\gamma} \frac{1}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s - \Psi_l,n,s \right] \frac{\psi_l(m),n,s}{\sum_m \psi_l(m),n,s}
\]
\[
= -\frac{\theta}{1-\gamma} \frac{1}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{1-\gamma} \frac{\psi_l,m,n,s}{\sum_l \Psi_l,n,s \sum_m \psi_l(m),n,s}
\]
\[
= -\frac{\theta}{d_l(m),n,s} \frac{M_{l,s}}{M_s} \frac{M_{l,s}}{M_s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{1-\gamma}.
\]

The implied elasticity is
\[
-\frac{\partial \frac{d_l(m),n,s}{d_l(m),n,s}}{\partial M_{l,s}} = \frac{\theta}{1-\gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l,s}}{M_s}.
\]

The derivative to the third term can be derived as
\[
\frac{\partial}{\partial d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{1-\gamma} = -\theta \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{-\gamma} \left[ \sum_m \psi_l(m),n,s \right]^{\frac{1}{1-\gamma} - 1} \frac{\psi_l(m),n,s}{d_l(m),n,s}
\]
\[
= -\theta \frac{1}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{-\gamma} \Psi_l,n,s \frac{\psi_l(m),n,s}{\sum_m \psi_l(m),n,s}
\]
\[
= -\theta \frac{1}{d_l(m),n,s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{-\gamma} \frac{\psi_l,m,n,s}{\sum_l \Psi_l,n,s \sum_m \psi_l(m),n,s}
\]
\[
= -\frac{\theta}{d_l(m),n,s} \frac{M_{l,s}}{M_s} \frac{M_{l,s}}{M_s} \left[ \sum_l \Psi_l,n,s + \sum_j \psi_j,n,s \right]^{1-\gamma}.
\]

The implied elasticity is
\[
-\frac{\partial \frac{d_l(m),n,s}{d_l(m),n,s}}{\partial M_{l,s}} = \frac{\theta}{1-\gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l,s}}{M_s}.
\]

The implied elasticity for the fourth term is
\[
-\frac{\partial \left( c_l(m),s d_l(m),n,s \right)^{\theta}}{\partial d_l(m),n,s} \frac{d_l(m),n,s}{\left( c_l(m),s d_l(m),n,s \right)^{\theta}} = -\theta.
\]
Finally, we add up the elasticity in (34), (35), (36) and (37) to have

\[
\frac{\theta}{1 - \rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) + \frac{\theta}{1 - \gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l(m),s}}{M_{l,s}} + \frac{\theta}{1 - \rho} \frac{M_{l(m),s}}{M_{l,s}} \Pi_l \theta
\]

\[
= \frac{\theta}{1 - \rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) + \frac{\theta}{1 - \gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l(m),s}}{M_{l,s}} - \frac{\theta}{1 - \rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) \frac{M_{l(s),s}}{M_{l,s}}
\]

\[
= \frac{\theta}{1 - \rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) + \frac{\theta}{1 - \gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l(m),s}}{M_{l,s}} + \frac{\theta}{1 - \rho} \left( 1 - \frac{M_{l(s),s}}{M_{l,s}} \right) \frac{M_{l(m),s}}{M_{l,s}}
\]

\[
= \left( \frac{\theta}{1 - \rho} - \theta \right) \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) + \left( \frac{\theta}{1 - \gamma} - \theta \right) \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l(m),s}}{M_{l,s}}
\]

\[
= \frac{\theta \rho}{1 - \rho} \left( 1 - \frac{M_{l(m),s}}{M_{l,s}} \right) + \frac{\theta \gamma}{1 - \gamma} \left( 1 - \frac{M_{l,s}}{M_s} \right) \frac{M_{l(m),s}}{M_{l,s}}.
\]
A.5 The Derivation of Trade Share and Price Index

The trade flows from \( l(m) \) to \( n \) can be written as (we drop subscript \( n \) and \( s \) for most variables to simplify the notation)

\[
X_{l(m),n,s} = M_s P\left(Y = \{l, m\}\right) \int_{\tilde{\phi}^*}^{+\infty} x_{l(m),n,s}(\tilde{\phi}) P\left(Z = \tilde{\phi} \mid Y = \{l, m\}\right) d\tilde{\phi}
\]

\[
= \theta M_s \sum_m \frac{\psi(l(m))}{\psi(l(m))} \left[ \sum_l \phi_l + \sum_{j \in S} \phi_j \right]^{-\gamma} \left( \frac{\sigma}{\sigma - 1} \tau_i \right)^{1-\sigma} \left[ \int_{\tilde{\phi}^*}^{+\infty} \left( \tilde{\phi} \right)^{\sigma - \theta - 2} d\tilde{\phi} \right] E_{n,s} P_{n,s}^{\sigma - 1}
\]

\[
= \theta M_s \sum_m \frac{\psi(l(m))}{\psi(l(m))} \left[ \sum_l \phi_l + \sum_{j \in S} \phi_j \right]^{-\gamma} \left( \frac{\sigma}{\sigma - 1} \tau_i \right)^{1-\sigma} \left( \tilde{\phi}^* \right)^{\sigma - \theta - 1} E_{n,s} P_{n,s}^{\sigma - 1}
\]

\[
= \Theta M_s \sum_m \frac{\psi(l(m))}{\psi(l(m))} \left[ \sum_l \phi_l + \sum_{j \in S} \phi_j \right]^{-\gamma} \tau_i^{\theta} \left( c_{n,s} f_{n,s} \right) \theta \frac{\sigma}{\sigma - 1} P_{n,s}^{\theta}
\]

where \( \Theta = \sigma^{\frac{\theta - \sigma - 1}{\theta - \sigma + 1}} \left( \frac{\theta}{\theta - \sigma + 1} \right)^{-\theta - 1} \), and \( \tilde{\phi}^* \) is given in equation (7). The second equality holds by plugging in the formula of \( P\left(Y = \{l, m\}\right) \) as in (9), \( x_{l(m),n,s}(\tilde{\phi}) \) as in (21), and \( P\left(Z = \tilde{\phi} \mid Y = \{l, m\}\right) \) as in (8).

Analogously, one can derive the trade flows from country \( j \) to \( n \) as

\[
X_{j,n,s} = M_s P\left(Y = \{j\}\right) \int_{\tilde{\phi}^*}^{+\infty} x_{j,n,s}(\tilde{\phi}) P\left(Z = \tilde{\phi} \mid Y = \{j\}\right) d\tilde{\phi}
\]

\[
= \Theta M_s \sum_l \frac{\psi(l)}{\psi(l)} \left[ \sum_l \phi_l + \sum_{j \in S} \phi_j \right]^{-\gamma} \tau_i^{\theta} \left( c_{n,s} f_{n,s} \right) \theta \frac{\sigma}{\sigma - 1} P_{n,s}^{\theta}
\]

\[
= \Theta M_s \sum_l \frac{\psi(l)}{\psi(l)} \left[ \sum_l \phi_l + \sum_{j \in S} \phi_j \right]^{-\gamma} \tau_i^{\theta} \left( c_{n,s} f_{n,s} \right) \theta \frac{\sigma}{\sigma - 1} P_{n,s}^{\theta}
\]
The aggregate price index is

\[
P_{n,s} = \left[ M_s P(Y = \{l, m\}) \sum_{l,m} \int_{\phi_{i,n,s}}^{+\infty} \tilde{p}(\phi)^{1-\sigma} P(Z = \phi \mid Y = \{l, m\}) \, d\phi \right. \\
+ M_s P(Y = \{j\}) \sum_{j \in S} \int_{\phi_{j,n,s}}^{+\infty} \tilde{p}(\phi)^{1-\sigma} P(Z = \phi \mid Y = \{j\}) \, d\phi \right]^{1-\sigma} \\
= \left[ M_s \theta \sum_{l,m} \frac{\psi_l(m)}{\sum_m \psi_l(m)} \Psi_l \left[ \sum_l \Psi_l + \sum_j \sum_{l \in S} \Psi_l \right]^{-\gamma} \left( \frac{\sigma}{\sigma-1} \tau_l \right)^{1-\sigma} \left[ \int_{\phi_{l,n,s}}^{+\infty} \tilde{p}_s^{-\theta-2} \, d\phi \right] \right]^{1-\sigma} \\
+ M_s \theta \sum_{l \in S} \frac{\psi_l(m)}{\sum_m \psi_l(m)} \Psi_l \left[ \sum_l \Psi_l + \sum_j \sum_{l \in S} \Psi_l \right]^{-\gamma} \left( \frac{\sigma}{\sigma-1} \tau_l \right)^{1-\sigma} \left[ \int_{\phi_{l,n,s}}^{+\infty} \tilde{p}_s^{-\theta-2} \, d\phi \right] \right]^{1-\sigma}
\]

The second equality holds because \( p(\phi)^{1-\sigma} = \tilde{p}_s^{-\theta-1} \left( \frac{\sigma}{\sigma-1} \tau_l \right)^{1-\sigma} \).

Plugging in the value of \( \tilde{p}_s^* \) defined in equation (7) and note that \( \sum_m \frac{\psi_l(m)}{\sum_m \psi_l(m)} = 1 \),

\[
= \left[ \Theta M_s \left( \frac{C_{n,s} f_{n,s}}{E_{n,s}} \right)^{\vartheta} \left[ \sum_l \Psi_{l,n,s} + \sum_j \sum_{l \in S} \Psi_{l,n,s} \right]^{-\gamma} \left( \sum_l \Psi_{l,n,s}^{\vartheta} + \sum_j \sum_{l \in S} \Psi_{l,n,s}^{\vartheta} \right) \right]^{1-\sigma}
\]

\[\equiv
P_{n,s}^\vartheta = \left[ \Theta M_s \left( \frac{C_{n,s} f_{n,s}}{E_{n,s}} \right)^{\vartheta} \left[ \sum_l \Psi_{l,n,s} + \sum_j \sum_{l \in S} \Psi_{l,n,s} \right]^{-\gamma} \left( \sum_l \Psi_{l,n,s}^{\vartheta} + \sum_j \sum_{l \in S} \Psi_{l,n,s}^{\vartheta} \right) \right]^{-1}\]

Plugging the price index formula into trade flow to have the trade share from \( l(m) \) to \( n \) is

\[
\Pi_{l(m),n,s} = \frac{\psi_l(m,n,s)}{\sum_l \psi_l(m,n,s)} \times \frac{\psi_l(m,n,s)}{\sum_l \psi_l(m,n,s)} \times \frac{\left[ \sum_l \Psi_{l,n,s}^{\vartheta} \right]^{\tau_l^{\vartheta}}}{\left[ \sum_l \Psi_{l,n,s}^{\vartheta} \right]^{\tau_l^{\vartheta}} + \sum_j \sum_{l \in S} \psi_{l,n,s}^{\vartheta} \tau_{j,n,s}^{\vartheta}}.
\]

The price index is

\[
P_{n,s} = \left[ \Theta M_s \left( \frac{C_{n,s} f_{n,s}}{E_{n,s}} \right)^{\vartheta} \left[ \sum_l \Psi_{l,n,s} + \sum_j \sum_{l \in S} \Psi_{l,n,s} \right]^{-\gamma} \left( \sum_l \Psi_{l,n,s}^{\vartheta} + \sum_j \sum_{l \in S} \Psi_{l,n,s}^{\vartheta} \right) \right]^{-\frac{1}{2}}
\]

again \( \Theta = \frac{\sigma-\theta-1}{\sigma-1} \left( \frac{\theta}{\sigma-1} \right)^{-\theta} \), and \( \vartheta = \frac{\sigma-1-\theta}{\sigma-1} \).
A.6 The Simple Representation of Trade Shares

$$\Pi_{l(m),n,s} = \frac{\psi_{l(m),n,s}}{\sum_{m} \psi_{l(m),n,s}} \times \frac{\Psi_{l,n,s} \tau_{i,n,s}^\vartheta}{\left[\sum_l \Psi_{l,n,s} \tau_{i,n,s}^\vartheta + \sum_{j \in S} \psi_{j,n,s} \tau_{j,n,s}^\vartheta \right]}$$

$$= \frac{\psi_{l(m),n,s}}{\sum_{m} \psi_{l(m),n,s}} \times \frac{\psi_{l,n,s} \tau_{i,n,s}^\vartheta}{\sum_l \psi_{l,n,s} + \sum_j \psi_{j,n,s} \tau_{i,n,s}^\vartheta + \sum_{j \in S} \psi_{j,n,s} \tau_{j,n,s}^\vartheta}$$

$$= \frac{P(Y = \{l, m\}) \tau_{i,n,s}^\vartheta}{\sum_{l,m} P(Y = \{l, m\}) \tau_{i,n,s}^\vartheta + \sum_{j \in S} P(Y = \{j\}) \tau_{j,n,s}^\vartheta}$$

Analogously, one can show

$$\Pi_{j,n,s} = \frac{M_j \tau_{j,n,s}^\vartheta}{\sum_{l,m} M_{l(m)} \tau_{i,n,s}^\vartheta + \sum_{j \in S} M_j \tau_{j,n,s}^\vartheta}.$$ 

Rewrite in terms of production unit to have

$$\Pi_{r,u,s} = \frac{M_{r,s} \tau_{r,u,s}^\vartheta}{\sum_{r'} M_{r',s} \tau_{r',u,s}^\vartheta}.$$
A.7 The Derivation of Labor Market Variables

Migration Share: Workers choose to work in the region-sector pair that brings them the highest utility. If a worker from labor group $g$ chooses to work in province $l$ and sector $s$, it implies $x_{g,l,s} \leq \frac{\tau_{g,l',s'}x_{g,l',s'}}{\tau_{g,l,s}V_{l,s}}$. Note $x_{g,l,s}$ is drawn from $G_{g,l,s}(x) = \exp(-x^{-\kappa})$, independently across all regions and sectors. Denote $g_{g,l,s}$ as the probability density function of labor productivity distribution. Then we have:

$$\Lambda_{g,l,s} = \int_{0}^{\infty} \prod_{m' \neq m \text{ or } s'' \neq s} G_{g,l,s}(\frac{\tau_{g,l',s'}V_{l',s'}}{\tau_{g,l,s}V_{l,s}}x_{g,l',s'})g_{g,l,s}(x)dx$$

$$= \int_{0}^{\infty} \kappa \exp\left(-\sum_{n} \tau_{g,n,s'}V_{n,s'}/\tau_{g,l,s}V_{l,s}\right)\kappa x^{-\kappa} dx/\Lambda_{g,l,s}$$

The second equality is obtained by using the functional form of distribution $G_{g,n,l}(x)$. The second equality is derived by integral and also noting $\tau_{g,n,l} = 0$ for region $n$ outside of labor group $g$’s country of residence. Q.E.D.

Average Efficiency Units: We compute the average efficiency units for group $g$ workers that work in region $m$ and sector $s$. Note this is a conditional expected value of ability for workers actually going to region $l$ and sector $s$:

$$E[x_{g,l,s} | \text{choose } l, s] = \int_{0}^{\infty} x \prod_{n' \neq n \text{ or } s' \neq s} G_{g,l,s}(\frac{\tau_{g,l',s'}V_{l',s'}}{\tau_{g,n,s'}V_{n,s'}}x_{g,l',s'})g_{g,l,s}(x)dx/\Lambda_{g,m,s}$$

$$= \int_{0}^{\infty} \kappa \exp\left(-\sum_{n,s'}(\tau_{g,n,s'}V_{n,s'})^{\kappa}(\tau_{g,l,s}V_{l,s})^{-\kappa}x^{-\kappa}\right)dx/\Lambda_{g,l,s}$$

$$= \left(\sum_{n,s'} T_{g,n,s'}(\tau_{g,n,s'}V_{n,s'}/\tau_{g,l,s}V_{l,s})^{\kappa}\right)^{1/\kappa} \int_{0}^{\infty} y^{-1/\kappa} \exp(-y)dy$$

$$= (1/\Lambda_{g,l,s})^{1/\kappa} \Gamma\left(1 - \frac{1}{\kappa}\right).$$

The second equality uses the functional form of distribution $G_{g,n,l}(x)$. The third equality uses the method of integration by substitution by letting $y = \sum_{n,s'}(\tau_{g,n,s'}V_{n,s'}/\tau_{g,l,s}V_{l,s})^{\kappa}x^{-\kappa}$. The last equality makes use of the migration share in equation (16) and the definition of Gamma function $\Gamma(z) = \int_{0}^{\infty} y^{z-1} \exp(-y)dy$. Q.E.D.
A.8 Model Extension

We relax the distribution in equation (3) to allow the productivity correlation across Chinese provinces to differ from the productivity correlation across countries. Assuming productivity vector is drawn from

\[ F(\bar{\phi}_l(m), s; \bar{\phi}_j, s) = 1 - \left\{ \sum_l \left( \sum_m A_{l(m), s} \phi_l(m), s \right)^{\frac{1}{1-\rho}} + \sum_j A_{j, s} \phi_j, s\right\}^{1-\delta}, \]

with the support defined on \( \phi_l(m), s > \left\{ \sum_l \left( \sum_m A_{l(m), s} \phi_l(m), s \right)^{\frac{1}{1-\rho}} + \sum_j A_{j, s} \phi_j, s\right\}^{1-\delta} \), for all \( l, m \) and \( j \). This multivariate Pareto distribution has an additional correlation parameter, where \( \delta \) captures firms’ productivity correlation across countries. It is worth mentioning that \( \delta \) not only captures the productivity correlation between any two foreign countries, but also captures the productivity correlation between any China’s province and a foreign country. To see this, the joint distribution between an arbitrary province-regime \( l(m) \) in China, and a foreign country \( j \) is

\[ F(+\infty, \ldots, \phi_l(m), s, +\infty, \ldots, \phi_j, s, +\infty) = 1 - \left[ A_{l(m), s} \phi_l(m), s + A_{j, s} \phi_j, s\right]^{1-\delta}. \]

Follow the similar steps as the proof in Appendix A.1, one can obtain the share of country \( n \)’s expenditure in sector \( s \) that spent on goods produced by province \( l \) and regime \( m \) is

\[ \Pi_{l(m), n, s} = \frac{\psi_{l(m), n, s}}{\sum_m \psi_{l(m), n, s}} \times \frac{\Psi_{l, n, s}}{\sum_l \Psi_{l, n, s}} \times \frac{\left[ \sum_l \psi_{l, n, s} \right]^{\frac{1}{1-\rho}} \tau_{i, n, s}^{\frac{\theta}{1-\rho}}}{\left[ \sum_l \psi_{l, n, s} \right]^{\frac{1}{1-\rho}} \tau_{i, n, s}^{\frac{\theta}{1-\rho}} + \sum_j \psi_{j, n, s} \tau_{j, n, s}^{\frac{\theta}{1-\rho}}}. \]

where \( \psi_{l(m), n, s} = A_{l(m), s} (c_{l(m), s} d_{l(m), n, s})^{-\frac{\theta}{1-\rho}}, \Psi_{l, n, s} = \left[ \sum_m \psi_{l(m), n, s} \right]^{\frac{1}{1-\rho}}, \) and \( \psi_{j, n, s} = A_{j, s} (c_{j, s} d_{j, n, s})^{-\frac{\theta}{1-\rho}}. \)
A.9 Variables in Proportional Changes

The proportional changes of trade share in the form of equation (13) is

\[ \hat{\Pi}_{r,u,s} = \frac{\hat{M}_{r,s} \hat{\varphi}_{r,u,s}}{\sum_r \hat{M}_{r,s} \hat{\varphi}_{r,u,s} \Pi_{r,u,s}}. \]

where \( \hat{M}_{r,s} = \hat{P}(Y = \{l, m\}) \) when \( r \) refers to a province-regime combination in China. We have first term is

\[ \hat{P}(Y = \{l, m\} \mid Y = \{l\}) = \frac{\psi_{l,m,n,s}^l}{\sum_m \psi_{l,m,n,s}^l} = \frac{\psi_{l,m,n,s}^l}{\sum_m \psi_{l,m,n,s}^l} \]

\[ = \frac{\psi_{l,m,n,s}^l}{\sum_m \psi_{l,m,n,s}^l} \]

\[ = \frac{\psi_{l,m,n,s}^l}{\sum_m \psi_{l,m,n,s}^l} \]

where \( \hat{\psi}_{l,m,n,s}^l = \hat{\Lambda}_{l,m,s}(\hat{c}_{l,m,s} \hat{d}_{l,m,n,s} \hat{\tau}_{l,n,s})^{-\frac{\varphi}{\sigma}}. \) The proportional changes for the second term is

\[ \hat{P}(Y = \{l\}) = \frac{\psi_{l,n,s}^l}{\sum_l \psi_{l,n,s}^l} = \frac{\psi_{l,n,s}^l}{\sum_l \psi_{l,n,s}^l} \]

where \( \hat{\psi}_{l,n,s}^l = \left[ \frac{\sum_l \hat{\psi}_{l,n,s}^l M_{l,s}}{M_{l,s}} \right]^{-\frac{\varphi}{\sigma}} \), and \( \hat{\psi}_{j,n,s} = \hat{\Lambda}_{j,s}(\hat{c}_{j,s} \hat{d}_{j,n,s} \hat{\tau}_{j,n,s})^{-\frac{\varphi}{\sigma}}. \)

Analogously, \( \hat{M}_{r,s} = \hat{P}(Y = \{j\}) \), when \( r \) refers to a foreign country \( j \), where

\[ \hat{P}(Y = \{j\}) = \frac{\hat{\psi}_{j,n,s}}{\sum_l \hat{\psi}_{l,n,s} M_{l,s}} + \frac{\hat{\psi}_{j,n,s}}{\sum_j \hat{\psi}_{j,n,s} M_{j,s}}. \]

Putting together, the proportional changes in trade shares are

\[ \hat{\Pi}_{l,m,n,s} = \frac{\hat{\psi}_{l,m,n,s}^l}{\sum_m \hat{\psi}_{l,m,n,s}^l M_{l,s}} \times \frac{\hat{\psi}_{l,n,s}^l}{\sum_l \hat{\psi}_{l,n,s}^l M_{l,s}} \]

\[ = \frac{\hat{\psi}_{l,n,s}^l}{\sum_l \hat{\psi}_{l,n,s}^l M_{l,s}} \phi_{l,n,s}^l \]

\[ \hat{\Pi}_{j,n,s} = \frac{\hat{\psi}_{j,n,s}^l}{\sum_j \hat{\psi}_{j,n,s}^l M_{j,s}} \phi_{j,n,s}^l \]

Based on the proportional changes in trade share, one can obtain the proportional changes in aggregate price index as

\[ \hat{P}_{r,s} = \left( \frac{\hat{E}_{r,s} M_{r,s}}{\hat{E}_{r,s}} \phi_{r,s}^l \right) \left( \frac{\sum_l \hat{\psi}_{l,n,s}^l M_{l,s} \phi_{l,n,s}^l \Pi_{l,n,s} + \sum_j \hat{\psi}_{j,n,s}^l \phi_{j,n,s}^l \Pi_{j,n,s}}{\sum_l \hat{\psi}_{l,n,s}^l M_{l,s} \phi_{l,n,s}^l \Pi_{l,n,s} + \sum_j \hat{\psi}_{j,n,s}^l \phi_{j,n,s}^l \Pi_{j,n,s}} \right)^{-\frac{\gamma}{\sigma}}. \]
B Data Description

B.1 Data Source

China’s Provincial Imports and Exports by Types: China Customs Transactions Database is collected by China’s General Administration of Customs. It covers very dis-aggregated information on imports and exports at the transaction level. For each transaction, it records the trading price, quantity, firms’ name, identification number, zip code, and whether a transaction was processing or ordinary. The product type is reported using 8-digit Harmonized System (HS) classification. To obtain provincial imports and exports by processing and ordinary trade, we first aggregate the transactions into the provincial level to obtain the trade flows between each Chinese province and other countries by each of the 8-digit HS product. We then map the 8-digit HS code of our Custom’s data to the 4-digit ISIC Rev 3 code based on the concordance which are provided by World Integrated Trade Solution (WITS).73 The 4-digit ISIC code has 145 unique industries. We aggregate the 4-digit ISIC code to 2-digit ISIC code,74 and finally map it to our 29 industry aggregation based on Table 6.

The 2-digit ISIC Rev 3 industry code has 40 industrial categories. We group them to a finer 29 categories as shown in Table 6. We also use China Customs Transactions Database in year 1988-1991, and 1997 to analyze China’s provincial level export trends.75 For the period 1998-1991, the data on trade flows are recorded using 5-digit Standard International Trade Classification (SITC); while for year 1997, the trade flows are reported using 6-digit HS code. We map the 5-digit SITC to HS code using the concordance provided by China Customs General Administration, and finally cluster it to our desired 29 industry aggregation following the same steps as we conducted for 2005 customs data.

73The concordance is available at WITS website, see https://wits.worldbank.org/product_concordance.html.
74The cluster can be simply done based on the first two digits of the 4-digits ISIC code.
75We obtain China Customs Transactions Database in year 1988-1991 from Center for International Data at the University of California, Davis. We obtain data in 1997 from Gordon Hanson.
Table 6: ** Tradable and Non-tradable Industries Using International Standard Industrial Classification (ISIC) Revision 3**

<table>
<thead>
<tr>
<th>Panel A: 16 Tradable Industries</th>
<th>ISIC, Rev 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food products, beverages and tobacco</td>
<td>C15T16</td>
</tr>
<tr>
<td>Textiles, textile products, leather and footwear</td>
<td>C17T19</td>
</tr>
<tr>
<td>Wood and products of wood and cork</td>
<td>C20</td>
</tr>
<tr>
<td>Pulp, paper, paper products, printing and publishing</td>
<td>C21T22</td>
</tr>
<tr>
<td>Coke, refined petroleum products and nuclear fuel</td>
<td>C23</td>
</tr>
<tr>
<td>Chemicals and chemical products</td>
<td>C24</td>
</tr>
<tr>
<td>Rubber and plastics products</td>
<td>C25</td>
</tr>
<tr>
<td>Other non-metallic mineral products</td>
<td>C26</td>
</tr>
<tr>
<td>Basic metals</td>
<td>C27</td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>C28</td>
</tr>
<tr>
<td>Machinery and equipment, nec</td>
<td>C29</td>
</tr>
<tr>
<td>Computer, Electronic and optical equipment</td>
<td>C30T33X</td>
</tr>
<tr>
<td>Electrical machinery and apparatus, nec</td>
<td>C31</td>
</tr>
<tr>
<td>Motor vehicles, trailers and semi-trailers</td>
<td>C34</td>
</tr>
<tr>
<td>Other transport equipment</td>
<td>C35</td>
</tr>
<tr>
<td>Manufacturing nec; recycling</td>
<td>C36T37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: 13 Non-tradable Industries</th>
<th>ISIC, Rev 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>C01T05</td>
</tr>
<tr>
<td>Mining</td>
<td>C10T14</td>
</tr>
<tr>
<td>Utility supply</td>
<td>C40T41</td>
</tr>
<tr>
<td>Construction</td>
<td>C45</td>
</tr>
<tr>
<td>Retail</td>
<td>C50T52</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>C55</td>
</tr>
<tr>
<td>Transportation and communications</td>
<td>C60T64</td>
</tr>
<tr>
<td>Financial intermediation</td>
<td>C65T67</td>
</tr>
<tr>
<td>Real estate and business services</td>
<td>C70T74</td>
</tr>
<tr>
<td>Public administration and defence; compulsory social security</td>
<td>C75</td>
</tr>
<tr>
<td>Education</td>
<td>C80</td>
</tr>
<tr>
<td>Health and social work</td>
<td>C85</td>
</tr>
<tr>
<td>Other services</td>
<td>C90T95</td>
</tr>
</tbody>
</table>

**China’s Inter-provincial Trade:** We measure China’s inter-provincial bilateral trade flows and provincial sectoral output using China’s regional input-output table. China’s National Bureau of Statistics collected its first regional input-output survey in year 1987. After that the survey is collected for every five years. We use input-output table of year 2007, which is the closest available year to 2005. We deflate these trade flows and output to year 2005 by the growth rates of China’s sectoral output between 2005 to 2007.

China’s input-output table reports industries using 2-digit China’s Standard industrial classification code (CSIC), and contains 42 industries. We map China’s CSIC code to 2-digit ISIC code using the concordance in Dean and Lovely (2010). Finally, we cluster the 2-digit ISIC code to our desired 29 industry aggregation following Table 6.
The Location Choice Probability of Firms: We first based on equilibrium conditions (9) - (12) to pin down the relative probability between any two locations (including any foreign countries and China’s provinces). Second, we divide provincial firms into processing and ordinary regime using equilibrium conditions which imply the provincial share of firms in each regime equals the export share. Combining equation (9) - (12), one can have

\[
P\left( Y = \{l\} \right) = \frac{\sum_m \Pi_{l,m,n,s} \tau_{i,n,s} - \vartheta_{i,n,s}}{\Pi_{j,n,s} \tau_{j,n,s} - \vartheta_{j,n,s}} \cdot \tag{38}
\]

where \( \tau_{i,u,s} \) denotes China’s export tariff, and \( \Pi_{l(m),n,s} \) and \( \Pi_{j,n,s} \) are \( n \)'s expenditure share in sector \( s \) on goods produced by \( l(m) \) and \( j \), respectively. We also know that

\[
\sum_l P\left( Y = \{l\} \right) + \sum_{j \in S} P\left( Y = \{j\} \right) = 1 \cdot \tag{39}
\]

We solve \( P\left( Y = \{l\} \right) \) and \( P\left( Y = \{j\} \right) \) for all \( l \) and \( j \) from systems of equation (38) and (39). Next, the share of provincial firms in each regime \( m \) equals the export share, such that

\[
P\left( Y = \{l, m\} | Y = \{l\} \right) = \frac{\Pi_{l(m),u,s}}{\sum_m \Pi_{l(m),u,s}}.
\]

China Labor Market: We use China’s Population Survey 2005 to measure China’s internal migration flow, wages, and sectoral employment. China’s Population Survey 2005 is a mini version of population census. Our sample covers about 0.2% of overall population, with roughly 2.6 million observations. The data provides detailed information on individual’s province of Hukou registration, the current province of residence, sectors and occupations of employment, and earnings. We restrict the sample to individuals who were between 20 and 60 years old and not attending school.

We use these data to construct the labor stock by each group \( \{L_g\} \), and sectoral-migration rates \( \{\Lambda_{g,m,s}\} \) for each of our 30 China’s labor groups, \( g \), at each destination province, \( m \), and at each sector, \( s \). We also measure the average income earned by each labor group, at each destination and sector, denoted as \( \{w_{g,m,s}\} \). For groups which have insufficient observations at a given destination-sector cell, we assign the average destination-sector wage to that group. It is important to note that the observed wage for each group at each sector and destination reflects a mixture of equilibrium wage rates per efficiency unit and average efficiency units (self-selection). As discussed earlier, we consider 30 destination provinces, and 29 sectors.

Foreign Labor Market: nd only considers one aggregate labor group for each of the foreign countries that we included. Therefore, the information required for each of the foreign labor
markets is a vector of shares of sectoral employment, \( \{ \Lambda_{g,i,s} \} \), and a vector of sectoral average wages, \( \{ w_{g,i,s} \} \).

We extract data from IPUMS–International and Luxembourg income study (LIS) to construct these variables. ISIC code is available in both datasets, however manufacturing industries are reported as a single aggregation. For each country, we thus divide the share of manufacturing employment into 16 detailed (tradable) manufacturing sectors by using proportions of country’s sectoral output. When wage variables are missing from IPUM-International or LIS, we supplement sectoral wages with the Occupational Wages around the World (OWW) Database. We assume that within each country, the average wage is the same across all 16 detailed manufacturing sectors. Then we assign the average sectoral wage at the broad manufacturing sector into detailed categories. Details of the data sources used for foreign countries are provided in the Table below.

**Table 7: Data Source to Measure Foreign Labor Market**

<table>
<thead>
<tr>
<th>Data Source</th>
<th>( w_{g,i,s} )</th>
<th>( \Lambda_{g,i,s} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPUMS-International</td>
<td>Brazil, Canada, India, Mexico, South Africa, Spain, United States</td>
<td>Argentina, Austria, Brazil, Canada, Chile, Denmark, Greece, Hungary, India, Indonesia, Ireland, Malaysia, Mexico, Philippines, Portugal, South Africa, Spain, Thailand, Turkey, United Kingdom, United States, Vietnam</td>
</tr>
<tr>
<td>Luxembourg Income Study</td>
<td>Austria, Chile, Denmark, Finland, Greece, Germany, Hong Kong, Italy, Ireland, Japan, Korea, Malaysia, Norway, Philippines, Portugal, United Kingdom</td>
<td>Finland, Germany, Hong Kong, Italy, Japan, Korea, Norway, Singapore</td>
</tr>
<tr>
<td>Occupational Wages around the World</td>
<td>Thailand, Turkey, Vietnam</td>
<td>N/A</td>
</tr>
</tbody>
</table>

62
C Processing Exports and Sector Sorting of Migrants

C.1 Sector Processing-export Specialization and Migrants’ Employment

We show that fact that sectors which have higher employment share of migrants are more specialized in processing exports hold in other coastal provinces including Shanghai, Jiangsu and Zhejiang Provinces. Figure 5 plots provincial migrants’ manufacturing sector employment share against sector’s share of processing exports for China’s coastal provinces. The size of circle reflects provincial processing export volume in a given sector, and the blue dash line is the linear regression fit (observations are weighted by processing export volumes).

Figure 5: Provincial and Sectoral Migrants’ Employment Share VS the Share of Processing Exports

Notes: The size of each circle reflect province-sector export volume aggregate over all foreign destinations. The dash line is the linear fit weighted by province-sector export volume.
We find strong positive association between sector’s migration employment share and processing-export specialization among China’s exporting provinces which are also the major receiving provinces of migrants including Shanghai (in a), Jiangsu (in b) and Zhejiang (in c). To quantify this positive association, we perform the regression below

\[
\log \Pi_{l(p)|l,s} = a_l + a \log \Lambda_{l,s} + \epsilon_{l,s},
\]

where \( \Pi_{l(p)|l,s} \) is the share of processing exports in province \( l \) and sector \( s \), and \( \Lambda_{l,s} \) is the migrants’ employment share in province \( l \) and sector \( s \). \( a_l \) province fixed effect.

Table 8: Processing-export Share and Migrants’ Employment

|                          | Dependent Variable: \( \log \Pi_{l(p)|l,s} \) | Unweighted OLS | Weighted OLS |
|--------------------------|-----------------------------------------------|----------------|--------------|
| Migrant’s Employment Share | 0.211                                         | 0.770***       |
|                          | (0.169)                                       | (0.186)        |
| Provincial fixed effect  | Yes                                           | Yes            |
| Num. of Obs.             | 58                                            | 58             |

Notes: Estimation is based on observations formed by combinations of provinces and sectors. We restrict to four coastal provinces, Guangdong, Shanghai, Zhejiang and Jiangsu. Column (1) reports the estimates of unweighted regression. Regression estimates in Column (2) are weighted by processing export volume. Both regressions include provincial fixed effect, and standard errors are clustered at the provincial level.

Table 8 shows that within each coastal province, despite our small sample size, a 10% higher of industries’ migrants employment share is associate with 2.1% higher of industries’ share of processing exports in unweighted regression (although statistically insignificant), and a 7.7% higher of industries’ share of processing exports when weighting observations by export volume (statistically significant).

C.2 The Sector Sorting of Migrants, in Destination Provinces

Here, we analyze the pattern of sector sorting of internal migrants at destinations, and establish the importance of internal migration in manufacturing employment. In Figure 6, we plot the migrant share of provincial overall employment against the migrant share of provincial manufacturing employment, with an auxiliary 45-degree line (blue dashed line). The area of each circle in the plot represents the number of migrants that each province received.

One noteworthy evidence is that in coastal provinces and Beijing, internal migrants made
up a substantial portion of the overall provincial employment, and were even more crucial in manufacturing employment. In particular, internal migrants represented 35.2%, 28.9% and 25.3% of the overall provincial employment in Shanghai, Beijing and Guangdong, respectively. More strikingly, internal migrants disproportionately sorted into the manufacturing sector, as most provinces lie above the 45-degree line. Several provinces, such as Guangdong, Shanghai, Fujian and Zhejiang, stand out. Guangdong and Shanghai deserve an additional emphasis, as their migration shares of manufacturing employment reached 56% and 40%, respectively.

![Figure 6: Manufacturing vs. overall migrant shares of employment; circle size based on the number of migrants each province received](image)

A second finding evident in Figure 6 is that the larger the circle, the further away it is from the 45-degree line. This indicates that in provinces such as Guangdong, Zhejiang and Fujian, which absorbed large quantities of internal migrants, migrant workers were more inclined to manufacturing jobs. Figure 7 show that internal migrants were also disproportionately employed in low-skill sectors such as construction, hotel & restaurant, and retail trade, though their patterns of sector sorting were not as strong as the one observed in the manufacturing sector.

To reconcile with such patterns of sector sorting, there has to be large heterogeneity in provincial labor demand, migration barriers. Our quantitative model presented in Section 4 capture these possible sources of heterogeneity.
Figure 7: Sector vs overall employment share of migrants; circle size bases on the migrants each province received as a share of national total.

Figure 7 shows that Non-Hukou migrant workers were disproportionately employed at Hotel & restaurant, and retail trade sectors. For Hotel & restaurant sector, Beijing and Shanghai were the farthest away from the 45 degree line, indicating their migrants were most disproportionately employed at hotel and restaurant sectors. The sectoral sorting pattern also held for Guangdong, Tianjin, Zhejiang, Fujian and Jiangsu Provinces, though the degree of sorting was weaker. The right panel of figure 7 documents that the sector sorting pattern also weakly applied at retail trade sectors.
D The Time-Series Evidence of Migration and Trade

We provide evidence to show the cross-sectional relationship between migration and trade documented in Figure 1 was primarily established during 1990-2005, the period that our paper analyzes. The right Panel of Figure 8 plots the changes between 1990 and 2005 in provincial migration employment in manufacturing (normalized by manufacturing employment in 1990), against changes in manufacturing export volume (normalized by manufacturing output in 1990). It shows that provinces which faced larger increases in migrant employment in manufacturing sectors also experienced faster growth in manufacturing exports. The right Panel of Figure 8 plots the provincial employment share of internal migration at manufacturing sector in 1990 against provincial manufacturing export intensity, defined as the ratio between export to output in 1990. It shows that provincial migration share of manufacturing employment are below 5% in all provinces in 1990. Combining these two panels, we confirm that the cross-sectional pattern between migration and trade in 2005 was primarily established during 1990-2005.

Figure 8: Provincial Migrants’ Manufacturing Employment against Export/Output Ratio

Notes: Our measure on provincial manufacturing exports is based on China’s Customs Transactions database in 1990 and 2005. We measure China’s internal migration based on China micro-population census 1990 and 2005, and define migrants as the geographic mis-match between the province of Hukou registration and the province of residence: people whose Hukou are not registered in the province where they are currently working. The circle size bases on provincial exports as a share of national total.

provinces,\textsuperscript{77} and Panel (b) is for Guangdong Province only. We normalize variables by their initial year values. Exports are plotted in blue dashed line and migration in red solid line.

![Figure 9: Growth in Exports and Migrant Manufacturing Labor Force in Coastal Provinces, 1990-2005](image)

(a) Coastal Provinces

(b) Guangdong

The left panel shows China’s exports grew steadily from the late 1980s to 2000, and accelerated after China’s accession into WTO in 2001, whereas the red solid lines suggest the massive rise in migrant workers appeared before 2000, prior to the turning point of China’s export surges. Among coastal provinces considered in panel (a), migrant employment in manufacturing sector grew steadily in both the period of 1990-2000 and of 2000-2005. Panel (b) shows that in Guangdong Province, the epic rises in migrant employment of manufacturing took place prior to 2000, and grew relatively slowly after 2000.

The time-series evidence of migration and export growth shows that massive relocation of workers to coastal provinces started, if not prior to, no later than the surge in Chinese exports to the global market. This time-trend we show here has an important implication. The demand shifters, such as trade-induced migration in particular, would at most contribute modestly to driving China’s epic labor movement. Instead the Hukou reform in the form of eliminating temporary residence and certificate requirement, was the main driver of China’s intra-provincial non-Hukou migrants. These implications are consistent with our hypothesis that China’s massive internal migration promoted China’s manufacturing export growth.

\textsuperscript{77}We deflate the export volumes using inflation rates.
E Hukou Reform and the Spatial Sorting of Migrants

China’s Residence Registration System (Hukou) was launched in the late 1950s and was designated to control internal migration flows. The system assigns a Hukou to each household, mainly based on its residential location. A Hukou stipulates the geographic area in which a Chinese citizen is eligible to reside, work, and obtain public benefits (which entails education, health insurance, and pension). Moving out of the Hukou area was initially tightly controlled by the government. According to China’s 1982 Population Census, only 0.6% of China’s total population in 1982 resided out of their Hukou county.

The barriers to internal migration began to melt away in 1984. An important aspect of the policy change was introduction of temporary residence permits. Conditional on obtaining a temporary residence permit, people were allowed to live and work in locations other than their home cities. Until 2003, many cities had eliminated the requirement of temporary residence certificates and Chinese people thus gained more freedom to work outside their home cities, though they were still denied most of access to social welfare in the destination. The permission to live and work outside of the Hukou area is one of the main aspects of the Hukou reform, and also the one of which impact we intent to measure.\(^78\)

Next we discuss the spatial sorting pattern of China’s internal migration. According to China’s Population Survey 2005, internal migrants represent 5.1% of China’s population and 5.5% of overall employment. Table 10 presents the migration stock of each origin-destination pair as a share of national total migrants. Unsurprisingly, more than 78% of all internal migrants were bound for either highly developed coastal provinces or Beijing in 2005, as shown in column (1). Guangdong Province alone absorbed 35.6% of national migrants. Zhengjiang, Shanghai, Jiangsu, Beijing and Fujian were also important destinations, receiving 13.0%, 9.4%, 8.7%, 6.3%, and 5.8% of the national total, respectively.

Columns (2) to (4) break down internal migrants by three geographic areas of origin: Central Interior China, Western Interior China, and Northeast China. It is evident that central interior China was the leading emigrant region, sending 51.1% of national total migrants. Among destinations, migrants from Central Interior China to Guangdong Province made up the largest bilateral flow, representing 23.6% of the national total. Besides, migrants from Western Interior China accounted for 27.8% of the total, with those from Northeastern China only representing 4.8%.\(^79\) Table 11 also shows that internal migrants were on average younger and less educated than their counterparts both in the origin and in the destination. We also show that males were more likely to migrate than females.

\(^78\)There are other aspects of Hukou reform that took place during the late 1990s and 2000s. These policy changes include: 1) grant of more public goods to migrants; 2) abolition of rural-to-urban migration quota; and 3) simplification of migration through Hukou conversion for elderly parents, highly educated workers, skilled workers and investors.

\(^79\)The numbers do not add up to 1, because there were migration flows between provinces within each aggregated region as well. We do not show this in the table for brevity.
F Additional Tables and Figures

Table 9: The Provincial Export Impact by Different Margins of Trade, in Percentage Points

<table>
<thead>
<tr>
<th>Policy Shock</th>
<th>Intensive Margin $\theta = 3, \gamma = 0, \rho = 0$</th>
<th>Intensive &amp; Extensive Margin $\theta = 4.5, \gamma = 0, \rho = 0$</th>
<th>Intensive, Extensive &amp; Regime Margin $\theta = 4.5, \rho = 0.71, \gamma = 0$</th>
<th>Benchmark Model with Four Margins $\theta = 4.5, \rho = 0.71, \gamma = 0.55$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangdong Province</td>
<td>(1) 1.35 1.81 1.70 2.30</td>
<td>(2) 0.50 0.73 0.67 1.21</td>
<td>(3) 0.49 0.65 0.67 0.99</td>
<td>(4)</td>
</tr>
<tr>
<td>Migration Shock</td>
<td>1.35</td>
<td>1.81</td>
<td>1.70</td>
<td>2.30</td>
</tr>
<tr>
<td>Import Tariff</td>
<td>0.50</td>
<td>0.73</td>
<td>0.67</td>
<td>1.21</td>
</tr>
<tr>
<td>Export Tariff</td>
<td>0.49</td>
<td>0.65</td>
<td>0.67</td>
<td>0.99</td>
</tr>
<tr>
<td>Shanghai</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migration Shock</td>
<td>1.34</td>
<td>1.81</td>
<td>1.77</td>
<td>2.23</td>
</tr>
<tr>
<td>Import Tariff</td>
<td>0.63</td>
<td>0.86</td>
<td>0.75</td>
<td>1.19</td>
</tr>
<tr>
<td>Export Tariff</td>
<td>0.53</td>
<td>0.68</td>
<td>0.69</td>
<td>0.95</td>
</tr>
<tr>
<td>Jiangsu</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migration Shock</td>
<td>0.06</td>
<td>0.07</td>
<td>0.05</td>
<td>0.13</td>
</tr>
<tr>
<td>Import Tariff</td>
<td>0.52</td>
<td>0.73</td>
<td>0.68</td>
<td>1.16</td>
</tr>
<tr>
<td>Export Tariff</td>
<td>0.55</td>
<td>0.73</td>
<td>0.75</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Notes: the value in percentage point increase is calculated by following the same way as described in the notes of Table 3.
Table 10: **INTER-PROVINCIAL NON-HUKOU MIGRANTS AS A SHARE OF NATIONAL TOTAL**

<table>
<thead>
<tr>
<th>Destination</th>
<th>All origins (1)</th>
<th>Central Interior (2)</th>
<th>Western Interior (3)</th>
<th>Northeast (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangdong</td>
<td>35.6%</td>
<td>23.58%</td>
<td>9.79%</td>
<td>0.38%</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>13.0%</td>
<td>7.48%</td>
<td>4.51%</td>
<td>0.09%</td>
</tr>
<tr>
<td>Shanghai</td>
<td>9.4%</td>
<td>4.67%</td>
<td>1.40%</td>
<td>0.20%</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>8.7%</td>
<td>5.52%</td>
<td>2.19%</td>
<td>0.11%</td>
</tr>
<tr>
<td>Beijing</td>
<td>6.3%</td>
<td>3.53%</td>
<td>0.89%</td>
<td>0.72%</td>
</tr>
<tr>
<td>Fujian</td>
<td>5.8%</td>
<td>2.96%</td>
<td>2.53%</td>
<td>0.04%</td>
</tr>
<tr>
<td>All 6 provinces</td>
<td>78.8%</td>
<td>47.7%</td>
<td>21.3%</td>
<td>1.54%</td>
</tr>
<tr>
<td>All destinations</td>
<td>100%</td>
<td>51.1%</td>
<td>27.8%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

Notes: Each value represents the migration flow of a given origin-destination pair as a share of the national total. Central interior provinces include Hebei, Shanxi, Inner-Mongolian, Henan, Anhui, Hubei, Jiangxi, Guangxi and Hunan; Western interior provinces include Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang. Northeast provinces include Heilongjiang, Jilin and Liaoning.

Table 11: **SELECTION IN OBSERVED CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Non-Hukou Internal migrants</th>
<th>Hukou Residence at destination</th>
<th>Hukou Residence of origin province</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Education Distribution</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No schooling primary</td>
<td>2.4%</td>
<td>4.0%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Low secondary</td>
<td>20.7%</td>
<td>26.0%</td>
<td>31.0%</td>
</tr>
<tr>
<td>High school</td>
<td>56.3%</td>
<td>42.3%</td>
<td>45.1%</td>
</tr>
<tr>
<td>Some college</td>
<td>15.3%</td>
<td>16.9%</td>
<td>11.2%</td>
</tr>
<tr>
<td>College</td>
<td>3.6%</td>
<td>6.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td><strong>Panel B: Age and Gender Selection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Age</td>
<td>31.3</td>
<td>39.5</td>
<td>39.8</td>
</tr>
<tr>
<td>Fraction of Male</td>
<td>57.4%</td>
<td>53.7%</td>
<td>53.4%</td>
</tr>
</tbody>
</table>
Figure 10: China’s Average Export Tariff across Foreign Countries by sectors, in 1990 and 2005

Figure 11: China’s Import Tariff by sectors, in 1990 and 2005
Figure 12: Provincial Changes in Migration Frictions (Manufacture Sector)

Figure 13: Provincial Changes in Migration Frictions (All Sectors)
Figure 14: The Histogram of Changes in Firms’ Probability to Choose China’s Province and Export-regime, $\hat{P}(Y = \{l, m\})$

Notes: The histogram is plotted across all foreign destinations $n$, sectors $s$, where the export volume is greater than 100 million US dollars. For the case of export tariff, there is a probability mass around 0.05 that $\hat{P}(Y = \{l, m\})$ takes value greater than 3. We truncate the distribution $\hat{P}(Y = \{l, m\})$ takes value smaller than 3.
We analyze the main mechanism through which policy changes impact exports and how the effect is amplified by agglomeration economies. For tractability, we make several simplification assumptions that are in line with Chinese economy. First, we study policy changes in one single country (denoted by $i$) and hold general equilibrium variables such as income, expenditure, and price indices in foreign regions as fixed when we conduct policy changes. Second, there are two regions in country $i$, the coastal region (denoted as $c$) with low international trade costs and the inland region (denoted as $nc$) with high international trade costs. The trade costs between domestic regions are symmetric: $d_{c,nc} = d_{nc,c} = \bar{d} > 1$ and $F_{j,c} = F_{j,nc} \forall j$ with $\rho = 0$. This assumption mimics the “international hub” structure as in Cosar and Fajgelbaum (2016). Each region is initially inhabited by one labor group with identical population and distributions of idiosyncratic abilities, whereas firms in the coastal area is more productive than in the inland area. The migration costs are symmetric: $\tau_{c,nc} = \tau_{nc,c} = \bar{\tau} < 1$. Finally, there is one aggregate sector with no input-output linkages, and hence we omit the notation for sectors. To eschew the effect of tariff income on national income, we assume country $i$ imposes no tariffs on foreign goods.

**Proposition 3 (Policy Changes and Export Growth).** Consider country $i$ that experiences policy changes. Assume there are no agglomeration economies, i.e. $\alpha = 0$. Then, country $i$’s exports,
(1) increase with the reduction in migration costs (labor market liberalization);
(2) increase with the reduction in outward international trade costs or tariff rates levied by other countries (trade liberalization);
(3) increase with the number of firms (firm creation). 

Proposition 3 characterizes how various policy changes affect exports. In the proof, we show that labor market liberalization induces workers to move from the poor inner region to the rich coastal region. This in turn lowers labor costs in the coastal region which plays the role of the “international hub”. In such a way, labor market liberalization provides cheap labor to the exporting sector and reinforces export competitiveness in the global market. On the other hand, trade liberalization directly lowers international trade frictions for country $i$ and thus provides opportunities for export expansion. As a by-product, it also induces migration from the inner region to the coastal region that benefits more from trade liberalization. Finally, more potential firms allow country $i$ to offer more varieties to foreign markets and therefore improve export competitiveness. We next turn to the role of agglomeration economies in amplifying the contribution of policy changes to export growth.

---

80 In the simulations, we resort to solving the general equilibrium model to study the effect of policy changes.
81 To tractably prove result (3), we require a sufficient condition that the import ratio of absorption is small enough. This aims to shut down regional heterogeneity in responses of price indices to the number of firms.
Proposition 4 (Agglomeration Economies and Amplification Effects). Assume $\frac{1}{\kappa - 1} - \eta \bar{\sigma} > \alpha \geq 0$ and $\bar{d}$ is large enough. Then, when agglomeration economies are stronger (higher $\alpha$), the increase in exports due to labor market liberalization or trade liberalization becomes larger.

Proposition 4 theoretically establishes that the contribution of labor market liberalization or trade liberalization to export growth is larger when agglomeration economies are stronger. In particular, this amplification effect hinges on the magnitude of migration flows induced by the policy change. As labor market liberalization directly impacts migration flows, it is expected to have larger interaction effects with agglomeration economies than trade liberalization, which we will show by use of our simulation results in Section 7.\(^\text{83}\)

G.1 Proof of Proposition 3

G.1.1 Labor Market Liberalization

Without loss of generality, we assume $\bar{\tau}$ increases from $\bar{\tau} = 0$ to some $\bar{\tau} > 0$. We use subscript $\Delta \bar{\tau}$ to denote variables after labor market liberalization. Because of high international trade costs, assume the inner region has negligible export share of output, which is consistent with our data. Denote by $\bar{L}$ the measure of population for each labor group in country $i$. Since labor groups are divided only by their original regions, we can omit subscript $g$. We normalize the location parameter of the productivity distribution to be one for each labor group of country $i$, that is $T_{m,n} = 1 \forall m, n \in \{c, nc\}$. Because there is no tariff income and trade is balanced, the total expenditure is equal to labor income and hence there is a fixed proportion $\eta$ of labor doing marketing in each region of country $i$. The labor market clearing conditions for both regions can be written as (in two unknowns $\{w_c, w_{nc}\}$), by use of equation (17) and (18):

\[
\Gamma \left(1 - \frac{1}{\kappa}\right) \left(\Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc,nc}^{1-1/\kappa}\right) w_{nc} \bar{L} = \frac{A_{nc}(w_{nc})^{-\theta}}{A_{nc}(w_{nc})^{-\theta} + A_c(w_c \bar{d})^{-\theta}} X_{nc} + \frac{M_i A_{nc}(w_{nc} \bar{d})^{-\theta}}{M_i A_c(w_c)^{-\theta} + M_i A_{nc}(w_{nc} \bar{d})^{-\theta} + \sum_{j \neq i,m} M_j A_m(w_m d_{mc})^{-\theta}} X_c
\]

\[
\Gamma \left(1 - \frac{1}{\kappa}\right) \left(\Lambda_{c,c}^{1-1/\kappa} + \Lambda_{nc,c}^{1-1/\kappa}\right) w_c \bar{L} = \frac{A_c(w_c \bar{d})^{-\theta}}{A_{nc}(w_{nc})^{-\theta} + A_c(w_c \bar{d})^{-\theta}} X_{nc} + \frac{M_i A_c(w_c)^{-\theta}}{M_i A_c(w_c)^{-\theta} + M_i A_{nc}(w_{nc} d_{nc})^{-\theta} + \sum_{j \neq i,m} M_j A_m(w_m d_{mc})^{-\theta}} X_c + (w_c)^{-\theta} f g_c
\]

where $\Lambda_{nc,nc} = \frac{(w_c \bar{\tau} / P_c)^{\kappa}}{((w_c \bar{\tau} / P_c)^{\kappa} + (w_{nc} / P_{nc})^{\kappa})}, \Lambda_{c,nc} = \frac{(w_{nc} \bar{\tau} / P_{nc})^{\kappa}}{((w_{nc} \bar{\tau} / P_{nc})^{\kappa} + (w_c / P_c)^{\kappa})}$, $\Lambda_{nc,c} = 1 - \Lambda_{nc,nc}$ and $\Lambda_{c,c} = 1 - \Lambda_{c,nc}$. $f g_c = \sum_{n \in \Omega_{c,nc}} \frac{\bar{d} \bar{\sigma} - \sigma}{\bar{d} \bar{\sigma} + 1} \left(\frac{\varphi_c w_c F_{n,s}}{E_{n,s}}\right)^{\frac{\bar{d} \bar{\sigma} - \sigma - 1}{\bar{d} \bar{\sigma} + 1}} \left(1 + \xi_{i,n,s}\right) M_i A_c d_{cn}^{-\theta} P_n^{\beta} X_n$

\(^{82}\)This condition holds in our calibration.

\(^{83}\)Theoretically, changes in the number of firms are uniform across two regions and do not necessarily cause migration flows towards the coastal region, hence their interactions with agglomeration economy are ambiguous.
summarizes the aggregate demand conditions from foreign regions. The expenditures can be written as: \( X_c = \Gamma(1-\frac{1}{\kappa}) \left( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa} \right) w_c L \) and \( X_{nc} = \Gamma(1-\frac{1}{\kappa}) \left( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc,nc}^{1-1/\kappa} \right) w_{nc} L \).

We can show that \( w_c/P_c > w_{nc}/P_{nc} \) and \( w_{c,\Delta r}/P_{c,\Delta r} > w_{nc,\Delta r}/P_{nc,\Delta r} \), because \( A_c > A_{nc} \) and the coastal region can participate in trade with foreign regions. To see this, by rearranging the first equation of the labor market clearing conditions, we can obtain:

\[
\frac{A_c(w_c)^{-\theta-1} \left( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa} \right)}{M_i A_c(w_c)^{-\theta} + M_i A_{nc}(w_{nc})^{-\theta}} = \frac{M_i A_{nc}(w_{nc})^{-\theta-1} \left( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa} \right)}{M_i A_c(w_c)^{-\theta} + M_i A_{nc}(w_{nc})^{-\theta} + \sum_{j \neq i,m \in \Omega_i} M_j A_m(w_m d_{m,c})^{-\theta}}. \tag{40}
\]

In the initial case with \( \bar{r} = 0 \), we have \( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa} = 1 \) and \( \Lambda_{c,c}^{1-1/\kappa} + \Lambda_{nc,c}^{1-1/\kappa} = 1 \). It is easy to verify by contradiction that the equation can only hold if \( w_c > w_{nc} \) and \( A_c(w_c)^{-\theta-1} < A_{nc}(w_{nc})^{-\theta-1} \), otherwise the left-hand side of the equation will be larger than the right-hand side. Also note by the definition price index in equation (14), after some algebra, we can write equation (40) as:

\[
\frac{w_c/P_c}{w_{nc}/P_{nc}} = \left( \frac{w_c^{2\theta+1} A_{nc}}{A_c \cdot w_c^{2\theta+1}} \right)^{1/\theta} \left( \frac{\Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa}}{\Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,c}^{1-1/\kappa}} \right) > 1. \tag{41}
\]

The inequality is obtained by using \( w_c > w_{nc}, A_c(w_c)^{-\theta-1} < A_{nc}(w_{nc})^{-\theta-1}, \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc}^{1-1/\kappa} = 1 \) and \( \Lambda_{c,c}^{1-1/\kappa} + \Lambda_{nc,c}^{1-1/\kappa} = 1 \). We can follow the similar logic to show \( w_{c,\Delta r}/P_{c,\Delta r} > w_{nc,\Delta r}/P_{nc,\Delta r} \).\footnote{To theoretically prove \( w_{c,\Delta r}/P_{c,\Delta r} > w_{nc,\Delta r}/P_{nc,\Delta r} \), we also require a sufficient condition of \( \kappa < \sigma \), which is satisfied by our calibration.}

Denote by \( \bar{x} = x_{\Delta r}/x \) the proportional change for \( x \) before and after labor market liberalization. By combing two equations, we can obtain:

\[
\frac{\sum_{j \neq i,m \in \Omega_i} M_j A_m(w_m d_{m,c})^{-\theta}}{M_i A_c(w_c)^{-\theta} + M_i A_{nc}(w_{nc} d)^{-\theta} + \sum_{j \neq i,m \in \Omega_i} M_j A_m(w_m d_{m,c})^{-\theta}} \Gamma \left( 1 - \frac{1}{\kappa} \right) \left( \Lambda_{c,nc}^{1-1/\kappa} + \Lambda_{nc,nc}^{1-1/\kappa} \right) w_c L = (w_c)^{-\theta} f_{g,c} \tag{42}
\]

Hence, because \( w_{c,\Delta r}/P_{c,\Delta r} > w_{nc,\Delta r}/P_{nc,\Delta r} \), we obtain \( (\Lambda_{c,c,\Delta r})^{1-1/\kappa} + (\Lambda_{nc,c,\Delta r})^{1-1/\kappa} > \Lambda_{c,c,\Delta r} + \Lambda_{nc,c,\Delta r} \geq 1 = \Lambda_{c,c}^{1-1/\kappa} \). That is, the total labor supply to the coastal region increases after labor market liberalization. We can then prove the results of Proposition 3 by contradiction. Assume that \( \bar{w}_c > 0 \). By equation (40), we have \( \bar{w}_{nc} > 0 \). Then the left-hand side of equation (42) increases, whereas the right-hand side decreases after labor market liberalization. This cannot restore the equilibrium. Therefore, we have \( \bar{w}_c < 0 \) after the shock, which implies lower labor costs in the coastal region and leads to higher exports \((w_{c,\Delta r})^{-\theta} f_{g,c} > (w_c)^{-\theta} f_{g,c}) \). \textit{Q.E.D.}

G.1.2 Trade Liberalization

Denote by subscript \(-\Delta d\) the equilibrium with trade liberalization, that is, there is a proportional reduction in international trade frictions for each region. This can be induced by the
reduction in international trade costs or tariff rates levied by destination countries. As a result, \(fg_c\) increases after trade liberalization, \(fg_{c,-\Delta d} > fg_c\). Following the similar procedure as in the proofs in G.1.1, we can use equation (40) and (42) to prove by contradiction that

\[
\frac{w_{c,-\Delta d}/P_{c,-\Delta d}}{w_{nc,-\Delta d}/P_{nc,-\Delta d}} > \frac{w_c/P_c}{w_{nc}/P_{nc}} \quad \text{85}
\]

Hence, trade liberalization raises the ratio of real wage in the coastal region to that in the inner region. Intuitively, trade liberalization allows for more room of export expansion, which benefits the coastal region which acts as “international hub”.

Because \(\frac{w_{c,-\Delta d}/P_{c,-\Delta d}}{w_{nc,-\Delta d}/P_{nc,-\Delta d}} > \frac{w_c/P_c}{w_{nc}/P_{nc}}\), more workers move to the coastal region after trade liberalization and we obtain \(\Lambda_{c,c,-\Delta d}^1 + \Lambda_{nc,c,-\Delta d}^1 \geq \Lambda_{c,c,c}\). By equation (42), we can then obtain \(w_{c,-\Delta d}^{-\theta}fg_{c,-\Delta d} > w_c^{-\theta}fg_c\) by contradiction. Assume \(w_{c,-\Delta d}^{-\theta}fg_{c,-\Delta d} \leq w_c^{-\theta}fg_c\). This implies \(w_{c,-\Delta d} > w_c\) because \(fg_{c,-\Delta d} > fg_c\). By equation (40), this indicates \(w_{nc,-\Delta d} > w_{nc}\). Hence, the left-hand side of equation (42) will be larger after trade liberalization, whereas the right-hand side decreases by assumption. This cannot construct the equilibrium. Therefore, \(w_{c,-\Delta d}^{-\theta}fg_{c,-\Delta d} > w_c^{-\theta}fg_c\), which means that exports increase in response to trade liberalization.

\[
Q.E.D.
\]

G.1.3 Firm Creation

Denote by subscript \(\Delta M\) the equilibrium after increases in \(M_i\), that is, there is a proportional increase in the number of firms in country \(i\). We assume the import ratio of absorption is small enough, therefore changes in the number of firms will not have different effects on price indices in two regions. Then the ratio of real wage in two regions can be written as:

\[
\frac{w_c/P_c}{w_{nc}/P_{nc}} = \left(\frac{A_c + A_{nc}(d_{w_c}/w_{nc})^\theta}{A_{nc} + A_c(d_{w_{nc}}/w_c)^\theta}\right)^{1/\theta} \left(\frac{\Lambda_{c,c,c}^{1-1/\kappa} + \Lambda_{c,c,c}^{1-1/\kappa}}{\Lambda_{nc,c}^{1-1/\kappa} + \Lambda_{nc,c}^{1-1/\kappa}}\right)^{(\sigma-\mu)/\sigma}
\]

Combining this equation with equation (40) uniquely pin down \(\{w_c/w_{nc}, w_{c}/P_{c}, w_{nc}/P_{nc}\}\), which is independently of \(M_i\). Therefore, changes in \(M_i\) does not affect \(\{w_c/w_{nc}, w_{c}/P_{c}, w_{nc}/P_{nc}\}\). This implies that \((\Lambda_{c,c,c}\Delta M)^{1-1/\kappa} + (\Lambda_{nc,c,c}\Delta M)^{1-1/\kappa}\) is independently of \(M_i\). Note \(M_i\) is contained in \(fgc\) and \(fg_{c,\Delta M} > fd_{c}\). Using equation (42), we can prove \(w_{c,\Delta M}^{-\theta}M_{i,\Delta M} > w_{c,\Delta M}^{-\theta}M_i\) by contradiction. Assume \(w_{c,\Delta M}^{-\theta}M_{i,\Delta M} < w_{c,\Delta M}^{-\theta}M_i\). This implies \(w_{c,\Delta M}/w_c > (M_{i,\Delta M}/M_i)^{1/\theta}\).

Since \(w_c/w_{nc} = w_{c,\Delta M}/w_{nc,\Delta M}, w_{nc,\Delta M}^{-\theta}M_{i,\Delta M} < w_{nc}^{-\theta}M_i\). Hence, the left-hand side of equation (42) increases after increases in the number of firms, whereas the right-hand side of equation (42) decreases by assumption. This cannot restore the equilibrium. Therefore, \(w_{c,\Delta M}^{-\theta}M_{i,\Delta M} > w_{c,\Delta M}^{-\theta}M_i\), which implies \(w_{c,\Delta M}^{-\theta}fg_{c,\Delta M} > w_{c}^{-\theta}fg_c\). Exports increase with the number of firms \(M_i\).

\[
Q.E.D.
\]

85We still require the sufficient condition of \(\kappa < \sigma\).
G.2 Proof of Proposition 4

Denote by superscript $\Delta \alpha$ the variable from an equilibrium with an increase in $\alpha$. Without loss of generality, we consider $\alpha$ increases from $\alpha = 0$ to some $\alpha > 0$. We show the effect of labor market liberalization is amplified when $\alpha$ increases. Assume $\tilde{d}$ is large enough such that the within-country trade share of output is negligible. Notice that the ratio of real wage in two regions can be written as:

\[
\frac{w_c/P_c}{w_{nc}/P_{nc}} = \left( \frac{M_iA_c + \sum_{j \neq i, m} M_jA_m(w_m d_{m,c})^{-\vartheta} w_c^{\vartheta}}{M_iA_{nc}} \right)^{1/\vartheta} \left( \frac{1^{1-1/\kappa} + \Lambda_{c,c}^{1-1/\kappa}}{\Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,nc}^{1-1/\kappa}} \right)^{\vartheta - \eta + 1/\vartheta - 1}
\]  

(43)

With agglomeration economies, we obtain $A_c \propto \left( \Lambda_{nc,c}^{1-1/\kappa} + \Lambda_{c,c}^{1-1/\kappa} \right)^{\alpha \sigma}$ and $A_{nc} \propto \left( \Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,nc}^{1-1/\kappa} \right)^{\alpha \sigma}$.

We impose the restriction $\frac{1}{\vartheta} - \eta\tilde{\sigma} > \alpha \geq 0$ to ensure $\frac{w_c/P_c}{w_{nc}/P_{nc}}$ increases with $w_c$ in equation (43).

Assume that efficiency units in the inner region decreases in response to labor market liberalization. We prove by contradiction that $\frac{w_c^{\Delta \alpha}/w_{nc,\Delta \tau}}{w_{nc,\Delta \tau}/w_{nc,\Delta \tau}} > \frac{w_c^{\Delta \alpha}/P_c}{w_{nc,\Delta \tau}/P_{nc,\Delta \tau}}$. That is, the ratio of real wage in the coastal region to that in the inner region increases with agglomeration parameter $\alpha$. Intuitively, agglomeration economies allows the coastal region which receives most of migrants to further increase their productivity and thus exacerbate the wage gap.

Note in equation (42), $fg_c$ increases after labor market liberalization when there is agglomeration economies, because $A_c$ is contained in $fg_c$. It is easy to verify that $(w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_{c,\Delta \tau}^{\Delta \alpha} > (w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_c$, where $A_{c,\Delta \tau}^{\Delta \alpha}$ is the productivity level in the agglomeration economies, which varies in different scenarios. To show this by contradiction, assume $(w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_{c,\Delta \tau}^{\Delta \alpha} < (w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_c$. This implies $w_{c,\Delta \tau}^{\Delta \alpha}/w_{c,\Delta \tau} > (A_{c,\Delta \tau}^{\Delta \alpha}/A_c)^{1/\vartheta} > 1$. Therefore, in the equilibrium after labor market liberalization, the left-hand side in equation (42) increases with $\alpha$, whereas the right-hand side decreases by assumption. This cannot restore the equilibrium. Therefore, $(w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_{c,\Delta \tau}^{\Delta \alpha} > (w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} A_c$, which implies $(w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} f g_{c,\Delta \tau} > (w_{c,\Delta \tau}^{\Delta \alpha})^{-\vartheta} f g_c$. Note initial exports before labor market liberalization are the same in the economy with and without agglomeration economies. Therefore, the effect of labor market liberalization on export growth increases with $\alpha$. Similarly, we can show the effect of trade liberalization on export growth increases with $\alpha$. Q.E.D.

---

86We have showed in the proofs for Proposition 3 that $\Lambda_{nc,nc} + \Lambda_{c,nc}$ decreases in the inner region after labor market liberalization. Therefore, with $\kappa \rightarrow \infty$, it is easy to prove that total efficiency units supplied to the inner region, $\Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,nc}^{1-1/\kappa}$, decrease in the inner region after labor market liberalization. However, with a finite $\kappa$, there exists a selection effect such that $\Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,nc}^{1-1/\kappa}$ does not necessarily decrease after labor market liberalization, and therefore we need to assume this. This assumption is consistent with our data as the actual migration flow is almost one-sided from the inner region to the coastal region: $\Lambda_{c,nc}$ is negligible and $\Lambda_{nc,nc}$ decreases after labor market liberalization; hence $\Lambda_{nc,nc}^{1-1/\kappa} + \Lambda_{c,nc}^{1-1/\kappa}$ decreases in response to labor market liberalization $\forall \kappa > 1$. 79
We present alternative estimation strategy for labor supply elasticity. The literature has reached little agreement for the value of labor supply elasticity. We show that our baseline estimate is robust to two alternative approaches. It is worth noting that the interpretation of this parameter depends crucially on the context. In a Roy model of occupation sorting, $\kappa$ captures the income elasticity of occupation switching, whereas in a Roy model of migration sorting, it captures the income elasticity of migration reallocation. In our study, $\kappa$ captures the income elasticity of occupation and location switching.

The first alternative approach is based on the standard deviation of log real incomes, which is proposed by Tombe and Zhu (2015). Note that for workers from labor group $g$ that choose to work in region $m$ and sector $s$, their log real incomes, $\log(x_{g,m,s}V_{m,s})$, is distributed according to a Gumbel distribution $G_{inc}^{g,m,s}(y) = \exp\left( -\sum_{n,l} T_{g,n,l}(\tau_{g,n,l}V_{n,l}/\tau_{g,m,s})^\kappa \exp(-\kappa y) \right)$. As a property of Gumbel distribution, the variance of log real incomes within a group-destination-sector pair is $\pi^2/6 \kappa^2$. To obtain an empirical counterpart of this variance, we use Population Census 2005 and regress log income on education and a set of group-destination-sector dummy variables. We find the variance of the residual term is 0.34, which results in an estimate of $\kappa = 2.21$.

As a second alternative approach, we perform maximum likelihood estimation on the empirical wage distribution over the entire China’s working age population who were wage earners in 2005. We obtain an estimate of $\kappa = 2.1$. In Figure 15, we show that parametric assumption fits the empirical wage distribution decently well.

![Figure 15: Parameteric distribution vs wage empirical distribution](image)
I The Global Impacts of China’s Internal Migration

In a well globalized world economy, China’s internal migration might draw impacts on foreign countries through international trade. This section analyzes the global impact of China’s internal migration. All the quantitative results are based on a full version of our model, while we set China’s internal migration friction to the level as in 1990, which is estimated in Section 6. To provide an overview of our results, we find a larger impact of internal migration on exports to developed countries and in the computer, electronic & optical equipment sector. This result is driven by the following two facts. First, developed countries imported more from Chinese provinces that more intensively hired internal migrants. Second, the workforce of the computer, electronic & optical equipment sector was mostly composed by migrants.

Impacts on China’s sectoral production costs We proceed by first showing the effects of China’s internal migration on production costs at manufacture sectors among exporting provinces. Table 12 represents the impact of internal migration on wage units among five coastal provinces at four major exporting industries.

<table>
<thead>
<tr>
<th>Province</th>
<th>Computer &amp; electronic</th>
<th>Textiles, leather &amp; footwear</th>
<th>Electrical machinery &amp; apparatus</th>
<th>Machinery &amp; equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangdong</td>
<td>-22.1%</td>
<td>-17.1%</td>
<td>-14.8%</td>
<td>-7.7%</td>
</tr>
<tr>
<td>Shanghai</td>
<td>-5.8%</td>
<td>-6.5%</td>
<td>-2.8%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Fujian</td>
<td>-5.5%</td>
<td>-11.8%</td>
<td>-2.2%</td>
<td>-5.5%</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>-5.1%</td>
<td>-4.2%</td>
<td>-6.3%</td>
<td>-3.0%</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>-4.4%</td>
<td>-4.2%</td>
<td>-1.3%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

Consistent with the empirical evidence that Guangdong Province has experienced the largest increase of internal migration labor forces in manufacture sectors, as in Figure 1, the sectoral wage units fall the most in Guangdong Province. The decline in wage in Guangdong is the most notable at Computer & electronic industry, where sectoral wage falls by 22.1%. Wage unit also falls substantially in other industries such as Textiles, leather & footwear, Electrical machinery & apparatus, by 17.1% and 14.8%, respectively.

The impacts of internal migration on wage are also substantial in other coastal provinces, yet in smaller degree in comparison to Guangdong. A few notable cases are that, the wage units falls by 11.8% and 6.5% in Fujian province and in Shanghai at Textiles, leather & footwear sector, respectively. Resulting from internal migration, wage units also dropped by 6.3% at Electrical machinery & apparatus industry in Zhejiang province, by 5.5% at Machinery & equipment industry in Fujian province, and by 5.8% and 5.5% at Computer & electronic sector in Shanghai and Fujian Provinces, respectively.
The Impact on Bilateral Exports: This section explore the effects of internal migration on China’s export to foreign destination countries. Table 13 reports the effects of the reduction in China’s internal migration friction on China’s export by destinations and industries. We present the result on overall manufacture exports in column (2), and by four detailed manufacturing sectors along column (3)-(6). Along rows, we reports China’s aggregate export to all importers, and then to China’s top importers.

On the aggregate, the reduction in migration frictions has caused a 15.3% increase of China’s overall manufacture export growth between 1990 to 2005. The impacts are larger at computer, electronic & optical equipment and electrical machinery & apparatus sector, than at textiles, leather & footwear sector and Machinery & equipment sector. The decline in migration friction explains more at computer, electronic & optical equipment sector and electrical machinery & apparatus sector, by 21.0% and 20.4%, respectively, and also contributes to export growth at textiles, leather & footwear sector by 11.9% and at Machinery & equipment sector by 11.7%.

The impacts on China’s export growth to European and Northern American countries are larger than on the export growth to Asian countries. We present results by China’s top importers along the rows. In terms of the aggregate export, the reduction in migration frictions within China could explain 18.7% of export growth to France, the most decline among China’s top importing partners. China’s manufacture exports to other developed countries including United Kingdom, Australia and United States, Canada and Germany also would have been about 14.8%-17.7% lower in the absence of the reduction in China’s migration barriers. China’s exports to neighboring partners such as Taiwan, Japan and Korea are affected relatively less, with export to Korea only changing by 6.8%.

To investigate the source of heterogeneous effects of exports across foreign countries, Figure 16 plots proportional changes in China’s aggregate bilateral exports to each foreign importers, against the weighted average in provincial employment share of internal migration, where the weights are used as the value of provincial and sectoral exports to each foreign importer. These weights capture the China’s export value added by migrant workers as a share of the value added by labor.
Table 13: **The Effects of Reduction in Migration Barriers**

<table>
<thead>
<tr>
<th>Importer</th>
<th>Broad manufacturing</th>
<th>Computer &amp; Electronic</th>
<th>Textiles, leather &amp; footwear</th>
<th>Electrical machinery &amp; apparatus</th>
<th>Machinery &amp; equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>All importers</td>
<td>-15.3%</td>
<td>-21.0%</td>
<td>-11.9%</td>
<td>-20.4%</td>
<td>-11.7%</td>
</tr>
<tr>
<td>France</td>
<td>-18.7%</td>
<td>-23.8%</td>
<td>-13.5%</td>
<td>-23.4%</td>
<td>-12.1%</td>
</tr>
<tr>
<td>Australia</td>
<td>-15.1%</td>
<td>-19.4%</td>
<td>-13.0%</td>
<td>-17.0%</td>
<td>-11.9%</td>
</tr>
<tr>
<td>United States</td>
<td>-17.7%</td>
<td>-21.4%</td>
<td>-15.7%</td>
<td>-24.8%</td>
<td>-12.9%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>-16.6%</td>
<td>-22.9%</td>
<td>-11.8%</td>
<td>-23.1%</td>
<td>-12.2%</td>
</tr>
<tr>
<td>Canada</td>
<td>-15.4%</td>
<td>-20.3%</td>
<td>-11.1%</td>
<td>-23.6%</td>
<td>-12.1%</td>
</tr>
<tr>
<td>Germany</td>
<td>-14.8%</td>
<td>-16.8%</td>
<td>-13.7%</td>
<td>-25.1%</td>
<td>-12.8%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>-13.8%</td>
<td>-17.8%</td>
<td>-17.2%</td>
<td>-21.2%</td>
<td>-14.8%</td>
</tr>
<tr>
<td>Japan</td>
<td>-10.8%</td>
<td>-18.8%</td>
<td>-8.2%</td>
<td>-19.0%</td>
<td>-11.1%</td>
</tr>
<tr>
<td>Korea</td>
<td>-6.8%</td>
<td>-19.8%</td>
<td>-4.2%</td>
<td>-9.2%</td>
<td>-7.8%</td>
</tr>
</tbody>
</table>

Figure 16: **Proportional Changes in China’s Bilateral Exports Against Average Provincial Employment Share of Internal Migration Weighted by the Value of Provincial and Sectoral Exports to This Foreign Importer**

Unsurprisingly, foreign countries for which we found a larger proportional decline in imports from China, are those which are more likely to import from China’s provinces where the manufacture sectors employ migrant workers more intensively. On the one hand, American and European countries are more likely to import from China’s coastal provinces where the manufacture sectors use internal migration labor more intensively.\(^87\) The weighted provincial...

\(^87\)For example, among China’s exports to the US, 34.8% are produced by Guangdong, 18.4% by Jiangsu, and 15.0% by Shanghai.
employment shares of internal migration are among the highest in countries such as Chile (40.4%), Spain (38.0%), and France (37.3%). The export value added by internal migrants are also substantial to countries such as Mexico, the United States, the United Kingdom, etc.

On the other hand, East and Southeast Asian countries such as Korea, Vietnam and Japan lie in the Northwest of the plot. This indicates those countries are more likely to import from China’s coastal provinces where the manufacture sectors use internal migration labor less intensively. For example, 18.1% of China’s exports to Korea is produced by Shangdong province, in which the share of migrants in manufacture workers is 3.8%.

Impacts on the global trade pattern: We next focus on the global economy and asks that in the absences of China’s reduction in migration barriers, how would the global trade pattern among foreign countries have been different. We represent the results by grouping countries into multiple trade blocs including NAFTA, EU, Oceania, East Asian countries, Southeast Asian countries and South American countries.88

The Panel A of Table 14 displays proportional changes in bilateral trade flows and domestic absorption. Importers are arranged along the rows, while exporters are along the columns. Unsurprisingly, the reduction in China’s exports lead foreign countries to trade more with other partners. Southeast Asian and East Asian countries experience the largest percentage increase in trade shares. Southeast Asia would have exported 3.4% more, and East Asia countries would have exported 3% more to NAFTA countries. Southeast Asian and East Asian countries also experience an increase in export to EU countries by about 2.2-2.3%.

Panel B of Table 14 reports the increase in export volume of each trade bloc as a share of total increases in world trade volume, excluding China’s exports and imports. It is notable that East Asian exporters reap 42.2% of increases in the world exporting volume among countries excluding China. Southeast Asian countries also account for 18.3% of the increase in world exporting volume, smaller in magnitude than that of EU countries (22.2%). NAFTA countries, Oceania and South American countries are affected less, with 10.7%, 4.0% and 2.6% of increases in the world trade volume, respectively.

Welfare effects: we show aggregate welfare impact on each foreign country. We find 25 out of our 32 foreign countries enjoy a welfare gain due to China’s reduction in migration frictions between 1990 to 2005. The average proportional changes in aggregate welfare are 0.073%, while higher Chinese good prices and lower China’s import demand cause the average losses of 0.025% and 0.065%, respectively. These estimates are largely in line with the literature.89

88NAFTA countries include Canada, United States and Mexico; South American countries include Argentina, Brazil and Chile; East Asian countries include Japan, Korea and Taiwan; Southeast Asian countries include Cambodia, Indonesia, Malaysia, Philippines, Singapore, Viet Nam and Thailand; Oceania includes Australia and New Zealand; EU countries include Austria, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Norway, Portugal, Spain, Sweden and United Kingdom.

89Handley and Limão (2017) finds the reduction in trade policy uncertainty after China’s accession to WTO is associated with a 0.4% increase in US consumer welfare in 2005. Their estimate is larger than ours (0.074% for US), as they find a larger effect on exports to US (38.3%) than our exercise (16.4%) and they also consider entry
Table 14: **PROPORTIONAL CHANGES IN AGGREGATE TRADE VOLUME BY REGIONAL TRADE BLOCS**

<table>
<thead>
<tr>
<th>Import / Export</th>
<th>NAFTA</th>
<th>EU</th>
<th>Oceania</th>
<th>East Asia</th>
<th>SE Asia</th>
<th>South America</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Proportional changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAFTA</td>
<td>0.6%</td>
<td>0.9%</td>
<td>2.3%</td>
<td>3.0%</td>
<td>3.4%</td>
<td>1.4%</td>
</tr>
<tr>
<td>EU</td>
<td>0.4%</td>
<td>0.3%</td>
<td>2.0%</td>
<td>2.3%</td>
<td>2.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Oceania</td>
<td>-0.4%</td>
<td>-0.5%</td>
<td>0.6%</td>
<td>1.1%</td>
<td>1.2%</td>
<td>0%</td>
</tr>
<tr>
<td>East Asia</td>
<td>-0.7%</td>
<td>-0.2%</td>
<td>0.8%</td>
<td>0.9%</td>
<td>1.2%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>SE Asia</td>
<td>-0.3%</td>
<td>-0.3%</td>
<td>0.8%</td>
<td>1.2%</td>
<td>1.0%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>South America</td>
<td>-0.2%</td>
<td>-0.1%</td>
<td>1.1%</td>
<td>1.9%</td>
<td>1.8%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

| % by exporters | 10.7% | 22.2%| 4.0%    | 42.2% | 18.3% | 2.6% |

Notes: Changes are with respect to the baseline calibrated equilibrium.

We further decompose aggregate welfare changes into two direct effects caused by China and indirect effects, where the indirect effects are a combination of forces that capture general equilibrium reactions, including changes in prices and export demand from countries other than China and changes in prices and labor demand for marketing services.

Table 15: **PROPOSITIONAL CHANGES IN AGGREGATE WELFARE**

<table>
<thead>
<tr>
<th>Country</th>
<th>Aggregate welfare effects</th>
<th>Changes in import prices from China</th>
<th>Changes in export demand by China</th>
<th>Other indirect effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Taiwan</td>
<td>-0.341</td>
<td>-0.032</td>
<td>-0.552</td>
<td>0.244</td>
</tr>
<tr>
<td>Thailand</td>
<td>-0.155</td>
<td>-0.040</td>
<td>-0.091</td>
<td>-0.024</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.068</td>
<td>-0.027</td>
<td>-0.046</td>
<td>0.004</td>
</tr>
<tr>
<td>France</td>
<td>-0.062</td>
<td>-0.023</td>
<td>-0.023</td>
<td>-0.016</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.013</td>
<td>-0.026</td>
<td>-0.016</td>
<td>0.055</td>
</tr>
<tr>
<td>United States</td>
<td>-0.074</td>
<td>-0.036</td>
<td>-0.035</td>
<td>-0.003</td>
</tr>
<tr>
<td>Australia</td>
<td>-0.192</td>
<td>-0.044</td>
<td>-0.063</td>
<td>-0.086</td>
</tr>
<tr>
<td>Chile</td>
<td>-0.255</td>
<td>-0.056</td>
<td>-0.104</td>
<td>-0.096</td>
</tr>
<tr>
<td>Argentina</td>
<td>-0.137</td>
<td>-0.013</td>
<td>-0.076</td>
<td>-0.048</td>
</tr>
</tbody>
</table>

Table 15 reports, in the absence of China’s reduction in migration frictions, the percentage changes of the aggregate welfare impact on a few countries. As we showed in the last section, East Asian and Southeast Asian exporters experience gains in trade flows to other countries (except China) in the counterfactual exercise. However, most of these countries tend and technology upgrading in a dynamic setting which could amplify the effect. Hsieh and Ossa (2016) finds that China’s productivity growth between 1995 to 2007 is associated with a small spillover effect on real income in other countries, ranging between -0.2% to 0.2%.
to experience welfare losses, as they import intensively from China. For example, Taiwan, the contiguous trading partner with mainland China, experiences a 0.552% loss in welfare due to the reduction in export demand by mainland China, which offsets the gain of 0.244% from indirect effects, mainly the expansion of exports to other countries.

The welfare effects differ among European countries. On one hand, countries such as Hungary, Ireland, Portugal and Finland, experience gains in aggregate welfare. This is driven by the facts that 1) China acts as their export competitor, and 2) they are less likely to import from China. On the other hand, countries such as United Kingdom, France and Germany, generally import intensively from China, making their losses from China’s prices outweighs the indirect effects.

As for NAFTA countries, Mexico experiences gains in aggregate welfare, as Mexico is one of China’s main competitors in manufacturing production. The United States suffers welfare losses of 0.074%, whereas the welfare losses for Canada are slightly higher than that of the US. These welfare losses are mostly because those countries import intensively from China.

All Oceania and South American countries have welfare losses in the counterfactual exercise, by a range of 0.045-0.255%, mostly resulting from lower export demand by China. Among these countries, the impact on Chile is the largest. This is because Chile sold 4.8% of its total output to China in 2005. Hence, Chile’s reduction in exports to China (15.2%) in the counterfactual exercise results in a large welfare effect.

To further understand the reason behind cross-country variation in welfare changes that are related to higher import prices of Chinese goods, we associate these changes with the expenditure share of goods produced by China’s migrants in Figure 17. There is a strongly negative and almost linear relationship between them: countries (such as Chile, Australia, New Zealand) which have larger expenditure shares on goods produced by China’s migrants, suffer larger proportional losses in welfare that result from higher import prices of Chinese goods in the counterfactual exercise.

\[ \text{To calculate the expenditure share on goods produced by China’s migrants for each country, we multiply this country’s expenditure share on Chinese goods by the fraction of China’s exports (to that country) produced by migrants.} \]
Figure 17: Welfare changes associated with China’s import prices against expenditure share on Chinese goods produced by migrants.