Trade Wars and Industrial Policy along the Global Value Chains*

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Abstract

We provide a quantitative estimation of the welfare impacts of the US-China trade conflict starting at 2018. We first document that the Trumpian tariffs were initially concentrated in a few high-tech manufacturing industries emphasized by the "Made in China 2025" (MIC 2025) initiative. Comparing to other industries, these industries (i) exhibit stronger economies of scale, and (ii) their production inputs have lower elasticity of substitution. Motivated by these features, we extend the quantitative trade model of Caliendo and Parro (2015) by incorporating sectoral external economies of scale and CES input-output linkages. We calibrate the model to 7 major economies and 95 disaggregated industries and examine the impacts of the Trumpian tariffs and the MIC 2025 initiative. We find that the first wave Trumpian tariffs reduce the US real wages, but increase the US welfare. Their direct welfare effects are small: -0.008 percent for China and 0.023 percent for the U.S. The total welfare effects of the Trumpian tariffs and China's retaliation are larger: -0.04 percent for China and -0.28 percent for the U.S. Surprisingly,China's MIC 2025 industrial policy increases the US welfare and the Trumpian tariffs increase China's incentive to implementing the industrial policy. We also examine US and China policies under the non-cooperative Nash equilibrium and find that China would subsidize its high-tech production by around 5 percent and the U.S. would impose tariffs on both high-tech imports from China and high-tech exports to China. Finally, we find that Brazil and India benefit from the trade wars, but Japan suffers.

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JEL classification: *F12*; *F13*; *F17*; *F51.*

"So the steel and aluminum actions we've taken deal more or less with the present. This action on intellectual property rights deals with the future." –*Wilbur Ross (March 22, 2018)*

1 Introduction

The ever-escalating trade war between China and the United States is profoundly affecting the world trading system. Some recent studies, e.g. Amiti et al (2018) and Fajgelbaum et al (2019), find that the US initiated 2018 trade war (on China and other countries in general) have resulted in significant income losses for the US consumers and firms. This raises some natural questions: What is the motivation of the trade war? Is there any economic justification for the protectionism tariffs implemented by the Trump administration? In this paper, we examine the nature of the Trumpian tariffs and provide a quantitative estimation of the welfare impacts of these tariffs on both China and US.

We first document that the protectionism tariffs initially imposed by the Trump administration (on July 2018) are not correlated with the size of the US imports from China. Instead, they are concentrated in few high-tech manufacturing industries emphasized by the "*Made in China 2025*" (henceforth "MIC 2025") initiative such as aerospace, advanced IT equipment, railway equipment, power generating and distribution equipment, and robotics. These suggest that the first wave Trumpian tariffs were aimed at China's industrial policies rather than Chinese imports. We should therefore go beyond the standard trade model and consider the role of industrial policies in evaluating the impact of the China-US trade war.

To achieve this, we extend the quantitative trade model in Caliendo and Parro (henceforth CP, 2015) by incorporating (i) sectoral external economies of scale, and (ii) nested-CES input-output linkages. These extensions are motivated by (i) the extensive literature that rationalizes industrial policies by sectoral external economies of scale,[1] and (ii) the recent findings that different industries are largely complements to one another as inputs in downstream industries' production.[2] We show that both extensions are important in evaluating welfare effects of trade and industrial policies.

We then calibrate our model to 7 major economies and 95 disaggregated industries. We calibrate sectoral external economies of scale to various empirical practices in the literature, finding that manufacturing sectors emphasized by the "MIC 2025" indeed exhibit stronger

[1] The literature that rationalizes industrial policies by external economies of scale can be at least traced back to Pigou (1920). See Bartelme et al. (2019) for the summary and recent advances of this literature.

[2] See Atalay (2017) for the identification of inter-sectoral elasticities of substitution in the production function.

economies of scale than other sectors. Moreover, we estimate the inter-sectoral elasticities of substitution in the production function following the strategy developed by Atalay (2017), finding that the "MIC 2025" sectors have lower elasticities of substitution than other sectors in producing downstream products.

Armed with the calibrated model, we first quantify the welfare effects of the Trumpian tariffs on July 2018 without considering China's retaliation. We find that the direct welfare effects of these protectionism tariffs are limited: −0.008 percent for China and 0.023 percent for the U.S.[3] These protectionism tariffs hurt China by shrinking the scale of China's high-tech manufacturing production. They also hurt the U.S. workers by lowering the U.S. real wage by 0.039 percent. This loss mainly comes from the increasing prices of final and intermediate goods in the U.S. Notably, the U.S. welfare gain from the Trumpian tariffs on July 2018 is entirely due to the increase in the tariff revenue.

Then we quantify the impacts of China's industrial subsidies, revealing some surprising results. First, we show that the Chinese industrial policies in the form of subsidizing the high-tech industries listed in the "MIC 2025", actually increase the US welfare. This is because the subsidies have resulted in lower costs of the intermediate inputs imported by the US firms. Second, under the Trumpian tariffs aiming at China's high-tech industries, the "MIC 2025" actually yields larger welfare gains for China. Intuitively, industrial policies would lead to larger welfare gains if the economy has been distorted by tariffs imposed by other countries.

We proceed by analyzing a non-cooperative game in which the U.S. chooses its protectionism tariffs proportionate to their actual levels on July 2018, whereas China chooses a uniform production subsidy on its high-tech industries. The Nash equilibrium consists of the U.S. tariffs about 4.4 percent higher than their actual levels on July 2018 and a 5.2% production subsidy on the Chinese high-tech industries.

Our quantitative characterization of the non-cooperative equilibrium rationalizes the co-existence of protectionism tariffs and industrial subsidies. This result reveals a key feature of the recent US-China trade war: two countries are actually competing for the scale of the high-tech manufacturing industries. We show that the "MIC 2025" subsidies unambiguously increase the scale of the high-tech industries in China and reduce the scale of the same industries in the US. And the Trumpian tariffs have the exact opposite effect. Therefore, a better understanding of the current China-US trade war, we should examine more carefully the role of industry scales in shaping an economy's comparative advantage in the long run. In particular, if the Trumpian tariffs decrease the scales of China's high-tech industries and thereby hurt China's comparative advantage in manufacturing, it could be welfare-improving for China to respond by subsidizing these industries.

[3] We measure the welfare by the real income.

Finally, we evaluate the consequences of the ever-escalating trade war between the U.S. and China. We find that the protectionism tariffs imposed by the Trump administration on December 2019 and China's retaliation lead to considerable welfare losses for both countries: -0.042 percent for China and -0.28 percent for the U.S. If the trade war finally results in trade decoupling between the U.S. and China, i.e. they impose prohibitive tariffs on each other's products, then the U.S. real income would decrease by 0.81 percent and the Chinese real income would decrease by 0.08 percent. This suggests that there is room for trade negotiation between the U.S. and China to avoid such huge losses.

Related Literature. Our work first relates to empirical studies on the US-China trade war starting at 2018 (Amiti, Redding, Weinstein, 2019; Fejgelbaum et al., 2019; Cavallo et al., 2019; Ma and Meng, 2019), which focus on the partial equilibrium price or employment effects of the Trumpian tariffs. We complement this literature by quantifying general equilibrium effects of trade policies in a more flexible framework, and considering China's retaliation and industry policies.

This paper also relates to the quantitative frameworks on trade policies (Caliendo and Parro, 2015; Ossa, 2014; Caliendo et al., 2017). We extend these frameworks by incorporating sectoral economies of scale and nested-CES IO linkages, which are shown to be relevant in characterizing high-tech industries targeted by the Trumpian tariffs.

There are few studies that measure sectoral economies of scale and consider the interaction of trade and industrial policies. Bartelme et al. (2019) identify sectoral external economies of scale from bilateral trade flows and suggest that given their estimates the gains from industrial policies are quite limited. Lashkaripour and Lugovskyy (2018) identify sectoral external economies of scale using firm-product-transaction-level trade data and demonstrate the potential gains from industrial policies. Our work complements this literature by examining the interdependence in detailed policy context of the real world.

Finally, our paper relates to the literature on non-Cobb-Douglas production networks. Atalay (2017) estimates the elasticity of substitution across input sectors, finding that they are usually less than 1. Baqaee and Farhi (2019) characterize the general equilibrium under more general production linkages, suggesting that the elasticity of substitution across input sectors are important to welfare consequences of trade shocks. Our paper contributes to this literature by demonstrating the importance of nested-CES IO linkages to understanding the welfare implications of the US-China trade conflicts.

The remaining sections are arranged as follows. Section 2 introduces our data sets and motivational facts about the US-China trade conflicts. Section 3 builds and characterizes our general equilibrium model. Section 4 calibrates our model and conducts counterfactuals. Section 5 concludes.

2 Data and Facts

2.1 Data

Our study relies on a system of world trade with 6 major economies (the US, China, Japan, EU[4], Brazil, India) and the rest of world (ROW). To be as disaggregate as possible on industry classifications for the US-China trade, we match China's IO table (133 sectors) with the IO table of the US (389 sectors), and end up with 95 disaggregated industries, including 60 manufacturing industries (including mining), 1 agriculture, and 34 services sectors. We then partition the 2014 World Input-Output Table (WIOT) into these 95 sectors.[5] Based on this data, we could extract information on gross production, value-added, internal trade, and importantly input-output structure.

Bilateral trade flows prior to the trade war are collected from 2016 UN-Comtrade. Tariff data is from the 2017 World Integrated Trade System (WITS). Both are available at six-digit HS level (HS-6) and we collapse bilateral trade and tariff into 61 tradable sectors using a self-constructed crosswalk. "Section 301" tariff data for each wave is collected from the notices by the United State Trade Representative Office (USTR), which is available at eight-digit HS product level and is matched to 61 tradable sectors in our data as weighted averages using 2017 US import data as weights. China's retaliation tariff lists are from the notices published by the China's Ministry of Commerce (MofCom). And we similarly use China's import data reported by the Customs Office of China to calculate weighted average tariff for each sector in each retaliation wave.

2.2 Facts about the US-China Trade Conflicts

2.2.1 Timeline of the Trade War

The official "Section 301" report was issued on April 3, 2018, which marked the start of tariff war and retaliations between the two largest countries in the world. The original list includes a list of 1,333 eight-digit HS products which worth approximately 50 billion dollars. This list was then revised on June 15: 818 HS-8 products remained on the list and was subject to an additional 25 percent tariff effective since July 6, 2018. A new set of 284 HS-8 products were added to the list and was subject to an additional 25 percent tariff effective since August 23, 2018. We dub this list of tariff lines as *wave 1.*

China almost immediately announced its retaliation plan. And, as a response to China's retaliation against wave 1, an additional $200 billion of Chinese imports, dubbed as the *wave*

[4]EU includes 28 countries. The list is available upon request.

[5]There are only 22 tradable sectors in WIOT, so we adopt each country's export share to partition into 61 tradable sectors in our matched data. 34 non-tradable sectors in the WIOT is matched one-to-one with services sectors in our data.

2 products, was proposed be have 10 percent additional tariffs since September 24, 2019. This new list covers nearly 6,000 HS-8 products. *Wave 3* refers to the event that the Trump administration decided to raise the 10 percent tariff on wave 2 products to 25 percent, on May 10, 2019. *Wave 4* covers the 15 percent tariffs on additional Chinese imports of about 110 billion dollars, imposed on September 1, 2019. Finally *Wave 5* covers the rest of about 160 billion Chinese imports which was schedule to be levied an additional 15 percent tariff on December 15, 2019.[6]

In summary, there have been altogether five waves of protectionism tariffs implemented or proposed by the Trump administration, on July and August 2018, September 2018, May 2019, September 2019, and December 2019, respectively. Adopting a "tic-for-tat" strategy, China's retaliation immediately followed each wave of the U.S. tariffs. The retaliations, however, did not seem to have a focus except that for the first wave it targeted mostly on the agriculture products such as soybean and meat.

2.2.2 Patterns of Tariff War Escalation

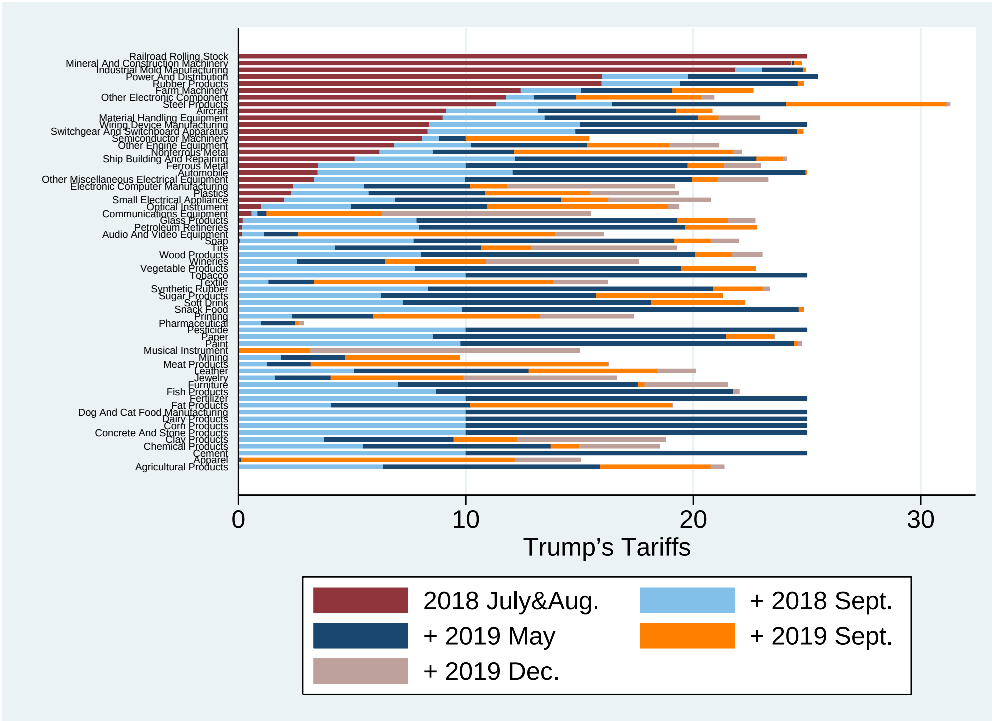
Figure 1 summarizes the sectoral distribution of the Trumpian tariffs and China's retaliation for each wave. The first wave of Trump's "Section 301" tariffs were concentrated in very few industries. These industries, as argued by the US government, are "strategically important to, and benefit from, the 'Made in China 2025' program ('MIC 2025') and other Chinese industrial policies" (USTR, 2018 June Notice).[7] This wave of Trump protectionism includes an additional 25 percent tariff on 818 HS-8 products, effective on July 6, 2018; and an additional 25 percent tariff on 284 HS-8 products, effective on Aug 23, 2018.

Did the first wave of the Trumpian tariffs target on industries that China has comparative advantage in? If so, then the Trumpian tariffs may indeed aim at reducing the U.S. trade deficit from China, as claimed by President Trump. We examine this possibility by looking at the sectoral distribution of the U.S. imports from China before trade conflicts. Panel (a) of Figure 2 shows clearly that the Trump's tariffs did not initially target on the Chinese top exporting categories to the U.S. before trade wars such as electronic computers, communication equipment, toys, and textile and apparel. In other words, the Trump administration initially imposed protectionism tariffs on industries that China did not have revealed comparative advantage.

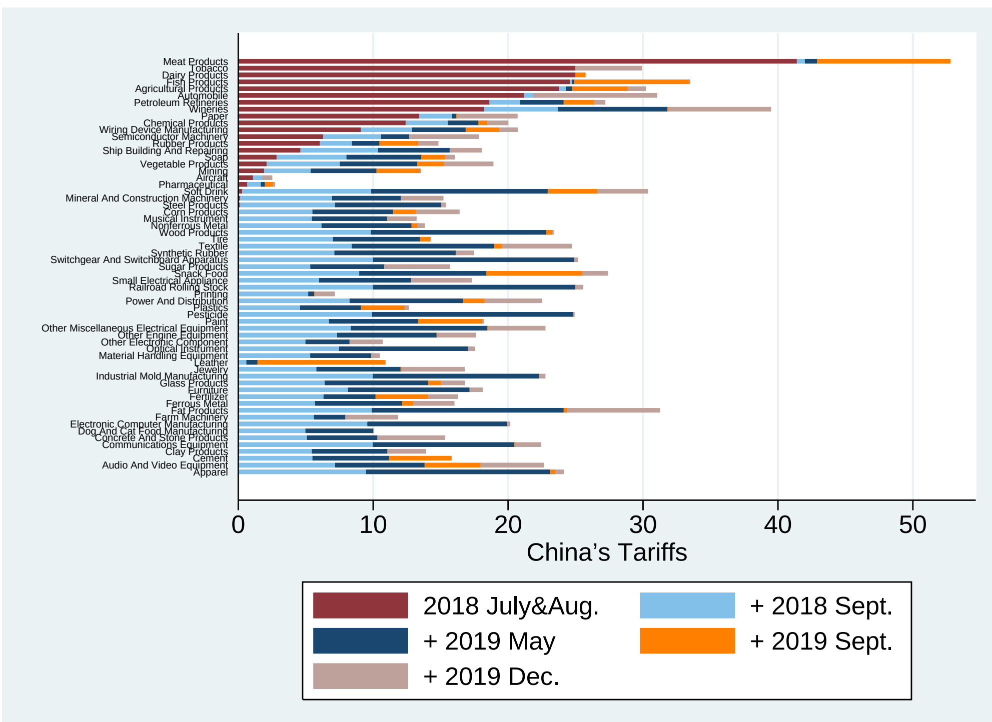
Did the first wave of the Trumpian tariffs actually target on high-tech industries supported by "MIC 2025", as also claimed by the Trump administration? "MIC 2025" has em-

[6]An update on December 13, 2019: According to the Phase I deal principally agreed upon by both countries' negotiators, the *Wave 5* tariffs was cancelled and the *Wave 4* tariffs were cut in half — it is now 7.5 percent. Our study does not reflect this change yet.

[7]See the Section 301 Fact Sheet at `https://ustr.gov/about-us/policy-offices/press-office/fact-sheets/2018/june/section-301-investigation-fact-sheet`.



(a) U.S. Tariff



(b) Chinese Tariff

Figure 1: The Trumpian Tariffs and China's Retaliation

Figure 2: The First Wave of Trumpian Tariffs and US Imports from China before Trade Wars

(Note: the US Imports from China is from UN-Comtrade 2016.)

phasized ten industries as the key to the growth of Chinese manufacturing: next-generation information technology, CNC machine tools and robotics, aviation and aerospace, high-tech shipping, advanced railway equipment, new energy vehicles, power equipment, new materials, biological technology, and agricultural machinery. We match them to the manufacturing sectors in our data.[8] Figure 3 suggests that the Trump's protectionism tariffs were indeed initially concentrated on those "MIC 2025" industries. The sectoral distribution of the initial Trumpian tariffs is consistent with the U.S. criticism on China using distortive industrial policies to seize economic dominance of certain advanced technology sectors.

Figure 1 also shows that the US-China trade war was escalated at a later stage to include other product categories. After the last wave of protectionism tariffs, both countries impose the tariffs that are greater than 20 percent on most of the manufacturing sectors.

Although the Trumpian tariffs were initially concentrated in few high-tech industries emphasized by "MIC 2025", the impacts of tariff wars can be transmitted via input-output linkages. Figure 4 shows that these high-tech products are used as inputs for many downstream sectors, including service sectors.

In a nutshell, the facts presented in this section suggest that the Trump's protectionism tariffs initially did not aim at correcting US-China trade imbalances, as claimed by President Trump, but instead, targeting on the Chinese high-tech industries emphasized by "MIC 2025". Moreover, these high-tech products are used by many industries as inputs. How would the features of high-tech industries shape the impacts of tariff wars? Will the Trump's

[8]Table B.3 summarizes the coverage of "MIC 2025" industries in our data.

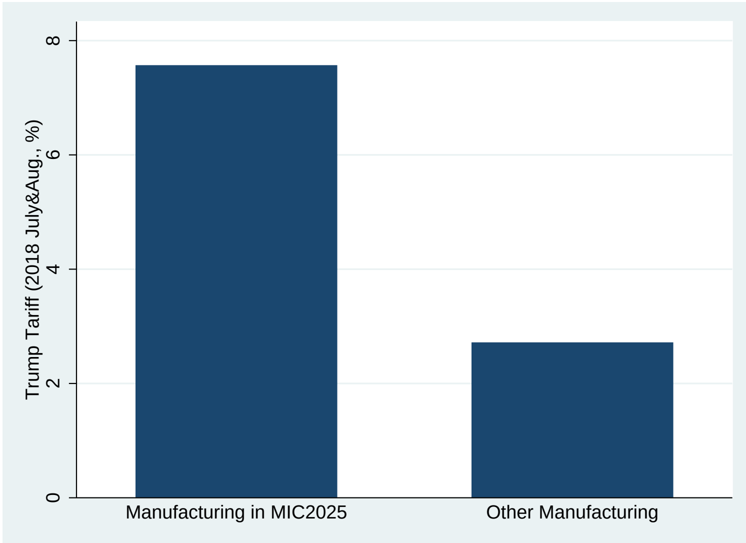
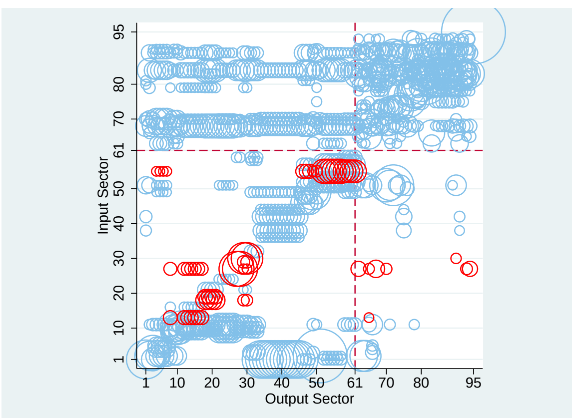
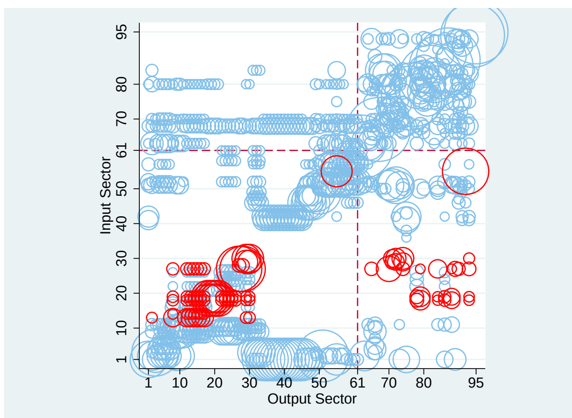


Figure 3: The First Wave of Trumpian Tariffs and "MIC 2025" Industries



(a) U.S.



(b) China

Figure 4: IO Linkages in the U.S. and China
(Note: Sector 1-61 are goods sectors and the rest are service sectors. The bubble size represents the share of input. We drop the observations with less than 3% input share. The red bubble refers to the "MIC 2025" industries as inputs.)

protectionism tariffs on high-tech industries prevent China from implementing "MIC 2025"? In the next section, we will develop a quantitative framework to understand the implications of high-tech industries for trade and industrial policies.

3 Model

In this section, we propose a multi-country general equilibrium model that incorporates salient features of high-tech industries. We argue that these industries have strong economies of scale and low substitutability as inputs for other sectors. Semiconductor is a typical example: (i) the production cost of semiconductors decreases dramatically as the production scale increases, and (ii) semiconductors can hardly be replaced by any other intermediates in producing electronic equipments. To capture these two features, we introduce sectoral external economies of scale and general CES input-output linkages into a quantitative model à la Caliendo and Parro (2015).

Consider a world with N countries, indexed by i and n, with a mass L_i workers in each i. There are J sectors, indexed by j and s. Workers are immobile across countries but perfectly mobile across sectors. Each sector consists a unit mass of varieties. The representative consumer of country i has a two-tiered nested-CES preference:

$$U_i = \left[\sum_{j=1}^{J} \alpha_i^j \left[\int_0^1 \left[C_i^j(\omega) \right]^{\frac{\sigma_j - 1}{\sigma_j}} d\omega \right]^{\frac{\sigma_j}{\sigma_j - 1} \frac{\rho_C - 1}{\rho_C}} \right]^{\frac{\rho_C}{\rho_C - 1}}, \tag{1}$$

where ρ_C is the elasticity of substitution across final sectors and σ_j is the elasticity of substitution across consumption varieties in sector j. We assume that each variety is produced under perfect competition using labor and composite intermediates.

International trade is subject to three types of trade costs. First, there is an iceberg trade cost τ_{in}^j of shipping goods from i to n, with $\tau_{ii}^j = 1$. Second, there is an *ad valorem* tariff t_{in}^j imposed by importing country n on goods j from country i, with $t_{ii}^j = 0$. Third, there is an *ad valorem* tariff e_{in}^j imposed by exporting country i on goods j from country i. Notably, this export tariff is isomorphic as industrial subsidies once it is negative and uniform for all destination country n, including $n = i$.

3.1 Technology

We extend the production technology in CP (2015) in two dimensions: (i) sectoral external economies of scale, and (ii) nested-CES input-output linkages. We summarize our production technology by the following unit cost function: the unit cost of variety ω of intermediate j in country i is $c_i^j(\omega) = \frac{1}{z_i^j(\omega)} c_i^j$ where

$$c_i^j = \frac{1}{\left(L_i^j\right)^{\psi_j}} \left[\left(\beta_i^j\right)^{\rho_j^L} w_i^{1-\rho_j^L} + \left(1-\beta_i^j\right)^{\rho_j^L} \left(P_i^{Mj}\right)^{1-\rho_j^L} \right]^{\frac{1}{1-\rho_j^L}}, \quad \sum_s \gamma_i^{sj} = 1, \tag{2}$$

where

$$P_i^{Mj} := \left(\sum_{g \in G_i^j} \left[\sum_{s \in g} \left(\gamma_i^{sj}\right)^{\eta_i^{gj}} \left(P_i^s\right)^{1-\eta_i^{gj}} \right]^{\frac{1-\mu_i^j}{1-\eta_i^{gj}}} \right)^{\frac{1}{1-\mu_i^j}} \tag{3}$$

is the price index of composite intermediates for producing good j in country i, and ρ_j^L is the elasticity of substitution between labor and composite intermediates in sector j. Notably, L_i^j is the labor allocated to sector j of country i.

Production exhibits sectoral economies of scale. $\psi_j \geq 0$ characterizes the external economies of scale in sector j.

The nested-CES structure of input-output linkages in Equation (2) allows flexible substitutability across sectors in producing downstream goods. For downstream sector j in country i, its inputs are partitioned into groups $g \in G_i^j$. We denote P_i^s as the price index of good s in country i, η_i^{gj} as the elasticity of substitution within group g for producing good j in country i, and μ_i^j as the elasticity of substitution across groups for producing good j in country i. If $\eta_i^{gj} \geq \mu_i^j$ for all (i, j, g), then intermediates are more substitutable within each group than across groups.

The Hicks-neutral productivity $z_i^j(\omega)$ is drawn independently from the following Frechet distribution:

$$Pr\left[z_i^j(\omega) \leq z\right] = \exp\left\{-T_i^j z^{-\theta_j}\right\}, \quad z > 0, \quad \theta_j > \max\{\sigma_j - 1, 1\}, \tag{4}$$

where T_i^j characterizes the average productivity of sector j in country i and θ_j characterizes the dispersion of productivities in sector j.

3.2 Equilibrium

In this subsection, we characterize the aggregate economy and define the equilibrium. Based on the property of Frechet distribution and the ideal price index of CES preferences, the sectoral price index can be expressed as

$$P_n^j = \left[\sum_{i=1}^{N} T_i^j \left[c_i^j \tau_{in}^j \left(1 + t_{in}^j\right) \left(1 + e_{in}^j\right) \right]^{-\theta_j} \right]^{-\frac{1}{\theta_j}}. \tag{5}$$

Following Eaton and Kortum (2002), the expenditure share of country n on good j from country i is given by

$$\pi_{in}^{j}=\frac{X_{in}^{j}}{X_{n}^{j}}=\frac{T_{i}^{j}\left[c_{i}^{j}\tau_{in}^{j}\left(1+t_{in}^{j}\right)\left(1+e_{in}^{j}\right)\right]^{-\theta_{j}}}{\left(P_{n}^{j}\right)^{-\theta_{j}}}. \tag{6}$$

Sectoral employment satisfies:

$$w_{i}L_{i}^{j}=\frac{\left(\beta_{i}^{j}\right)^{\rho_{j}^{L}}\left(w_{i}\right)^{1-\rho_{j}^{L}}}{\left(\beta_{i}^{j}\right)^{\rho_{j}^{L}}\left(w_{i}\right)^{1-\rho_{j}^{L}}+\left(1-\beta_{i}^{j}\right)^{\rho_{j}^{L}}\left(P_{i}^{Mj}\right)^{1-\rho_{j}^{L}}}\sum_{n=1}^{N}\frac{X_{in}^{j}}{\left(1+t_{in}^{j}\right)\left(1+e_{in}^{j}\right)}. \tag{7}$$

Then wage is determined by labor market clearing:

$$\sum_{j=1}^{J}L_{i}^{j}=L_{i}. \tag{8}$$

We assume that export tariffs, if there are any, are collected before import tariffs. Therefore, the total income is given by

$$Y_{i}=w_{i}L_{i}+\sum_{j=1}^{J}\sum_{n=1}^{N}\frac{e_{in}^{j}}{1+e_{in}^{j}}X_{in}^{j}+\sum_{j=1}^{J}\sum_{k=1}^{N}\frac{t_{ki}^{j}}{\left(1+t_{ki}^{j}\right)\left(1+e_{ki}^{j}\right)}X_{ki}^{j}. \tag{9}$$

The aggregate price index for final consumption goods can be expressed as

$$P_{n}=\left[\sum_{j=1}^{J}\left(\alpha_{n}^{j}\right)^{\rho_{C}}\left(P_{n}^{j}\right)^{1-\rho_{C}}\right]^{\frac{1}{1-\rho_{C}}}. \tag{10}$$

Finally, the sectoral expenditure can be expressed by

$$X_{i}^{j}=\left(\alpha_{i}^{j}\right)^{\rho_{C}}\left(\frac{P_{i}^{j}}{P_{i}}\right)^{1-\rho_{C}}Y_{i}+\sum_{s=1}^{J}\frac{\left(1-\beta_{i}^{s}\right)^{\rho_{s}^{L}}\left(P_{i}^{Ms}\right)^{1-\rho_{s}^{L}}}{\left(\beta_{i}^{s}\right)^{\rho_{s}^{L}}\left(w_{i}^{j}\right)^{1-\rho_{s}^{L}}+\left(1-\beta_{i}^{s}\right)^{\rho_{s}^{L}}\left(P_{i}^{Ms}\right)^{1-\rho_{s}^{L}}}\frac{\left(\gamma_{i}^{js}\right)^{\eta_{i}^{gs}}\left(P_{i}^{j}\right)^{1-\eta_{i}^{gs}}}{\sum_{j'\in g}\left(\gamma_{i}^{j's}\right)^{\eta_{i}^{gs}}\left(P_{i}^{j'}\right)^{1-\eta_{i}^{gs}}}$$
$$\times\frac{\left[\sum_{j'\in g}\left(\gamma_{i}^{j's}\right)^{\eta_{i}^{gs}}\left(P_{i}^{j'}\right)^{1-\eta_{i}^{gs}}\right]^{\frac{1-\mu_{i}^{s}}{1-\eta_{i}^{gs}}}}{\left(P_{i}^{Ms}\right)^{1-\mu_{i}^{s}}}\sum_{n=1}^{N}\frac{X_{in}^{s}}{\left(1+t_{in}^{s}\right)\left(1+e_{in}^{s}\right)}. \tag{11}$$

Definition 1 (Equilibrium) *Given parameters* $\left(\theta_{j},\psi_{j},\rho^{C},\rho_{j}^{L},\alpha_{i}^{j},\beta_{i}^{j},\gamma_{i}^{js},\eta_{i}^{gj},\mu_{i}^{j};L_{i},e_{in}^{j},t_{in}^{j},T_{i}^{j},\tau_{in}^{j}\right)$, *the equilibrium consists of* $\left(w_{i},L_{i}^{j},P_{i}^{j},X_{i}^{j}\right)$ *such that*

1. *Price indices (P_n^j) are given by Equation (5).*

2. *Sectoral labor allocation satisfies Equation (7).*

3. *Wage is pinned down by Equation (8).*

4. *Sectoral good market clearing holds as in Equation (11).*

3.3 Equilibrium in Relative Changes

Definition 1 establishes a system of $3NJ + N$ nonlinear equations in the $3NJ + N$ unknowns which can be solved given a numeraire. A challenge is that this system depends on the set of parameters $\left(T_i^j, \tau_{in}^j\right)$ which are difficult to calibrate.

To address this problem, we compute the changes of equilibrium outcomes with respect to tariff changes using the "exact-hat" algebra developed by Dekle, Eaton, and Kortum (2008). We denote the value of any variable Z after change as Z' and $\hat{Z} = Z'/Z$.

We first introduce some notations that will be used for the "exact-hat" algebra. Let $\tilde{\alpha}_j := \frac{\alpha_j^{\rho_C} P_j^{1-\rho_C}}{\sum_{j'=1}^{J} \alpha_{j'}^{\rho_C} P_{j'}^{1-\rho_C}}$ be the consumption share. Let $\tilde{\beta}_s = \frac{\beta_s^{\rho_s^L}}{\beta_s^{\rho_s^L} + \left(1-\beta_s^{\rho_s^L}\right)(P_s^M)^{1-\rho_s^L}}$ be the value-added share. Let χ_i^{gj} be the input expenditure share on group g for producing good j in country i, and $\tilde{\gamma}_i^{sj}$ be the input expenditure share of sector s within group g for all $s \in g$.

Suppose that we have the values of $\left(\mu_i^j, \eta_i^{gj}, \psi_j, \rho_j^L, \rho^C, \theta_j\right)$. Also we have the data on $\left(X_{in}^j, t_{in}^j, e_{in}^j, \tilde{\alpha}_i^j, \tilde{\beta}_i^j, \chi_i^{gj}, \tilde{\gamma}_i^{sj}\right)$. Then we can compute the equilibrium changes, $\left(\hat{w}_i^j, \hat{L}_i^j, \hat{P}_i^j, \hat{X}_i^j\right)$, by solving a system of $4NJ$ nonlinear equations. The details of the equation system are presented in the Appendix A.1.

3.4 Decomposing Welfare Effects of Trade Wars

We proceed by discussing how important it is to account sectoral external economies of scale and nested-CES IO linkages to quantify welfare effects from tariff changes. In particular, we decompose welfare gains from trade into three parts: (i) gains from being able to consume foreign goods; (ii) gains from changes in intermediate inputs prices; and (iii) gains from changes in sectoral size.

For any variable y, we denote the level of y after tariff changes as y' and let $\hat{y} = y'/y$. Then we have the following results:

Proposition 2 (Decomposing Welfare Effects from Tariff Changes) *Suppose that $\rho_C =$*

$\rho_j^L = 1$. *Then changes in the real wage with respect to tariff changes are*

$$\log\left(\frac{\hat{w}_i}{\hat{P}_i}\right) = \sum_{j=1}^{J} \alpha_i^j \left[\underbrace{-\frac{1}{\theta_j}\log\left(\hat{\pi}_{ii}^j\right)}_{\textit{Final Goods}} + \underbrace{\frac{\psi_j}{\beta_i^j}\log\left(\hat{L}_i^j\right)}_{\textit{Scale Economy}} \underbrace{-\frac{1-\beta_i^j}{\beta_i^j}\left(\log\hat{\Xi}_i^j + \frac{1}{\theta_j}\log\left(\hat{\pi}_{ii}^j\right)\right)}_{\textit{Intermediates}} \right], \quad (12)$$

where the sectoral linkages are summarized by

$$\hat{\Xi}_i^j = \left(\sum_{g\in G_i^j} \chi_i^{gj} \left[\sum_{s\in g} \tilde{\gamma}_i^{sj} \left(\frac{\hat{P}_i^s}{\hat{P}_i^j}\right)^{1-\eta_i^{gj}} \right]^{\frac{1-\mu_i^j}{1-\eta_i^{gj}}} \right)^{\frac{1}{1-\mu_i^j}}. \quad (13)$$

The first term on the right-hand-side of Equation (12) is the standard sufficient statistic for the welfare gains from trade figured out by Arkolakis, Costinot, and Rodriguez-Clare (2012). It captures welfare gains from being able to access more foreign final varieties.

The second term on the right-hand-side of Equation (12) represents the welfare implications of sectoral economies of scale, which depend crucially on parameters $(\psi_j)_{j=1}^J$. For sectors with large ψ_j, small changes in the sectoral sizes could lead to large productivity and welfare effects. Notice that producers do not internalize their impacts on sector sizes. So there is room for the government of each country to manipulate its own and other countries' sectoral sizes.

The third term on the right-hand-side of Equation (12) characterizes welfare gains from being able to access more foreign intermediates, including the round-about production of each sector as well as sectoral IO linkages, $\hat{\Xi}_i^j$. Notice that $\hat{\Xi}_i^j$ depends not only on the observed expenditure shares, say δ_i^{gj} and χ_i^{sj}, but also on the elasticities of substitution across sectors, i.e. η_i^{gj} and μ_i^j. Under small μ_i^j, the price changes in group g could be magnified into large welfare changes, even if the expenditure share δ_i^{gj} is small. This captures an important feature of high-tech industries such as semi-conductors: their shares in total input expenditure may not be substantial during the period without trade wars, but can rise dramatically when protectionism tariffs are imposed.

3.5 An Illustrative Example

To investigate countries' incentives for trade and industrial policies, we consider a two-country-two-sector case, i.e. $N = J = 2$. We assume that the utility and production functions are Cobb-Douglas. Sector 1 is high-tech with $\psi_1 = \psi > 0$. Sector 2 is low-tech with $\psi_2 = 0$. We assume that the low-tech good is produced by labor and the high-tech good is produced by labor and composite high-tech goods, with value-added share β. We assume that $\tau_{12}^j = \tau_{21}^j = 1.2$ for all j. In the baseline, we set $\theta = 4$, $\psi = 0.1$, $\alpha_i^1 = 0.2$, and $\beta = 0.5$.

To resemble the recent US-China trade conflicts, we regard country 1 as a North country, with comparative advantage in the high-tech industry, i.e. $T_1^1 = 1.5$ and $T_i^j = 1$ for $(i, j) \neq (1, 1)$, and country 2 as a South country, with larger country size, i.e. $L_1 = 1$ and $L_2 = 1.5$.

We first focus on country 1's tariff on high-tech imports, t_{21}^1, and country 2's subsidies on high-tech industry, $e_{21}^1 = e_{22}^1 = e_2^1$.

Figure 5 illustrates two countries' best responses of industry subsidies and tariffs on the high-tech industry. That is, country 2's optimal industrial subsidy on the high-tech industry, with respect to country 1's tariffs on high-tech imports, t_{21}^1, and country 1's optimal tariffs on high-tech imports, with respect to country 2's industrial subsidies on the high-tech industry. It shows clearly that as country 1 raises its tariffs on high-tech imports, country 2 has incentives to increase its subsides on the high-tech industry.

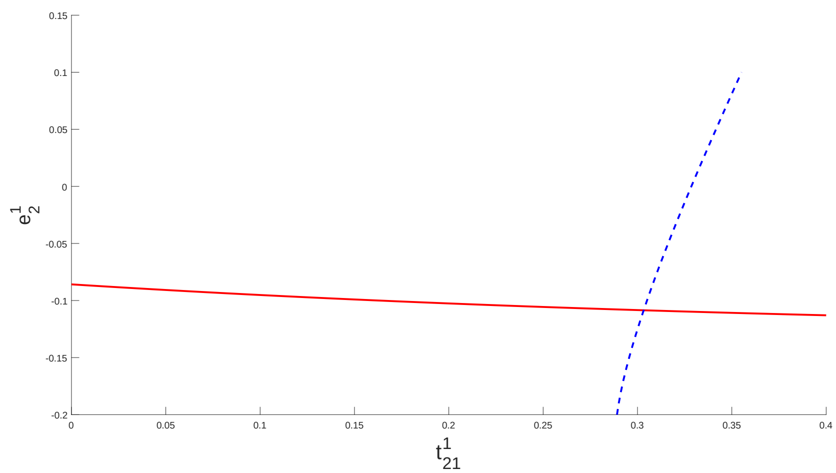


Figure 5: Best Responses of Tariffs and Subsidies on the High-Tech Industry

The Nash equilibrium consists of country 1's import tariffs and country 2's industrial subsidies on the high-tech industry. Table 1 suggests that in the Nash equilibrium, the North country imposes high tariffs on high-tech imports from the South, and the South's best response is to subsidize its high-tech production. The tariff and subsidy rates are higher if the economy of scale in the high-tech industry is stronger. Interestingly, if the high-tech products do not serve as intermediates, the South would impose higher subsidies on its high-tech industry. This is because without input-output linkages the South's subsidies on its high-tech production do not benefit the firms in the North. Finally, due to its comparative disadvantage in the high-tech industry, the South has incentives to subsidize its high-tech production even without increasing returns to scale.

We then consider other policies that are implemented or discussed in the recent US-China trade conflicts.

Table 1: Nash Equilibrium

	e_2^1	t_{21}^1
$\psi = 0.1,\ \beta = 0.5$	-0.1085	0.3033
$\psi = 0.15,\ \beta = 0.5$	-0.1433	0.4429
$\psi = 0,\ \beta = 0.5$	-0.0367	0.1994
$\psi = 0.1,\ \beta = 1$	-0.1593	0.2777
$\psi = 0,\ \beta = 1$	-0.0939	0.1817

(Notes: t_{in}^j refers to the rate of tariff levied by country n on the imports of good j from country i. e_{in}^j refers to the rate of tariff levied by country i on the exports of good j to country n. e_i^j refers to the production subsidy on industry j in country i.)

Table 2: Nash Equilibrium with Further Retaliations

	Country 1: North				Country 2: South			
	t_{21}^1	e_1^1	e_{12}^1	t_{21}^2	e_2^1	t_{12}^1	t_{12}^2	e_{21}^1
Country 2's retaliation by tariffs	0.3257	n.a.	n.a.	n.a.	-0.0861	0.2784	0.3873	n.a.
Country 1's retaliation by industry policy	0.4179	0.0899	n.a.	n.a.	-0.0995	0.1784	0.3498	n.a.
Country 1's export control	0.1476	-0.0432	0.4814	n.a.	-0.1366	-0.0531	0.2942	n.a.
Country 2's retaliation by export subsidy	0.1443	-0.0410	0.4705	n.a.	-0.1532	-0.0881	0.2877	0.0171
All retaliations	0.3095	-0.0508	0.2545	0.2298	-0.1257	0.0418	0.2693	0.0186

(Notes: t_{in}^j refers to the rate of tariff levied by country n on the imports of good j from country i. e_{in}^j refers to the rate of tariff levied by country i on the exports of good j to country n. e_i^j refers to the production subsidy on industry j in country i.)

4 Quantification

4.1 Calibration

Guided by the "exact-hat" algebra, we need data on bilateral trade shares $\left(\pi_{in}^j\right)$, sectoral consumption shares $\left(\tilde{\alpha}_i^j\right)$, sectoral value-added shares $\left(\tilde{\beta}_i^j\right)$, sectoral expenditure (X_n^j), input expenditure shares $\tilde{\delta}_i^{js}$, and the tariff rates $\left(t_{in}^j, e_{in}^j\right)$, to conduct counterfactual exercises. We need the values of parameters $\left(\mu_i^j, \eta_i^{gj}, \psi_j, \rho_C, \rho_j^L, \theta_j\right)$.

The data used in quantification is the same with the one introduced in Section 2.1. More details for data sources and data construction are presented in the appendix.

Parameter	Definition	Value	Source
ρ_C	Elasticity of Sub. across consumption industries	$\rho_C = 1$	-
ρ_j^L	Elasticity of Sub. b/w labor and intermediates	$\rho_j^L = 1$	-
θ_j	Trade elasticity	Table B.2	Bartelme et al. (2019)
ψ_j	Sectoral scale economies	Table B.2	Bartelme et al. (2019)

Table 3: Parameters Calibrated from the Literature

We set $\rho_C = \rho_j^L = 1$ for all j, which are also broadly consistent with recent empirical evidence.

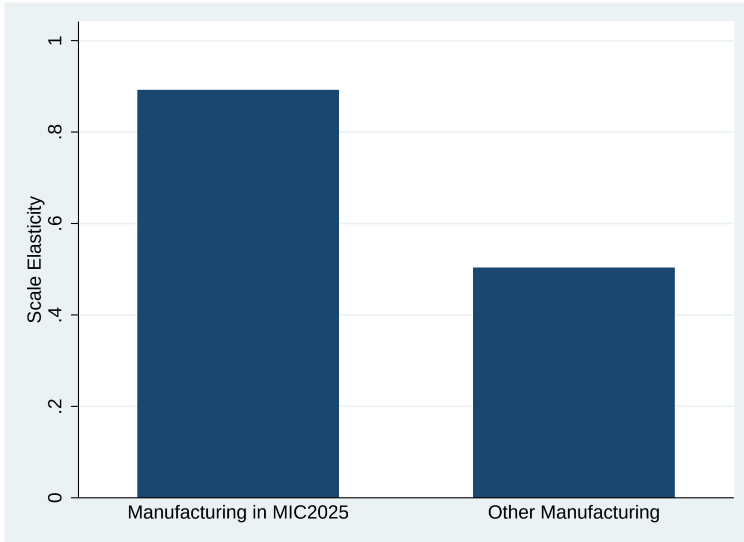


Figure 6: "MIC 2025" and Sectoral Economies of Scale: Lashkaripour and Lugovskyy (2017)

As shown in our illustrative example, sectoral economies of scale are critical in determining optimal industrial policies. However, estimating economies of scale is empirically challenging since it requires exogenous shocks on sectoral sizes that are uncorrelated with fundamental technology changes. We calibrate (ψ_j, θ_j) from two alternative sources. Our baseline calibration is based on Bartelme et al. (2019). They estimate (ψ_j, θ_j) jointly from international trade data, using constructed foreign shocks as instruments. As shown in Table B.2, their estimates suggest that the economies of scale are nearly uniform across manufacturing sectors, with the median about 0.1. Since they assume constant returns to scale in service sectors, the "MIC2025" sectors exhibit stronger economies of scale than other sectors (including services). We choose their estimates as our baseline calibration because they are conservative estimates on the economies of scale, relative to other estimates in the literature. Under this calibration, we are likely to get lower bounds on the welfare effects of industrial policies as well as optimal industrial policies.

Alternatively, we use the estimates on (ψ_j, θ_j) in Lashkaripour and Lugovskyy (2017). They have utilized the firm-partner-product-level import data in Colombia, the majority of which come from the United States, to jointly estimate (ψ_j, θ_j). As summarized in Table B.3, their estimated economies of scale are larger and more volatile across manufacturing sectors than those in Bartelme et al. (2019). As shown in Figure 6, the "MIC2025" sectors exhibit stronger economies of scale than other *manufacturing* sectors, based on the estimates in Lashkaripour and Lugovskyy (2017). Not surprisingly, China will gain more from the "MIC2025" industrial subsidies under this calibration. We regard the quantitative results under this calibration as sensitivity exercises and, to some extent, upper bounds on the welfare effects of industrial policies as well as optimal industrial policies.

4.2 Estimating (μ_j)

We proceed by specifying our nested-CES IO linkages. Although there is evidence supporting the nested-CES IO linkages, it is difficult to identify the nests and empirically estimate the elasticities of substitution within and between nests. Therefore, in our benchmark setting, we assume that the elasticity of substitution across input sectors is output-industry-specific, i.e. $\mu_i^j = \eta_i^{gj} = \mu_j$ for all (i, g, j). In this specification, changes in intermediate price indices can be expressed as:

$$\hat{P}_i^{Mj} := \left[\sum_{s=1}^{J} \tilde{\delta}_i^{sj} \left(\hat{P}_i^s \right)^{1-\mu_j} \right]^{\frac{1}{1-\mu_j}}, \tag{14}$$

where $\tilde{\delta}_i^{sj}$ is the fraction of industry j's intermediate expenditure on industry s in country i.

To estimate (μ_j), we utilize data from the U.S. BEA's GDP by Industry and Input-Output Accounts data spanning 1997-2017. The main variables that we use are changes in (i) the fraction of industry j's intermediate expenditure on industry s, $\Delta \log \delta_i^{js}$; (ii) industry s's output price index, $\Delta \log P_i^s$, and (iii) industry j's intermediate input price index, $\Delta \log P_i^{Mj}$.

Based on the definition of δ_i^{sj} and the properties of CES IO linkages, we have:

$$\Delta \log \delta_i^{sj} = (1 - \mu_j) \left(\Delta \log P_i^s - \Delta \log P_i^{Mj} \right) + \epsilon_i^{sj}, \tag{15}$$

where ϵ_i^{sj} is the measurement error.

The estimates on μ_j are listed in Table B.4. We map the industries in the BEA data to the industries in our data and show the mapping in Table B.3. Our estimates suggest that for most output sectors, the elasticity of substitution across inputs sectors are below 1. This result is consistent with Atalay (2017).

We then examine whether the "MIC 2025" industries have low elasticities of substitution as inputs. We average μ_j for each input sector, weighted by the IO shares before trade wars. Figure 7 shows that the "MIC 2025" industries indeed have lower elasticities of substitution as inputs than other manufacturing industries.

4.3 Trump Tariffs and China's Industrial Policies

Armed with our calibrated model, we examine the welfare consequences of the initial Trumpian tariffs as well as China's potential industrial subsidies proposed in the "MIC 2025". For the "MIC 2025", we assume a 5 percent production subsidy for each of the related high-tech industry. This subsidy is financed by lump-sum taxes from Chinese households.

Table 4 shows the welfare consequences of the first wave of Trumpian tariffs and the

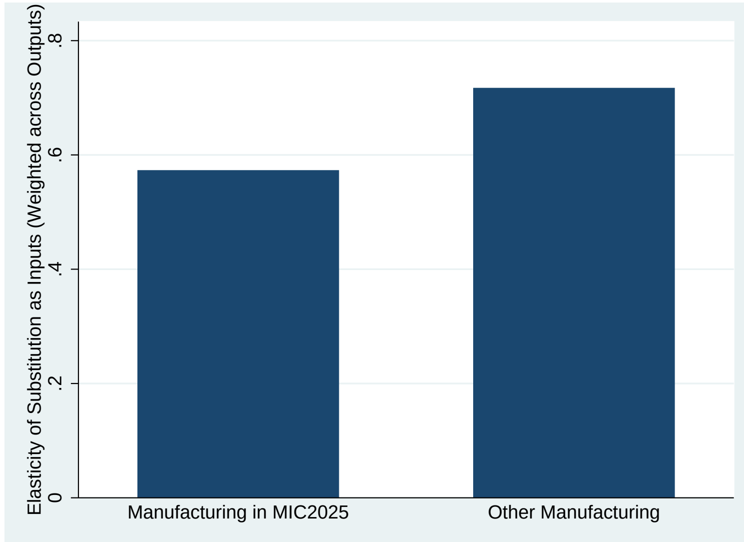


Figure 7: "MIC 2025" and Elasticity of Substitution as Inputs
(Note: the elasticity of substitution as input is the average elasticity of substitution across output sectors, weighted by the share of inputs.)

"MIC 2025". We also derive the welfare consequences when these two policies are both implemented. Based on these results, we compute the welfare effects of the "MIC 2025" in the presence of Trump's first wave tariffs, and inversely, the welfare effects of Trump's first wave tariffs in the presence of the "MIC 2025". We also decompose the welfare effects based on Proposition 2.

We first discuss the welfare effects of the Trumpian tariffs on the high-tech imports from China. Table 4 shows that the Trumpian tariffs hurt China and benefit the U.S. The Chinese real income decreases by 0.008%, mainly due to the decline in production scale of goods sectors. The shrinkage of high-tech industries results in considerable productivity and welfare losses in China.

The U.S. loses from the Trumpian tariffs in terms of the real wage but gains in terms of real income. Its loss is mainly due to the increase in intermediate prices for both goods and service sectors. China has provided a large amount of inputs to the U.S. goods and services sectors, including those high-tech "MIC 2025" industries. The Trumpian tariffs directly increase the prices of high-tech inputs imported from China, and also indirectly increase the prices by shrinking the production scale of these industries in China. These direct and indirect effects on intermediate prices tend to substantially hurt the U.S. economy.

The sectoral contributions to welfare consequences of the Trumpian tariffs are summarized in the Appendix section B.3. The results confirm that China mainly loses from the Trumpian tariffs due to the decline in production scale of high-tech industries, whereas the U.S. mainly loses from the increase in the prices of high-tech intermediates.

We proceed by discussing the welfare effects of the "MIC 2025" industrial subsidies on the

Table 4: Trump Tariffs (Wave 1: July/Aug. 2018) and "MIC 2025"

	China							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
Trump Wave 1	-0.008	-0.007	-0.001	0.000	-0.005	0.000	0.001	-0.003
MIC2025	0.134	1.527	0.502	0.004	0.482	0.000	0.114	0.424
Both	0.126	1.520	0.501	0.004	0.478	0.000	0.115	0.421
MIC under Trump Wave 1	0.135	1.527	0.502	0.004	0.482	0.000	0.114	0.424
Trump Wave 1 under MIC	-0.008	-0.007	-0.001	0.000	-0.004	0.000	0.001	-0.003
	U.S.							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
Trump Wave 1	0.023	-0.039	-0.024	0.003	0.014	0.000	-0.018	-0.013
MIC2025	0.007	0.008	0.160	-0.003	-0.841	0.000	0.680	0.012
Both	0.031	-0.043	0.113	0.000	-0.728	0.000	0.577	-0.006
MIC under Trump Wave 1	0.008	-0.004	0.137	-0.003	-0.741	0.000	0.596	0.008
Trump Wave 1 under MIC	0.025	-0.051	-0.047	0.003	0.115	0.000	-0.102	-0.017

Chinese high-tech industries. Table 4 shows that China gains substantially from the "MIC 2025". This is mainly due to the economies of scale in high-tech industries. By subsidizing high-tech industries, the "MIC 2025" shifts production factor from industries with low scale economies into industries with high scale economies.

Surprisingly, the "MIC 2025" actually increases the U.S. real income by 0.007%. The U.S. high-tech industries suffer from the decline in production scale due to the competition from China, but they also gains from having access to cheaper intermediate inputs. The overall effect is positive.

We also examine the interaction between trade and industrial policies. We find that the Trumpian tariffs, China gains more from subsidizing the "MIC 2025" industries. In other words, the Trumpian tariffs actually incentivize China's industrial subsidies. As discussed above, the benefits of industrial subsidies come from shifting labor from industries with low scale economies into industries with high scale economies. Since the Trumpian tariffs (Wave 1) intentionally target on China's high-tech industries that have strong economies of scale, these sectors in China become far below their optimal scales. This deviation from optimal scales increases China's incentives to subsidizes those "MIC 2025" industries.

We turn to solve the Nash equilibrium in which China retaliates the Trump tariffs optimally by subsidizing its high-tech production, whereas the U.S. retaliate the Chinese high-tech subsidies optimally by import tariffs and export control. Due to the high dimensionality, we impose the U.S. to levy tariffs on Chinese imports that are proportional to the Trump

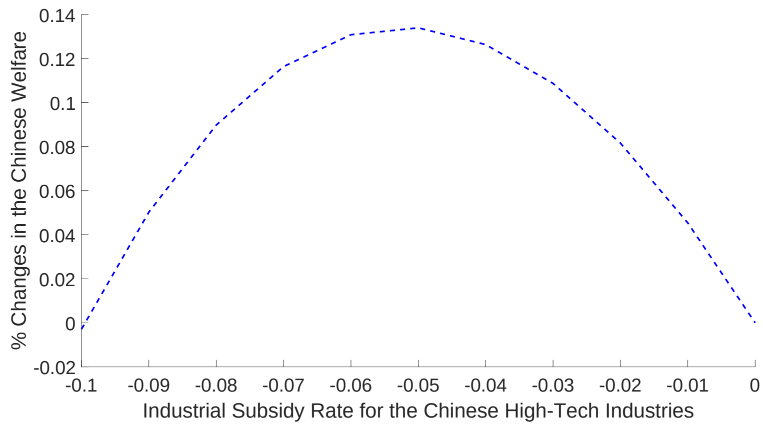


Figure 8: Welfare Effects of China's Uniform Subsidies on High-tech Industries

Table 5: Trump Tariffs (Wave 1: July/Aug. 2018) and "MIC 2025": Alternative Calibration of Economies of Scale

	China							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
Trump Wave 1	-0.0116	-0.0113	-0.0009	-0.0001	-0.0089	-0.0001	0.0032	-0.0046
MIC 2025	0.8396	2.1042	0.4060	0.0009	1.7361	-0.0022	-0.6475	0.6109
Both	0.8282	2.0931	0.4052	0.0008	1.7272	-0.0023	-0.6442	0.6065
MIC under Trump Wave 1	0.8399	2.1046	0.4060	0.0009	1.7362	-0.0022	-0.6474	0.6111
Trump Wave 1 under MIC	-0.0113	-0.0109	-0.0008	-0.0001	-0.0088	-0.0001	0.0033	-0.0044
	U.S.							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
Trump Wave 1	0.0161	-0.0459	-0.0104	0.0014	-0.0337	-0.0002	0.0163	-0.0192
MIC2025	0.0057	0.0060	0.0481	-0.0006	-0.2461	0.0001	0.1996	0.0049
Both	0.0228	-0.0415	0.0370	0.0008	-0.2796	0.0000	0.2153	-0.0149
MIC under Trump Wave 1	0.0068	0.0045	0.0475	-0.0005	-0.2460	0.0001	0.1990	0.0043
Trump Wave 1 under MIC	0.0171	-0.0475	-0.0111	0.0014	-0.0336	-0.0002	0.0157	-0.0198

Table 6: Trump Tariffs (Wave 1: July/Aug. 2018) and "MIC 2025": Other Economies

	Trump Wave 1							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
BRA	0.0005	-0.0001	0.0000	0.0000	0.0013	0.0000	-0.0013	0.0000
EU	-0.0022	-0.0027	0.0064	-0.0012	-0.0137	0.0000	0.0070	-0.0013
JPN	-0.0003	-0.0004	0.0006	0.0000	-0.0007	0.0000	0.0003	-0.0007
IND	0.0004	0.0000	0.0004	0.0000	-0.0005	0.0000	0.0002	-0.0001
ROW	0.0377	0.0258	-0.0093	0.0056	0.0678	0.0000	-0.0481	0.0098
	MIC 2025							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
BRA	0.0198	0.0050	0.0106	0.0001	-0.0688	0.0000	0.0614	0.0018
EU	-0.0285	-0.0262	0.1465	-0.0029	-0.9263	0.0000	0.7636	-0.0070
JPN	-0.0236	-0.0137	0.0228	-0.0014	-0.2331	0.0000	0.1958	0.0023
IND	0.0152	-0.0051	0.0230	-0.0012	-0.1641	0.0000	0.1398	-0.0025
ROW	-0.1521	-0.0092	0.2571	-0.0435	-1.1742	0.0000	0.9444	0.0070

tariffs (Wave 1: July/Aug. 2018). That is:

$$\left(\text{tariff}^{j}_{CN,US}\right)' = \text{tariff}^{j}_{CN,US} + t \times \text{Trump Tariff Wave } 1^{j}_{CN,US}. \tag{16}$$

We also assume that the U.S. imposes a uniform tariff, $e_{\text{USA,CHN}}$, on its high-tech export to China. Moreover, the "MIC 2025", as previously discussed, is assumed to be a subsidy e_{CHN} on the Chinese high-tech production, financed by lump-sum taxes on Chinese households.

The Nash equilibrium in the case is $\left(e^{*}_{\text{CHN}} = -0.053; t^{*} = 1.03, e^{*}_{\text{USA,CHN}} = 0.0525\right)$. Interestingly, regarding the "MIC 2025" as a roughly 5 percent subsidy in the Chinese high-tech production, it is nearly optimal for the Trump administration to impose its actual punitive tariffs on the Chinese imports on July 2018, associated with a 5 percent tariff on its high-tech exports to China. In the meantime, given the Trump tariffs and export control, it is optimal for China to subsidize its high-tech production by 5.3%.

Table 7: Welfare Effects of the N.E. $\left(e^{*}_{\text{CHN}} = -0.053; t^{*} = 1.03, e^{*}_{\text{USA,CHN}} = 0.0525\right)$

%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
BRA	0.0219	0.0051	0.0116	0.0000	-0.0739	0.0000	0.0655	0.0019
CHN	0.1316	1.6129	0.5357	0.0044	0.4949	0.0000	0.1307	0.4471
EUR	-0.0361	-0.0345	0.1681	-0.0054	-1.0200	0.0000	0.8335	-0.0107
IND	0.0182	-0.0047	0.0264	-0.0014	-0.1814	0.0000	0.1543	-0.0026
JPN	-0.0243	-0.0138	0.0278	-0.0016	-0.2608	0.0000	0.2185	0.0023
ROW	-0.1274	0.0101	0.2759	-0.0425	-1.2176	0.0000	0.9779	0.0164
USA	0.0479	0.0307	0.0934	0.0027	-0.5349	0.0000	0.4538	0.0157

4.4 The Upgrade of the US-China Trade Conflicts: Decoupling?

As summarized previously, the Trump administration continuously raises tariffs on the imports from China, pushing the tariff rates for nearly all manufacturing imports from China to about 25 percentage point. China retaliates by raising tariffs on its imports from the U.S. What are the welfare consequences of these further retaliations? Could there be the decoupling of the US-China trade relationship? If so, what are its implications for the U.S., China, and other economies?

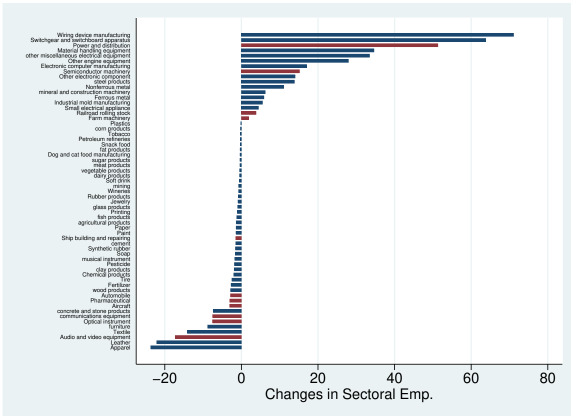
Table 8: Further Retaliations and the US-China Trade Decoupling

	Trump Tariffs Wave 5 and China's Retaliation							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
BRA	0.0034	0.0002	0.0016	-0.0001	-0.0033	0.0000	0.0020	0.0001
CHN	-0.0415	-0.0372	-0.0070	-0.0007	-0.0069	0.0000	-0.0061	-0.0165
EUR	0.0245	0.0225	0.0262	0.0006	-0.0670	0.0000	0.0533	0.0093
IND	0.0009	-0.0008	0.0025	0.0003	-0.0151	0.0000	0.0120	-0.0006
JPN	-0.0010	-0.0020	0.0030	0.0001	-0.0087	0.0000	0.0064	-0.0028
ROW	0.2730	0.1828	-0.0892	0.0421	0.5860	0.0000	-0.4154	0.0593
USA	-0.2802	-0.4544	-0.0793	-0.0024	-0.4193	0.0000	0.2167	-0.1701
	US-China Trade Decoupling							
%Δ in:	Welfare	Real Wage	Final Goods		Scale		Intermediates	
			Goods	Services	Goods	Services	Goods	Services
BRA	0.0048	0.0007	0.0018	-0.0001	-0.0030	0.0000	0.0019	0.0002
CHN	-0.0789	-0.0547	-0.0130	-0.0008	-0.0016	0.0000	-0.0149	-0.0243
EUR	0.0521	0.0500	0.0321	0.0031	-0.0547	0.0000	0.0485	0.0210
IND	0.0015	-0.0006	0.0038	0.0004	-0.0184	0.0000	0.0143	-0.0007
JPN	-0.0010	-0.0024	0.0040	0.0002	-0.0141	0.0000	0.0108	-0.0032
ROW	0.4024	0.2619	-0.1100	0.0617	0.7756	0.0000	-0.5524	0.0869
USA	-0.8071	-0.7475	-0.1270	-0.0068	-0.6668	0.0000	0.3348	-0.2817

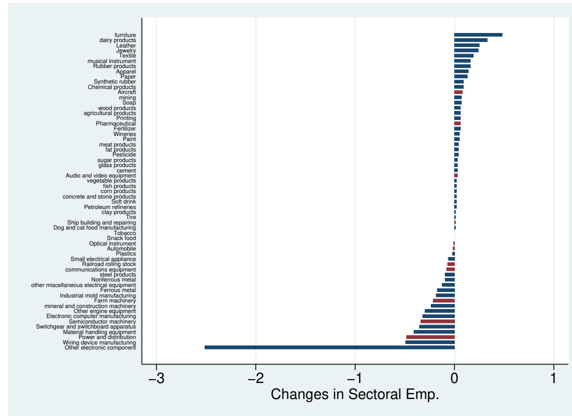
5 Conclusion

In this paper, we document that the Trumpian tariffs against China were initially concentrated in a few high-tech manufacturing industries supported by China's industrial policies, notably the "MIC 2025" project. We show that these industries exhibit strong external scale economy and have low substitutability as inputs for other sectors.

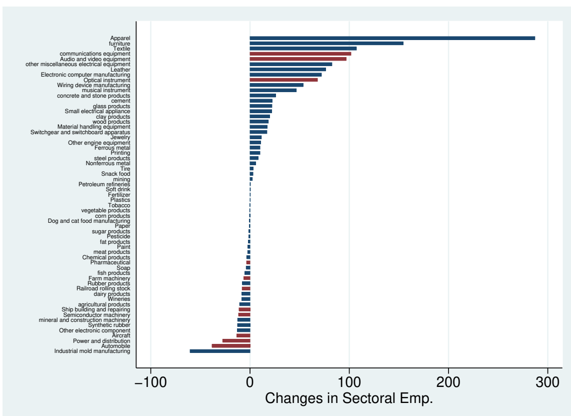
To quantify the impact of trade (i.e., the Trumpian tariffs) and industry policies (i.e., the "MIC 2025") and their interaction, we incorporate sectoral external scale economy and nested-CES input-output linkages into the Caliendo and Parro (2015) model, and calibrate it to 7 major economies and 95 disaggregated industries.



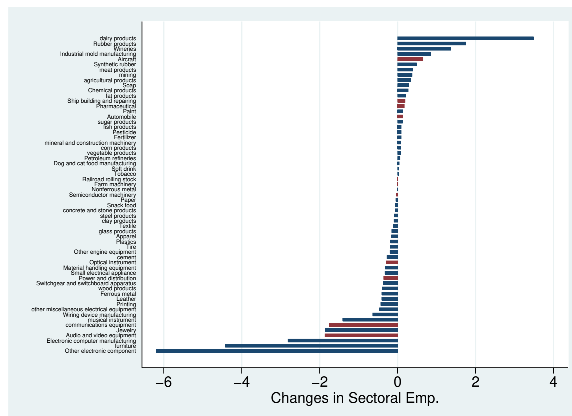
(a) Trump Tariff Wave 1: U.S.



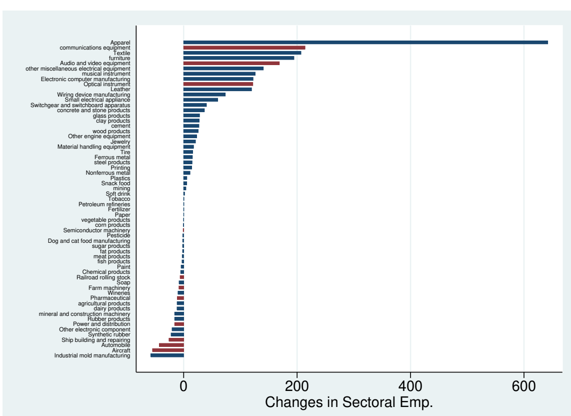
(b) Trump Tariff Wave 1: China



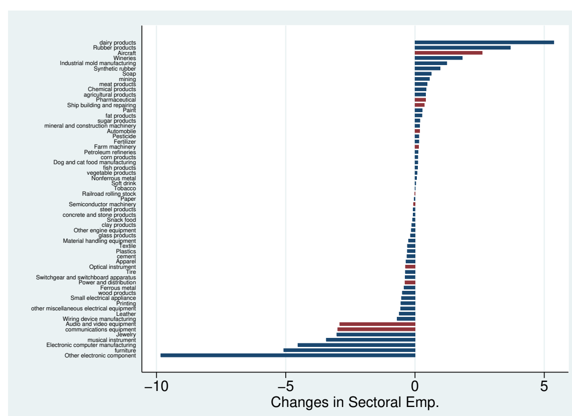
(c) Trade War Wave 5: U.S.



(d) Trade War Wave 5: China



(e) Decoupling: U.S.



(f) Decoupling: China

Figure 9: Changes in Sectoral Employment under Trade Conflicts (%Δ)
(Note: Wave 1 refers to the Trump tariffs on July/August 2018. Wave 5 refers to the Trump tariffs on December 2019 and the Chinese retaliations. Decoupling refers to infinite trade costs between the U.S. and China. Red bars refer to the high-tech industries in the "MIC 2025", whereas blue bars refer to other manufacturing industries.)

Our results show that China's subsidy to high-tech industries actually increases the US welfare due to lower input costs, whereas increases China's own welfare only if the scale effects are large. The "Section 301" tariffs imposed by the Trump administration, however, more than undo the impact of China's industrial policies on intermediate input costs, resulting in welfare loss to the US. Interestingly, when there is a punitive tariff schedule against China's high-tech industries, the "MIC 2025" actually yields larger welfare gains for China because it "corrects" the distortions caused by tariffs. Thus, a better understanding of the current China-US trade conflict should consider the role of industrial policies.

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Appendix A Theory and Numerical Examples

A.1 Equilibrium in Relative Changes

Changes in unit costs can be expressed as

$$\hat{c}_i^j = \frac{1}{\left(\hat{L}_i^j\right)^{\psi_j}} \left[\tilde{\beta}_i^j \left(\hat{w}_i\right)^{1-\rho_j^L} + \left(1-\tilde{\beta}_i^j\right)\left(\hat{P}_i^{Mj}\right)^{1-\rho_j^L}\right]^{\frac{1}{1-\rho_j^L}}, \tag{A.1}$$

where

$$\hat{P}_i^{Mj} := \left(\sum_{g \in G_i^j} \chi_i^{gj} \left[\sum_{s \in g} \tilde{\gamma}_i^{sj} \left(\hat{P}_i^s\right)^{1-\eta_i^{gj}}\right]^{\frac{1-\mu_i^j}{1-\eta_i^{gj}}}\right)^{\frac{1}{1-\mu_i^j}}. \tag{A.2}$$

Changes in trade share:

$$\hat{\pi}_{in}^j = \frac{\left[\hat{c}_i^j \widehat{1+t_{in}^j}\,\widehat{1+e_{in}^j}\right]^{-\theta_j}}{\left(\hat{P}_n^j\right)^{-\theta_j}}. \tag{A.3}$$

Changes in price indices:

$$\hat{P}_n^j = \left[\sum_{i=1}^N \pi_{in}^j \left[\hat{c}_i^j \widehat{1+t_{in}^j}\,\widehat{1+e_{in}^j}\right]^{-\theta_j}\right]^{\frac{1}{-\theta_j}}. \tag{A.4}$$

Changes in sectoral wage incomes:

$$\hat{w}_i \hat{L}_i^j w_i L_i^j = \frac{\tilde{\beta}_i^j \left(\hat{w}_i\right)^{1-\rho_j^L}}{\tilde{\beta}_i^j \left(\hat{w}_i\right)^{1-\rho_j^L} + \left(1-\tilde{\beta}_i^j\right)\left(\hat{P}_i^{Mj}\right)^{1-\rho_j^L}} \sum_{n=1}^N \frac{\hat{\pi}_{in}^j \hat{X}_n^j X_{in}^j}{\left(1+\left(t_{in}^j\right)'\right)\left(1+\left(e_{in}^j\right)'\right)}. \tag{A.5}$$

Changes in sectoral labor allocation satisfy:

$$\sum_{j=1}^J \hat{L}_i^j L_i^j = L_i. \tag{A.6}$$

Changes in the total income:

$$\hat{Y}_i Y_i = \hat{w}_i w_i L_i + \sum_{j=1}^J \sum_{n=1}^N \frac{\left(e_{in}^j\right)'}{1+\left(e_{in}^j\right)'}\left(X_{in}^j\right)' + \sum_{j=1}^J \sum_{k=1}^N \frac{\left(t_{ki}^j\right)'}{\left(1+\left(t_{ki}^j\right)'\right)\left(1+\left(e_{ki}^j\right)'\right)}\left(X_{ki}^j\right)'. \tag{A.7}$$

Changes in sectoral expenditure:

$$\hat{X}_i^j X_i^j = \frac{\tilde{\alpha}_i^j \left(\hat{P}_i^j\right)^{1-\rho_C}}{\sum_{s=1}^J \tilde{\alpha}_i^s \left(\hat{P}_i^s\right)^{1-\rho_C}} \hat{Y}_i Y_i + \sum_{s=1}^J \frac{\tilde{\gamma}_i^{js} \left(\hat{P}_i^j\right)^{1-\eta_i^{gs}}}{\sum_{j' \in g} \tilde{\gamma}_i^{j's} \left(\hat{P}_i^{j'}\right)^{1-\eta_i^{gs}}} \frac{\chi_i^{gs} \left[\sum_{j' \in g} \tilde{\gamma}_i^{j's} \left(\hat{P}_i^{j'}\right)^{1-\eta_i^{gs}}\right]^{\frac{1-\mu_i^s}{1-\eta_i^{gs}}}}{\sum_{g' \in G_i^s} \chi_i^{g's} \left[\sum_{j' \in g'} \tilde{\gamma}_i^{j's} \left(\hat{P}_i^{j'}\right)^{1-\eta_i^{g's}}\right]^{\frac{1-\mu_i^s}{1-\eta_i^{g's}}}}$$

$$\times \frac{\left(1 - \tilde{\beta}_i^s\right) \left(\hat{P}_i^{Ms}\right)^{1-\rho_s^L}}{\tilde{\beta}_i^s \left(\hat{w}_i^j\right)^{1-\rho_s^L} + \left(1 - \tilde{\beta}_i^s\right) \left(\hat{P}_i^{Ms}\right)^{1-\rho_s^L}} \sum_{n=1}^N \frac{(X_{in}^s)'}{\left(1 + (t_{in}^s)'\right)\left(1 + (e_{in}^s)'\right)}. \tag{A.8}$$

Changes in aggregate price indices:

$$\hat{P}_n = \left[\sum_{j=1}^J \tilde{\alpha}_n^j \left(\hat{P}_n^j\right)^{1-\rho_C}\right]^{\frac{1}{1-\rho_C}}. \tag{A.9}$$

A.2 Proof to Proposition 2

Inserting the unit cost in Equation (2) into trade shares in Equation (6) and concerning $\rho_C = \rho_j^L = 1$, we have the desired decomposition.

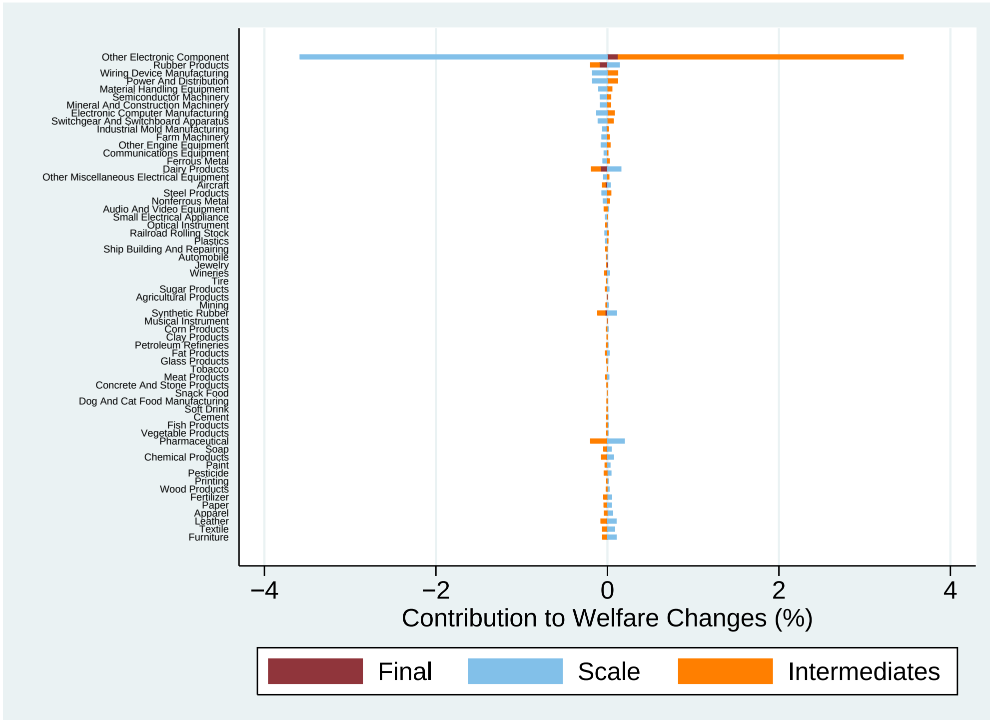
A.3 Nash Equilibrium with Further Retaliations in the Numerical Example

Appendix B Data and Quantification

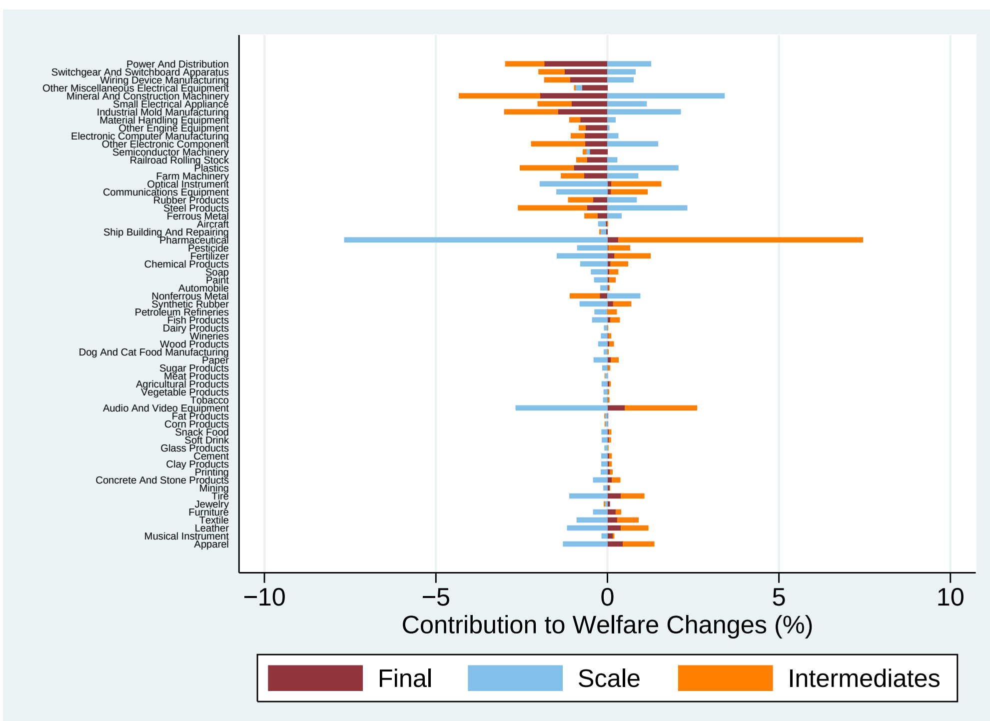
B.1 Trade Elasticities and Scale Economies

B.2 Estimates on (μ_j)

B.3 Sectoral Effects of Trade and Industrial Policies

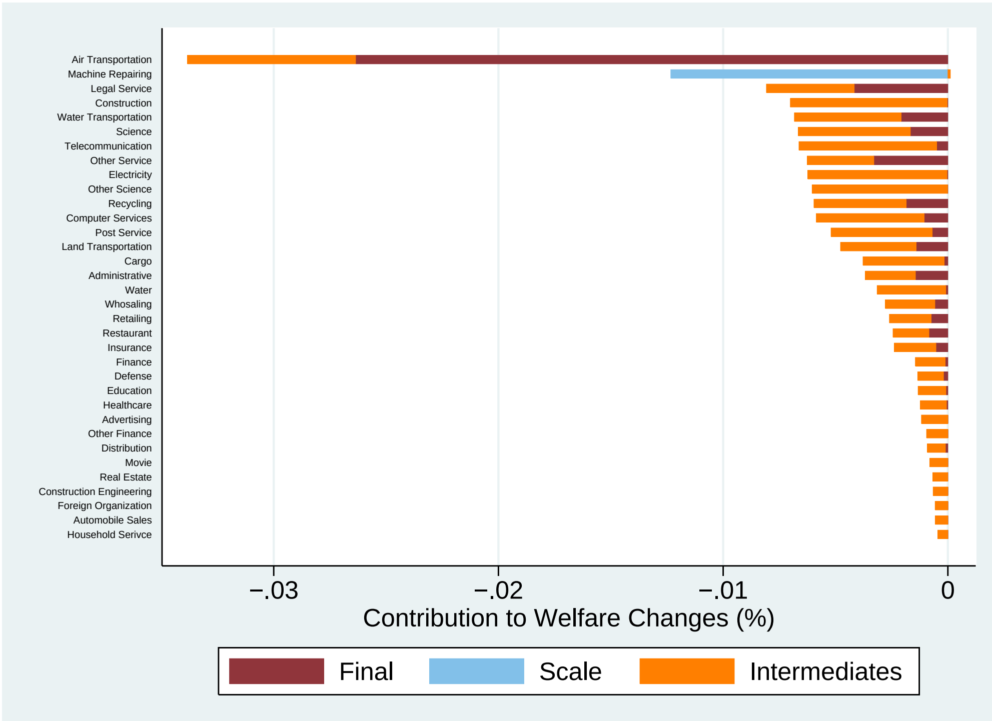


(a) China

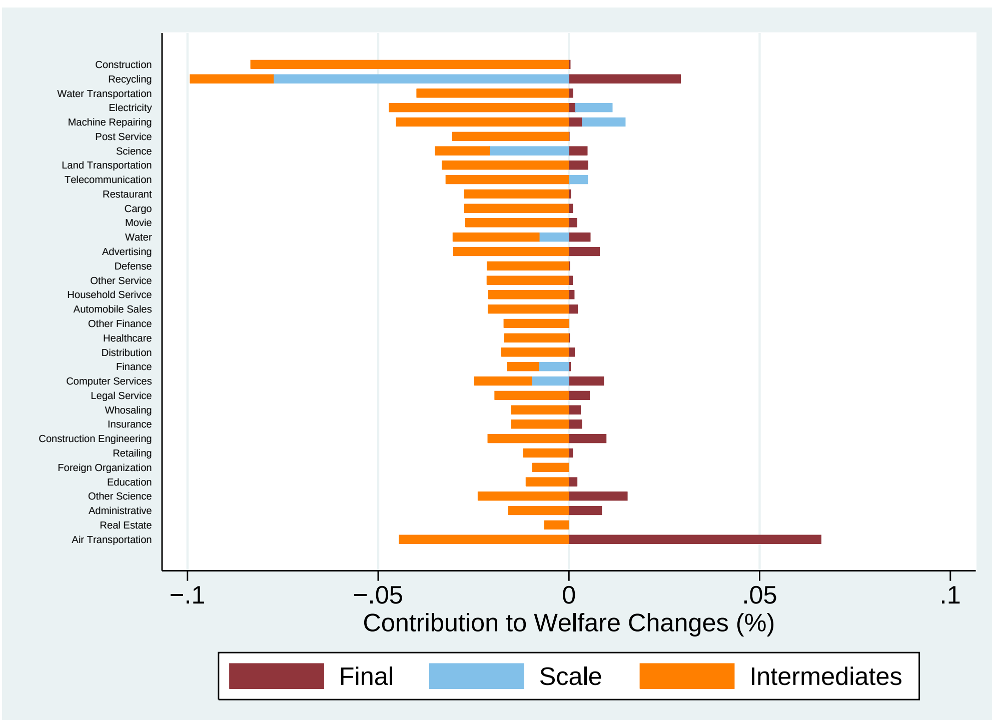


(b) U.S.

Figure B.1: The Impacts of Trump Tariffs (Wave 1: : July/Aug. 2018) on Goods Sectors

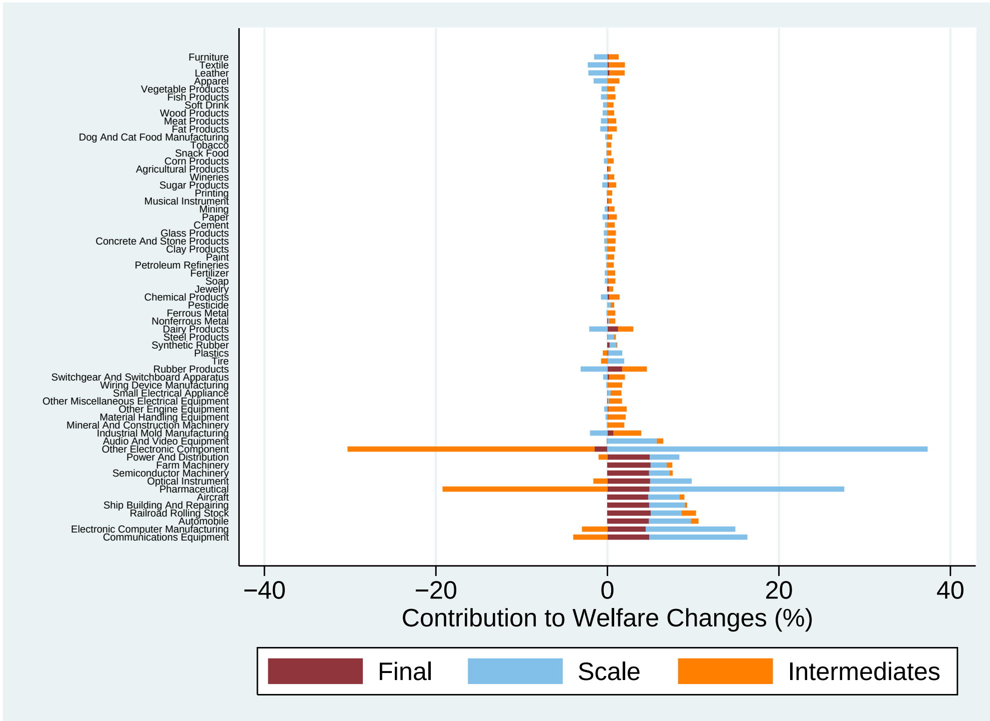


(a) China

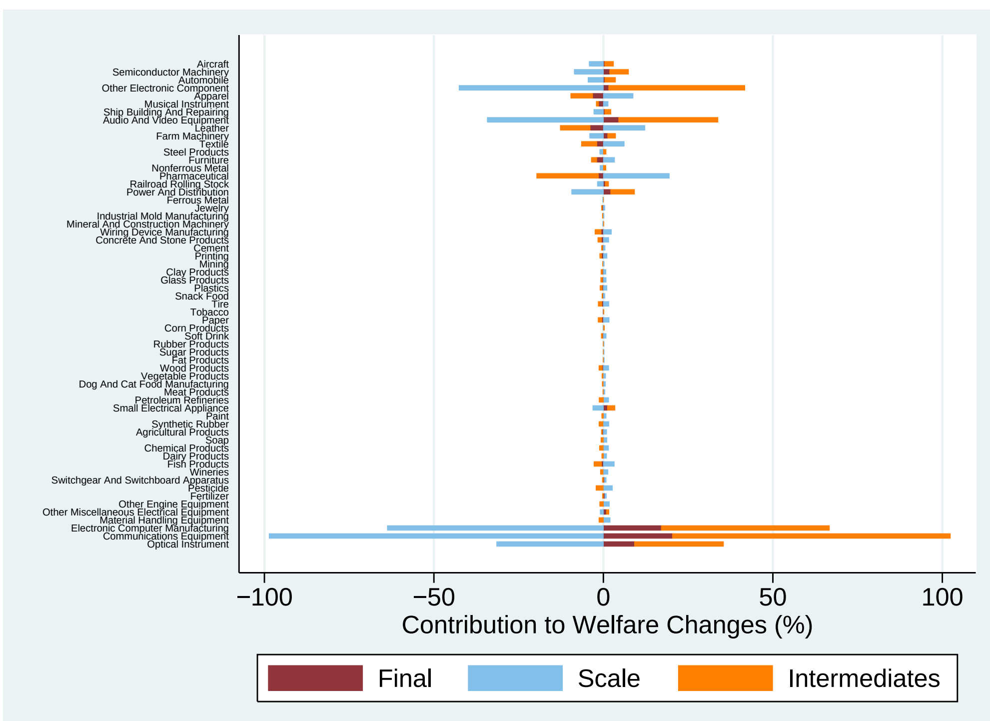


(b) U.S.

Figure B.2: The Impacts of Trump Tariffs (Wave 1) on Service Sectors

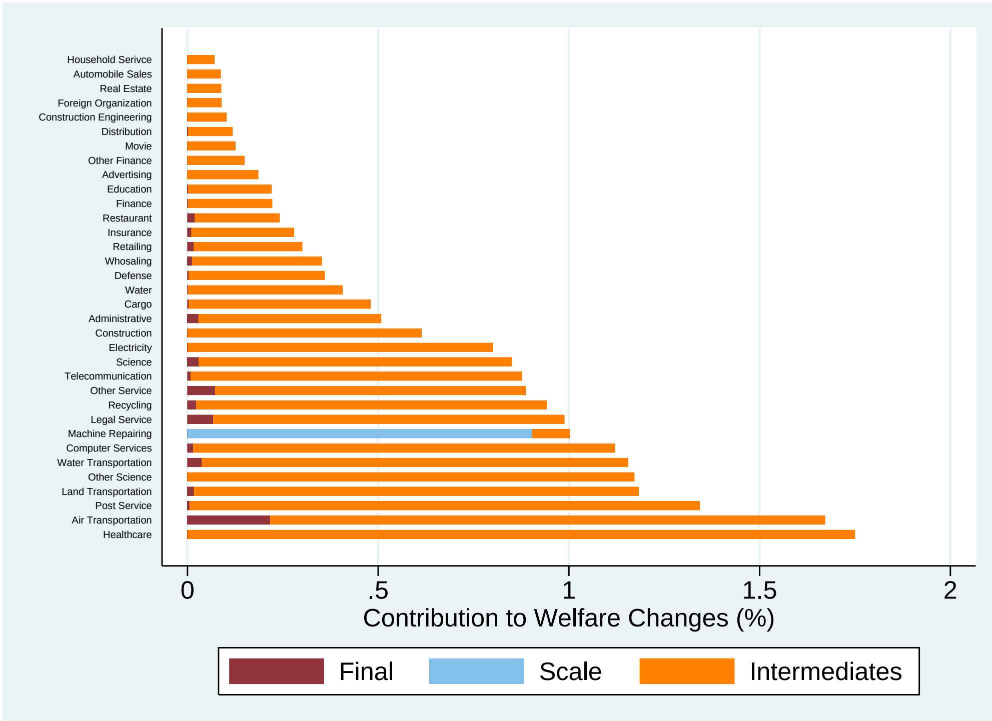


(a) China

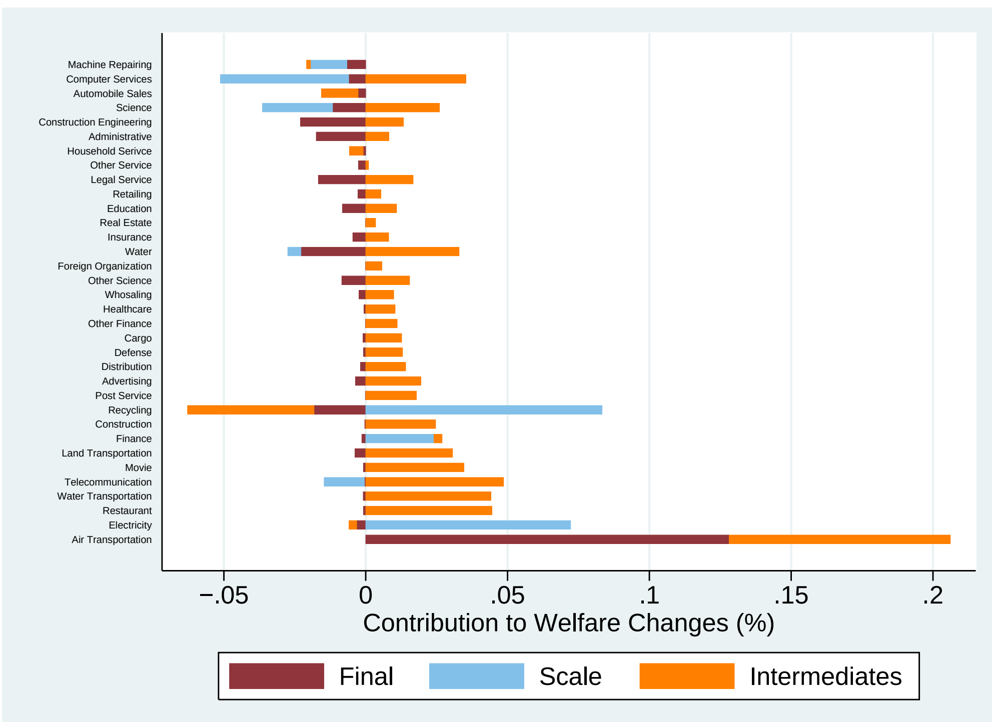


(b) U.S.

Figure B.3: The Impacts of "Made in China 2025" on Goods Sectors



(a) China



(b) U.S.

Figure B.4: The Impacts of "Made in China 2025" on Service Sectors

Table A.1: Nash Equilibrium: IO Linkages and Scale Economies

	$\beta = 1$							
	Country 1				Country 2			
	t^1_{21}	e^1_1	e^1_{12}	t^2_{21}	e^1_2	t^1_{12}	t^2_{12}	e^1_{21}
Country 2's retaliation by tariffs	0.2389	n.a.	n.a.	n.a.	-0.0870	0.3141	0.3535	n.a.
Country 1's retaliation by industry subsidy	0.2952	0.0647	n.a.	n.a.	-0.1048	0.2745	0.3370	n.a.
Country 1's export control	0.1261	-0.1152	0.1289	n.a.	-0.1256	0.2415	0.3266	n.a.
Country 2's retaliation by export subsidy	0.1167	-0.1178	0.1270	n.a.	-0.1325	0.2315	0.3245	-0.0881
All retaliations	0.2511	-0.0955	0.0385	0.2167	-0.1045	0.2566	0.3004	-0.0378
	$\beta = 1$ and $\psi = 0$							
	Country 1				Country 2			
	t^1_{21}	e^1_1	e^1_{12}	t^2_{21}	e^1_2	t^1_{12}	t^2_{12}	e^1_{21}
Country 2's retaliation by tariffs	0.1461	n.a.	n.a.	n.a.	-0.0060	0.3455	0.3512	n.a.
Country 1's retaliation by industry subsidy	0.2537	0.1665	n.a.	n.a.	-0.0455	0.2461	0.3187	n.a.
Country 1's export control	0.0876	-0.0244	0.2455	n.a.	-0.0628	0.2101	0.3118	n.a.
Country 2's retaliation by export subsidy	0.0771	-0.0277	0.2443	n.a.	-0.0727	0.1955	0.3088	-0.0231
All retaliations	0.2243	-0.0016	0.1354	0.2277	-0.0422	0.2222	0.2819	0.0260

(Notes: t^j_{in} refers to the rate of tariff levied by country n on the imports of good j from country i. e^j_{in} refers to the rate of tariff levied by country i on the exports of good j to country n. e^j_i refers to the production subsidy on industry j in country i.)

Table B.2: Trade Elasticities, Scale Economies, and Input Elasticities of Substitution

	Industry	Industry in BCDR (2019)	θ_j	ψ_j	μ_j	MIC 2025
1	Agricultural Products	Other	6.85	0	0.623	
2	Mining	Mineral Products	6.8	0.13	0.450	
3	Wood Products	Wood Products	8.7	0.11	0.931	
4	Clay Products	Wood Products	8.7	0.11	0.774	
5	Glass Products	Wood Products	8.7	0.11	0.774	
6	Cement	Wood Products	8.7	0.11	0.774	
7	Concrete And Stone Products	Wood Products	8.7	0.11	0.774	
8	Mineral And Construction Machinery	Machinery&Equipment	6.2	0.13	0.774	
9	Steel Products	Fabricated Metals	6.4	0.13	0.731	
10	Nonferrous Metal	Basic Metals	7.9	0.11	0.704	
11	Ferrous Metal	Basic Metals	7.9	0.11	0.704	
12	Farm Machinery	Machinery&Equipment	6.2	0.13	0.827	Y
13	Semiconductor Machinery	Computers&Electronics	9.4	0.09	0.827	Y
14	Optical Instrument	Computers&Electronics	9.4	0.09	0.827	Y
15	Industrial Mold Manufacturing	Electrical Machinery, NEC	10.1	0.09	0.827	
16	Material Handling Equipment	Electrical Machinery, NEC	10.1	0.09	0.827	
17	Other Engine Equipment	Electrical Machinery, NEC	10.1	0.09	0.827	
18	Electronic Computer Manufacturing	Computers&Electronics	9.4	0.09	0.308	
19	Communications Equipment	Computers&Electronics	9.4	0.09	0.308	Y
20	Audio And Video Equipment	Computers&Electronics	9.4	0.09	0.308	Y
21	Other Electronic Component	Computers&Electronics	9.4	0.09	0.308	
22	Small Electrical Appliance	Machinery&Equipment	6.2	0.13	0.594	
23	Power And Distribution	Electrical Machinery, NEC	10.1	0.09	0.594	Y
24	Switchgear And Switchboard Apparatus	Electrical Machinery, NEC	10.1	0.09	0.594	
25	Wiring Device Manufacturing	Electrical Machinery, NEC	10.1	0.09	0.594	
26	Other Miscellaneous Electrical Equipment	Electrical Machinery, NEC	10.1	0.09	0.594	
27	Automobile	Motor Vehicles	5.7	0.15	0.622	Y
28	Railroad Rolling Stock	Other Transport Equipment	5.4	0.16	0.644	Y
29	Ship Building And Repairing	Other Transport Equipment	5.4	0.16	0.644	Y
30	Aircraft	Other Transport Equipment	5.4	0.16	0.644	Y
31	Furniture	Wood Products	8.7	0.11	0.512	
32	Jewelry	Other	6.85	0	0.512	
33	Musical Instrument	Other	6.85	0	0.547	
34	Dog And Cat Food Manufacturing	Food, Beverages & Tobacco	4.4	0.16	0.564	
35	Corn Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
36	Fat Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
37	Dairy Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
38	Meat Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
39	Sugar Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
40	Snack Food	Food, Beverages & Tobacco	4.4	0.16	0.564	
41	Fish Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
42	Vegetable Products	Food, Beverages & Tobacco	4.4	0.16	0.564	
43	Soft Drink	Food, Beverages & Tobacco	4.4	0.16	0.564	
44	Wineries	Food, Beverages & Tobacco	4.4	0.16	0.564	
45	Tobacco	Food, Beverages & Tobacco	4.4	0.16	0.564	
46	Textile	Textiles	7.7	0.12	0.893	
47	Apparel	Textiles	7.7	0.12	0.753	
48	Leather	Textiles	7.7	0.12	0.753	
49	Paper	Paper Products	7.8	0.11	0.870	
50	Printing	Paper Products	7.8	0.11	1.005	
51	Petroleum Refineries	Coke/Petroleum Products	11.4	0.07	1.325	
52	Chemical Products	Chemicals	3.4	0.2	0.930	
53	Fertilizer	Chemicals	3.4	0.2	0.930	
54	Pesticide	Chemicals	3.4	0.2	0.930	
55	Pharmaceutical	Chemicals	3.4	0.2	0.930	Y
56	Paint	Chemicals	3.4	0.2	0.930	
57	Soap	Chemicals	3.4	0.2	0.930	
58	Plastics	Rubber & Plastic	2.9	0.25	0.897	
59	Rubber Products	Rubber & Plastic	2.9	0.25	0.897	
60	Synthetic Rubber	Rubber & Plastic	2.9	0.25	0.897	
61	Tire	Rubber & Plastic	2.9	0.25	0.897	
62	Machine Repairing	Rubber & Plastic	2.9	0.25	0.6922	
63	Electricity	Other	6.85	0	0.6922	
64	Water	Other	6.85	0	0.6922	
65	Recycling	Other	6.85	0	0.6922	
66	Construction	Other	6.85	0	0.6922	
67	Automobile Sales	Other	6.85	0	0.312	
68	Whosaling	Other	6.85	0	0.542	
69	Retailing	Other	6.85	0	0.489	
70	Land Transportation	Other	6.85	0	0.501	
71	Water Transportation	Other	6.85	0	1.524	
72	Air Transportation	Other	6.85	0	1.114	
73	Cargo	Other	6.85	0	0.784	
74	Post Service	Other	6.85	0	0.6922	
75	Restaurant	Other	6.85	0	0.484	
76	Distribution	Other	6.85	0	0.772	
77	Movie	Other	6.85	0	0.395	
78	Telecommunication	Other	6.85	0	0.719	
79	Computer Services	Other	6.85	0	0.467	
80	Finance	Other	6.85	0	0.296	
81	Insurance	Other	6.85	0	0.465	
82	Other Finance	Other	6.85	0	0.689	
83	Real Estate	Other	6.85	0	0.638	
84	Legal Service	Other	6.85	0	0.754	
85	Construction Engineering	Other	6.85	0	0.389	
86	Science	Other	6.85	0	0.782	
87	Advertising	Other	6.85	0	0.6922	
88	Other Science	Other	6.85	0	0.782	
89	Administrative	Other	6.85	0	0.692	
90	Defense	Other	6.85	0	0.675	
91	Education	Other	6.85	0	0.703	
92	Healthcare	Other	6.85	0	0.879	
93	Other Service	Other	6.85	0	0.855	
94	Household Serivce	Other	6.85	0	0.6922	
95	Foreign Organization	Other	6.85	0	0.6922	

Table B.3: Trade Elasticities and Scale Economies: Lashkaripour and Lugovskyy (2017)

	Industry	Industry in LL (2017)	θ_j	ψ_j
1	Agricultural Products	Agriculture & Mining	4.584	0.188
2	Mining	Agriculture & Mining	4.584	0.188
3	Wood Products	Wood	2.376	0.338
4	Clay Products	Wood	2.376	0.338
5	Glass Products	Wood	2.376	0.338
6	Cement	Wood	2.376	0.338
7	Concrete And Stone Products	Wood	2.376	0.338
8	Mineral And Construction Machinery	Machinery	2.471	0.315
9	Steel Products	Basic & Fabricated Metals	2.25	0.263
10	Nonferrous Metal	Basic & Fabricated Metals	2.25	0.263
11	Ferrous Metal	Basic & Fabricated Metals	2.25	0.263
12	Farm Machinery	Machinery	2.471	0.315
13	Semiconductor Machinery	Electrical & Optical Equipment	0.394	1.367
14	Optical Instrument	Electrical & Optical Equipment	0.394	1.367
15	Industrial Mold Manufacturing	Machinery	2.471	0.315
16	Material Handling Equipment	Electrical & Optical Equipment	0.394	1.367
17	Other Engine Equipment	Electrical & Optical Equipment	0.394	1.367
18	Electronic Computer Manufacturing	Electrical & Optical Equipment	0.394	1.367
19	Communications Equipment	Electrical & Optical Equipment	0.394	1.367
20	Audio And Video Equipment	Electrical & Optical Equipment	0.394	1.367
21	Other Electronic Component	Electrical & Optical Equipment	0.394	1.367
22	Small Electrical Appliance	Machinery	2.471	0.315
23	Power And Distribution	Electrical & Optical Equipment	0.394	1.367
24	Switchgear And Switchboard Apparatus	Electrical & Optical Equipment	0.394	1.367
25	Wiring Device Manufacturing	Electrical & Optical Equipment	0.394	1.367
26	Other Miscellaneous Electrical Equipment	Electrical & Optical Equipment	0.394	1.367
27	Automobile	Transport Equipment	0.463	0.575
28	Railroad Rolling Stock	Transport Equipment	0.463	0.575
29	Ship Building And Repairing	Transport Equipment	0.463	0.575
30	Aircraft	Transport Equipment	0.463	0.575
31	Furniture	Wood	2.376	0.338
32	Jewelry	Manufacturing (average)	2.055	0.22
33	Musical Instrument	Manufacturing (average)	2.055	0.22
34	Dog And Cat Food Manufacturing	Food	2.036	0.423
35	Corn Products	Food	2.036	0.423
36	Fat Products	Food	2.036	0.423
37	Dairy Products	Food	2.036	0.423
38	Meat Products	Food	2.036	0.423
39	Sugar Products	Food	2.036	0.423
40	Snack Food	Food	2.036	0.423
41	Fish Products	Food	2.036	0.423
42	Vegetable Products	Food	2.036	0.423
43	Soft Drink	Food	2.036	0.423
44	Wineries	Food	2.036	0.423
45	Tobacco	Food	2.036	0.423
46	Textile	Textiles, Leather & Footwear	2.418	0.278
47	Apparel	Textiles, Leather & Footwear	2.418	0.278
48	Leather	Textiles, Leather & Footwear	2.418	0.278
49	Paper	Paper	4.765	0.181
50	Printing	Paper	4.765	0.181
51	Petroleum Refineries	Petroleum	0.328	1.979
52	Chemical Products	Chemicals	2.389	0.36
53	Fertilizer	Chemicals	2.389	0.36
54	Pesticide	Chemicals	2.389	0.36
55	Pharmaceutical	Chemicals	2.389	0.36
56	Paint	Chemicals	2.389	0.36
57	Soap	Chemicals	2.389	0.36
58	Plastics	Rubber & Plastic	3.02	0.24
59	Rubber Products	Rubber & Plastic	3.02	0.24
60	Synthetic Rubber	Rubber & Plastic	3.02	0.24
61	Tire	Rubber & Plastic	3.02	0.24
62	Machine Repairing	Rubber & Plastic	3.02	0.24
63	Electricity	Nonmanufacturing (average)	3.058	0.27
64	Water	Nonmanufacturing (average)	3.058	0.27
65	Recycling	Nonmanufacturing (average)	3.058	0.27
66	Construction	Misc.	4	0
67	Automobile Sales	Misc.	4	0
68	Whosaling	Misc.	4	0
69	Retailing	Misc.	4	0
70	Land Transportation	Misc.	4	0
71	Water Transportation	Misc.	4	0
72	Air Transportation	Misc.	4	0
73	Cargo	Misc.	4	0
74	Post Service	Misc.	4	0
75	Restaurant	Misc.	4	0
76	Distribution	Misc.	4	0
77	Movie	Misc.	4	0
78	Telecommunication	Nonmanufacturing (average)	3.058	0.27
79	Computer Services	Nonmanufacturing (average)	3.058	0.27
80	Finance	Nonmanufacturing (average)	3.058	0.27
81	Insurance	Misc.	4	0
82	Other Finance	Misc.	4	0
83	Real Estate	Misc.	4	0
84	Legal Service	Misc.	4	0
85	Construction Engineering	Misc.	4	0
86	Science	Nonmanufacturing (average)	3.058	0.27
87	Advertising	Misc.	4	0
88	Other Science	Misc.	4	0
89	Administrative	Misc.	4	0
90	Defense	Misc.	4	0
91	Education	Misc.	4	0
92	Healthcare	Misc.	4	0
93	Other Service	Misc.	4	0
94	Household Serivce	Misc.	4	0
95	Foreign Organization	Misc.	4	0

Table B.4: Estimation Results of μ_j

Sector	Sector Name	μ_j	S.E.	# Obs.
111CA	Farms	0.531	0.220	897
113FF	Forestry, fishing, and related activities	0.715	0.212	826
211	Oil and gas extraction	0.688	0.116	822
212	Mining, except oil and gas	0.404	0.104	915
213	Support activities for mining	0.257	0.127	820
22	Utilities	0.611	0.172	894
23	Construction	0.389	0.133	926
321	Wood products	0.931	0.163	976
327	Nonmetallic mineral products	0.774	0.170	913
331	Primary metals	0.731	0.166	900
332	Fabricated metal products	0.704	0.133	915
333	Machinery	0.827	0.142	962
334	Computer and electronic products	0.308	0.178	885
335	Electrical equipment, appliances, and components	0.594	0.185	902
3361MV	Motor vehicles, bodies and trailers, and parts	0.622	0.169	946
3364OT	Other transportation equipment	0.644	0.204	880
337	Furniture and related products	0.512	0.240	900
339	Miscellaneous manufacturing	0.547	0.151	995
311FT	Food and beverage and tobacco products	0.564	0.133	975
313TT	Textile mills and textile product mills	0.893	0.188	919
315AL	Apparel and leather and allied products	0.753	0.216	825
322	Paper products	0.870	0.147	914
323	Printing and related support activities	1.005	0.152	986
324	Petroleum and coal products	1.325	0.256	966
325	Chemical products	0.930	0.129	1000
326	Plastics and rubber products	0.897	0.140	956
42	Wholesale trade	0.542	0.100	1100
441	Motor vehicle and parts dealers	0.312	0.155	1094
445	Food and beverage stores	0.428	0.077	1007
452	General merchandise stores	0.554	0.115	969
4A0	Other retail	0.485	0.113	1089
481	Air transportation	1.114	0.281	798
482	Rail transportation	0.723	0.161	872
483	Water transportation	1.524	0.219	655
484	Truck transportation	0.552	0.183	897
485	Transit and ground passenger transportation	0.169	0.187	744
486	Pipeline transportation	0.559	0.190	885
487OS	Other transportation and support activities	0.633	0.182	1025
493	Warehousing and storage	0.934	0.113	887
511	Publishing industries, except internet (includes software)	0.772	0.120	986
512	Motion picture and sound recording industries	0.395	0.122	951
513	Broadcasting and telecommunications	0.719	0.102	1036
514	Data processing, internet publishing, and other information services	0.481	0.137	973
521CI	Federal Reserve banks, credit intermediation, and related activities	0.324	0.114	903
523	Securities, commodity contracts, and investments	0.269	0.152	857
524	Insurance carriers and related activities	0.465	0.198	879
525	Funds, trusts, and other financial vehicles	0.689	0.148	616
HS	Housing	0.463	0.365	572
ORE	Other real estate	0.900	0.169	859
532RL	Rental and leasing services and lessors of intangible assets	0.550	0.170	960
5411	Legal services	0.754	0.181	877
5415	Computer systems design and related services	0.452	0.123	961
5412OP	Miscellaneous professional, scientific, and technical services	0.782	0.096	1140
55	Management of companies and enterprises	0.534	0.122	1107
561	Administrative and support services	0.739	0.147	1107
562	Waste management and remediation services	0.686	0.120	978
61	Educational services	0.703	0.173	1056
621	Ambulatory health care services	0.760	0.128	1059
622	Hospitals	1.120	0.188	1100
623	Nursing and residential care facilities	0.832	0.128	981
624	Social assistance	0.805	0.168	1031
711AS	Performing arts, spectator sports, museums, and related activities	1.082	0.153	1026
713	Amusements, gambling, and recreation industries	0.420	0.142	1098
721	Accommodation	0.480	0.152	1020
722	Food services and drinking places	0.488	0.087	1040
81	Other services, except government	0.855	0.118	1157
GFGD	Federal general government (defense)	0.579	0.143	958
GFGN	Federal general government (nondefense)	0.771	0.156	1048
GFE	Federal government enterprises	1.018	0.205	925
GSLG	State and local general government	0.579	0.120	1124
GSLE	State and local government enterprises	0.479	0.104	960