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Trade wars and industrial policy competitions: Understanding the US-China economic conflicts☆

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ABSTRACT

We provide the first quantitative evaluation of the impacts and interactions of the US-China trade wars and industrial policy competitions. We extend the model in Caliendo and Parro (2015) by incorporating sectoral external economies of scale. We find that (i) under our baseline calibration of scale economies, the "Made-in-China 2025" ("MIC 2025") subsidies tend to improve the welfare of both China and the U.S.; (ii) the US gains from Trumpian tariffs if China does not retaliate, and the gain is larger if China had implemented the "MIC 2025" project; (iii) in a non-cooperative tariff game targeting on high-tech industries supported by the "MIC 2025", both China and the U.S. impose high tariffs and endure welfare losses; and (iv) if it is feasible for the U.S. to subsidize its own high-tech industries, the U.S. would reduce its tariffs on high-tech imports from China and benefit from its own industrial subsidies. These results (i) provide a rationale for trade wars and industrial policy competitions between the U.S. and China and (ii) suggest that industrial subsidies, if properly implemented, may generate less distortion than import tariffs as a means of international competition.

1. Introduction

Industrial policy has been the primary concern in the US–China economic conflicts. In preparation for launching the trade war with China, the United States Trade Representative Office (USTR) under the Trump administration released the "Section 301" report on March 22, 2018. The report openly criticized China's industrial policies as aggressive and distorting. Among these industrial policies, the most notable is the "Made in China 2025" (MIC 2025) Project, which aimed to develop advanced technology sectors deemed essential to the future competitiveness of China's manufacturing industries. To further counter China's rising economic and political power, the U.S. government under the Biden administration has also turned to industrial policies. For example, the "CHIPS and Science Act", signed by President Biden on August 9, 2022, aims to support American semiconductor manufacturing with large subsides. The economic conflicts between the US and China have evolved from a trade war to competition in industrial policies.

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However, recent studies about the trade war between the United States and China, such as those of Amiti et al. (2019) and Fajgelbaum et al. (2020), do not take industrial policies into consideration. As a result, several important questions remain unanswered. Did the Trump administration's tariffs specifically target China's industrial policies as they claimed? What is the rationale behind using protectionist tariffs to counter other countries' industrial subsidies? Why did the Biden Administration move from a trade war to competition in industrial policies? And what are the welfare consequences of the trade war and industrial policy competition?

In this paper, we aim to provide the first quantitative evaluation of the impacts and interactions of the US–China trade war and industrial policy competition. To set the stage, we document that the initial wave of tariffs imposed by the Trump administration on imports from China specifically targeted high-tech industries supported by the "MIC 2025" Project. This finding highlights the importance of considering China's industrial policies when assessing the US–China trade war.

To that end, we incorporate a classical justification for industrial policies, *sectoral external economies of scale*, into a multi-country-multi-sector quantitative trade model à la Caliendo and Parro (2015). We then calibrate our model to 7 major economies and 44 sectors (including 22 tradable sectors) in 2017 using the OECD Inter-Country Input–Output database (ICIO). We calibrate the strength of sectoral external economies using the recent estimates of scale elasticities by Lashkaripour and Lugovskyy (2023). Under this calibration, the high-tech industries supported by the "MIC 2025" Project exhibit stronger economies of scale than other tradable sectors. This pattern helps rationalize China's industrial subsides and the Trump administration's tariffs on these high-tech industries.

With our calibrated model in place, we proceed to quantitatively evaluate the impacts of various trade and industrial policies, including the actual tariff changes in the US–China trade war, China's optimal uniform subsidy to its "MIC 2025" sectors, and the optimal tariffs and subsidies by the U.S. and China in non-cooperative Nash games.

It would be ideal to identify and quantify China's actual industrial subsidies under the "MIC 2025" Project. However, China's industrial subsidies take various forms, including direct subsidies reported by firms, as well as indirect subsidies in the forms of preferential credit policy, government sponsored venture capital investments, and subsidies to downstream sectors that boost demand for products in the "MIC 2025" industries. Unfortunately, there is a lack of comprehensive data that encompasses all these different types of subsidies and supporting policies under the "MIC 2025" Project. As a result, we compute the optimal uniform subsidy to the "MIC 2025" sectors as a benchmark for evaluating the "MIC 2025" industrial policies. As a robustness exercise, we also collect information on China's direct subsidies to firms using various firm-level datasets and compute the impacts of these observed subsidies. Their impacts are quantitatively much smaller, but qualitatively in line with those of the optimal uniform subsidy.

Our quantitative analysis reveals some key insights about the recent US–China economic conflicts. Here we highlight five of these insights.

1. *China's Optimal Uniform Subsidy to High-tech Industries*: Given the strong external economies of scale in the "MIC 2025" sectors, China's optimal uniform subsidy rate for these sectors is 7.96% (of sales). This policy results in a 2.47% increase in China's welfare, and, surprisingly, a 0.44% increase in the US welfare as well. Our structural decomposition suggests that China mainly gains from this subsidy through scale economies, whereas the U.S. (and all other major economies except for Japan) mainly gains through the decline in intermediate prices. We study this hypothetical scenario to understand China's incentives to subsidize its high-tech industries. Interestingly, when we examine the expansion of the "MIC 2025" sectors observed in Chinese data between 2015 and 2022, we find that the combination of the hypothetical optimal uniform subsidy and actual tariff changes during the US–China trade war better predicts this sectoral expansion than the combination of observed direct subsidies and actual tariff changes. This result underscores the usefulness of our model in understanding the impacts of the "MIC 2025" project.
2. *Welfare Effects of Trump Administrations' Tariffs on Imports from China*: We find that the welfare effects of the Trumpian tariffs depend critically on China's industrial policies. If China does not subsidize the "MIC 2025" sectors, Trumpian tariffs (*Wave 1*) would lead to a small welfare gain for the U.S. (0.027%), which is close to the result in Caliendo and Parro (2021) (0.024%). However, if China subsidizes the "MIC 2025" sectors by implementing its optimal uniform subsidy of 7.96%, then the U.S. gain from Trumpian tariffs (*Wave 1*) would be *larger*, (0.033%). Our structural decomposition suggests that in the presence of China's industrial subsidies, the U.S. gains *more* from Trumpian tariffs via scale economies. Intuitively, China's subsidies on the "MIC 2025" sectors shrink the production scale of these high-tech industries in the U.S., strengthening the U.S. incentives for protecting these industries by raising import tariffs.
3. *US–China Trade War*: To understand the US–China competition in the "MIC 2025" sectors, we evaluate equilibrium tariffs on these high-tech industries in both countries in a non-cooperative Nash tariff game. We find that in this Nash tariff game, both countries impose high tariffs on the "MIC 2025" sectors: the US optimal uniform tariff on these high-tech imports is 13.23%, higher than the average of the first wave Trumpian tariffs (6.23%) but lower than the average of the final wave Trumpian tariffs (21.52%), whereas the corresponding optimal tariff in China is 20.42%. These Nash tariffs lead to considerable welfare losses for both the U.S. (−0.017%) and China (−0.251%), as well as for other major economies (except for Japan). This exercise indicates that import tariffs introduce substantial distortions into the global economy, making them an inefficient means of competition between countries.
4. *US–China Industrial Policy Competition*: If it is feasible for the U.S. to subsidize its own high-tech industries, we show that, in a Nash game with both tariff and industrial policy competitions, the optimal policy for the US is a much lower tariff on Chinese high-tech imports (5.57%) plus a subsidy rate of 9.59% for its own high-tech industries. This policy combination would increase the U.S. welfare by 0.26%, even under the Chinese optimal retaliation tariffs. This result provides a rationale

for the Biden administration's move towards industrial policy, suggesting that industrial policies, if properly specified and implemented, result in less distortion than import tariffs as a means of competition between countries.

5. *Global Optimal Industrial Policy*: Finally, we consider global cooperation in industrial policies in which a global social planner chooses a uniform subsidy to the high-tech industries for each country to maximize the minimum of welfare gains across countries. We find that (i) all countries impose substantial subsidies to their high-tech industries; (ii) all countries, in particular developing countries, gain considerably from this policy cooperation; and (iii) these cooperative industrial subsidies shift the production of high-tech industries towards China.

In sum, our quantitative results rationalize (i) China's subsidies on the "MIC 2025" industries, (ii) the Trumpian tariffs targeting on these high-tech industries, and (iii) the Biden administration's recent proposal on subsidizing the U.S. semiconductor manufacturing. These results reveal that competitions in high-tech sectors with strong economies of scale are at the heart of the US–China economic conflicts. Moreover, how the U.S. and China compete matter: industrial policy competitions, if correctly implemented, are potentially more efficient than tariff wars.

Our work is closely related to recent quantitative explorations about trade and industrial policies. Bartelme et al. (2021) and Lashkaripour and Lugovskyy (2023) show that if one country implements its import tariffs and export subsidies optimally, then its optimal industrial policies depend only on the sectoral economies of scale. These two papers also empirically estimate sectoral economies of scale using different instruments. However, in reality, it is often politically infeasible for countries to impose a full set of unilaterally optimal trade policies. How countries should implement industrial subsidies in the real world is still an open question. Our work contributes to this literature by quantitatively evaluate the interdependence of trade and industrial policies in the context of the US–China trade war.

Our 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, which are shown to be relevant in characterizing high-tech industries targeted by the U.S. tariffs. In the real-word context of the US–China economic conflicts, we show that our model can be a useful tool in analyzing trade and industrial policy competitions among major economies.

Finally, our work relates to empirical and quantitative assessment of the US–China trade war starting from 2018. A growing literature, such as Amiti et al. (2019, 2020), Fajgelbaum et al. (2020), Cavallo et al. (2020), and Ma and Meng (2023), focuses on price, employment, and welfare effects of the Trumpian tariffs and China's retaliation. However, these studies do not pay much attention to industrial policies, which have been emphasized both in the announcements and in the implementations of various trade policies during the US–China trade war. Our paper is the first attempt to evaluate the interactions of trade and industrial policies in the US–China trade war.

We begin our analysis with a detailed introduction of policy background in Section 2, where we document motivational facts about the US–China trade war and industrial policy competitions. Then we develop a multi-country-multi-sector general equilibrium model with sectoral scale economies in Section 3. We then calibrate our model in Section 4 and use this model to quantify the incentives and impacts of the US–China trade war and industrial policy competition in Section 5. We conclude in Section 6.

2. Background and motivational facts

2.1. "Made-in-China 2025" project

Initially announced in 2015, China's "Made-in-China 2025" (henceforth "MIC 2025") Project set forth a plan to develop certain advanced technology sectors that are deemed essential to the future competitiveness of China's manufacturing industries.[1] These sectors include next-generation information technology, CNC machine tools and robotics, aeroplane and aerospace, high-tech shipping, advanced railway, new energy vehicles, power equipment, new materials, biotech, and agricultural machinery.[2]

The "MIC 2025" also sets explicit goals to be achieved by 2020 and 2025, including share of R&D expenditures, domestic market share of Chinese producers, self-reliance of key materials and components, and other targets. To achieve these goals, a set of supportive policy instruments, including financial access and fiscal incentives and subsidies, are provided to these key advanced technology sectors. The "MIC 2025" quickly became the backbone of a national strategy to build a powerful manufacturing nation and was written into the Thirteenth Five-Year National Economic and Social Development Plan Outline (13th Five-Year Plan). The 13th Five-Year Plan was published in 2016 during the National People's Congress meeting. Chapters 22 and 23 of the Plan laid out a guideline to implement the "MIC 2025" and a road-map to support emerging strategic industries to gain international competitiveness.[3]

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[1] Notice on Issuing "Made in China 2025" (State Council, Guo Fa [2015] No. 28, issued May 8, 2015). See http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm for details

[2] See "Made in China 2025 Key Area Technology Roadmap", issued by the National Strategic Advisory Committee on Building a Powerful Manufacturing Nation on Oct. 10, 2015.

[3] The "Five-Year Plan" is published every five years by the National People's Congress and is the most important and authoritative national development plan.

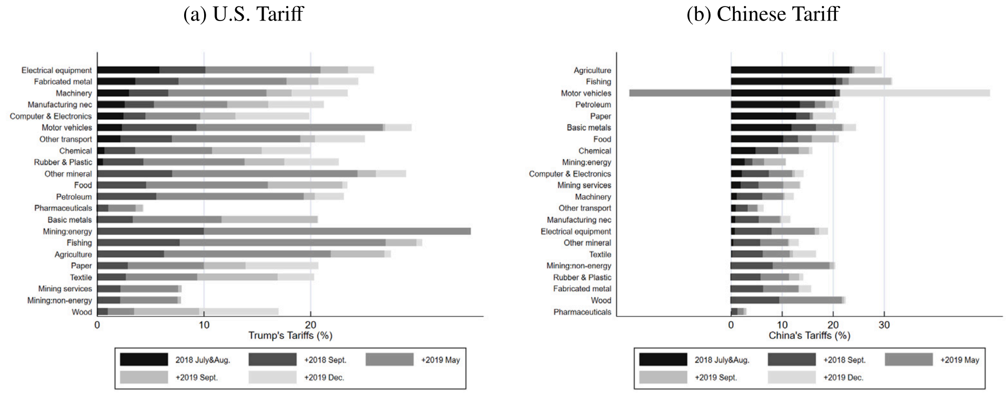

Fig. 1. Trumpian tariffs and China's retaliation.
Notes: Panel (a) shows the tariff increases in the five waves of the Trumpian tariffs on Chinese imports. Panel (b) shows China's retaliation tariffs, implemented immediately after each wave of the Trumpian tariffs. Both use the weighted average of tariffs across six-digit HS products within the same ICIO sector. The negative Chinese tariff on motor vehicles reflects the suspension of tariffs on motor vehicles on January 2019. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2.2. The US–China trade war starting from 2018

Regarding the "MIC 2025" as a set of aggressive and distorting industrial policies focusing on the high-tech sectors, the U.S. then-president Donald J. Trump instructed the U.S. Trade Representative (USTR) to initiate a "Section 301" investigation targeting China. The final official "Section 301" report was released on March 22, 2018, stating explicitly that "(the USTR) *investigates China's laws, policies, practices, or actions that may be unreasonable or discriminatory and that may be harming American intellectual property (IP) rights, innovation, or technology development*".

The original "Section 301" tariffs included a list of 1333 eight-digit HS products, which 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. The proposed list particularly targets the products regarded as "*strategically important to and benefit from*" China's distorting industrial policies, including the "MIC 2025" Project.[4] We label this revised list of tariff lines as *wave 1*. As shown in Panel (a) of Fig. 1, only a few sectors (red bar) were affected by the *wave 1* tariffs, and these are mostly high-tech sectors.

The tariff war later escalated. There were altogether five waves of protectionism tariffs implemented or proposed by the Trump administration, on July and August 2018 (*wave 1*), September 2018 (*wave 2*), May 2019 (*wave 3*), September 2019 (*wave 4*), and December 2019 (*wave 5*), respectively. Adopting a "tic-for-tat" strategy, China's retaliation immediately followed each wave of the U.S. tariffs. As shown in Fig. 1, after the last wave of protectionism tariffs, both countries impose the tariffs to levels that are much higher than the ongoing MFN rates.[5]

As discussed above, the Trumpian tariffs (*wave 1*) were announced to particularly target on China's industrial subsidies. Is this announcement consistent with sectoral patterns of Trumpian tariffs (*wave 1*)? To answer this question, we identify the four-digit HS products that are associated with the strategic industries listed by the "MIC 2025" Project, and then compare Trumpian tariffs (*wave 1*) on these industries to those on other manufacturing industries. We find that the average U.S. *wave 1* tariff on four-digit HS products associated with the "MIC 2025" Project is 12.07%, whereas the average U.S. *wave 1* tariff on other manufacturing products is 1.71%. This result suggests that Trumpian tariffs (*wave 1*) were indeed concentrated on the "MIC 2025" industries. It provides a *rationale* of the initial Trumpian tariffs: the U.S. has criticized China for using distorting industrial policies (like "MIC 2025") to seize economic dominance of certain advanced technology sectors. To counter the effects of China's industrial subsidies, the U.S. imposes penalty tariffs on these high-tech industries.

In Online Appendix A.1, we document several additional sectoral patterns of the Trumpian tariffs (*wave 1*). First, the initial Trumpian tariffs did not initially target on the goods that the U.S. imports most from China, such as personal computers and mobile phones. In contrast, these tariffs were concentrated in various machinery and equipment industries that the U.S. rarely imports from China. Second, the initial Trumpian tariffs are not for reducing the US–China trade imbalances, as they are not correlated with the size of US imports from China, nor with the revealed comparative advantages of the Chinese products. Finally, the initial Trumpian tariffs are not for preventing the US manufacturing job losses due to the "China shock" as emphasized in Autor et al. (2013).

[4] 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

[5] Due to the Phase One trade agreement, the wave 5 tariffs were cancelled and the wave 4 tariffs were cut in half.

In summary, the facts documented in this subsection indicate that the US–China trade war started in 2018 is essentially a *technology competition* centered on the high-tech industries emphasized by the "MIC 2025" Project.

2.3. From tariff war to industry policy competition

To counter China's rising economic and political power, and to take advantage of the gains in scale economy, the U.S. government under the Biden administration has also turned to industrial policies. The White House published the *National Strategy for Advanced Manufacturing*, initially in 2018 and updated in 2022, which emphasized the importance of regaining American leadership and competitiveness in advanced manufacturing.

Among these strategies the most notable one is the *CHIPS and Science Act*, signed by President Biden on August 9, 2022, which aimed to support American semiconductor manufacturing with huge subsidies.[6] Other examples include the *Executive Order on Advancing Biotechnology and Biomanufacturing* by President Biden, and more recently the *Inflation Reduction Act*, which unleashed vast subsidies for green energy and electric cars. The latter bill requires the electric vehicles that receive tax incentives to be assembled in North America. The economic conflicts between the US and China have evolved quickly from a trade war to the competition in industrial policies. As pointed out by the Economist Magazine, rather than trying to get other countries to cut subsidies, the Biden administration's unabashed focus is on building a subsidy architecture of its own.[7]

3. Model

In this section, we build a multi-country-multi-sector general equilibrium model to understand the incentives behind the trade war and industrial policy competition between the U.S. and China. In particular, we extend the model developed by Caliendo and Parro (2015) by incorporating sectoral scale economies à la Bartelme et al. (2021) and Lashkaripour and Lugovskyy (2023).

3.1. Environment

Consider a world with N countries, indexed by i and n, with a mass $\bar{L}_i$ workers in country 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.

Demand and Frictions. Preferences of the representative consumer of country i are summarized by a two-tiered utility function that is Cobb–Douglas for consumption of final goods across sectors and CES for consumption varieties within each sector:

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

where α_i^j is the expenditure share of final good j 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.

Shipping good j from i to n is subject to an iceberg trade cost, τ_{in}^j, with $\tau_{ii}^j = 1$ and an *ad valorem* import tariff $\tilde{t}_{in}^j$, with $\tilde{t}_{ii}^j = 0$. We also allow country i to levy an output tax, $\tilde{e}_{in}^j$, on its production of good j serving destination n, including itself, *i.e.* $n = i$. Notably, this output tax is isomorphic as industrial subsidies once it is *negative* and uniform for all destination country n, *i.e.* $\tilde{e}_{in}^j = \tilde{e}_i^j \leq 0$ for all n. We denote $t_{in}^j \equiv 1 + \tilde{t}_{in}^j$ and $e_{in}^j \equiv 1 + \tilde{e}_{in}^j$.

Technology. We extend the production technology in Caliendo and Parro (2015) by incorporating sectoral external economies of scale. 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

$$c_i^j = \underbrace{\frac{1}{\left(L_i^j\right)^{\psi_j}}}_{\text{Sectoral Scale Economy}} w_i^{\beta_i^j} \left[\prod_{s=1}^{J} \left(P_i^s\right)^{\gamma_i^{sj}}\right]^{1-\beta_i^j}, \quad \sum_{s=1}^{J} \gamma_i^{sj} = 1, \tag{2}$$

P_i^s is the price index of good s in country i and L_i^j is the labor allocated to sector j of country i. Notably, the parameter $\psi_j \geq 0$ is the scale elasticity that characterizes the strength of external economies of scale in sector j.

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

$$Pr\left[z_i^j(\omega) \leq z\right] = \exp\left\{-T_i^j z^{-\theta_j}\right\}, \quad z > 0, \quad \theta_j > \max\{\sigma_j - 1, 1\}, \tag{3}$$

[6] The bill authorizes nearly 280 billion dollars in spending in scientific R&D and technology commercialization, particularly in semiconductor manufacturing.

[7] The full report can be found via the following link: https://www.economist.com/finance-and-economics/2023/01/09/what-americas-protectionist-turn-means-for-the-world

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

We proceed by characterizing the aggregate economy and define the equilibrium. Based on the property of Frechét distribution and the ideal price index of CES preferences, the sectoral price index can be expressed as

$$P_n^j = \left[\sum_{i=1}^{N} T_i^j \left[c_i^j \tau_{in}^j t_{in}^j e_{in}^j\right]^{-\theta_j}\right]^{-\frac{1}{\theta_j}}. \tag{4}$$

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

$$\pi_{in}^j = \frac{X_{in}^j}{X_n^j} = \frac{T_i^j \left[c_i^j \tau_{in}^j t_{in}^j e_{in}^j\right]^{-\theta_j}}{\left(P_n^j\right)^{-\theta_j}}. \tag{5}$$

Sectoral employment satisfies:

$$w_i L_i^j = \beta_i^j \sum_{n=1}^{N} \frac{X_{in}^j}{t_{in}^j e_{in}^j}. \tag{6}$$

Then wage is determined by labor market clearing:

$$\sum_{j=1}^{J} L_i^j = \bar{L}_i. \tag{7}$$

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

$$Y_i = w_i \bar{L}_i + R_i, \quad R_i \equiv \underbrace{\sum_{j=1}^{J}\sum_{n=1}^{N} \frac{e_{in}^j - 1}{e_{in}^j} X_{in}^j}_{\text{Output Tax Revenue}} + \underbrace{\sum_{j=1}^{J}\sum_{k=1}^{N} \frac{t_{ki}^j - 1}{t_{ki}^j e_{ki}^j} X_{ki}^j}_{\text{Import Tariff Revenue}}. \tag{8}$$

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

$$P_n = \prod_{j=1}^{J} \left(P_n^j\right)^{\alpha_n^j}. \tag{9}$$

Finally, the sectoral expenditure can be expressed by

$$X_i^j = \alpha_i^j Y_i + \sum_{s=1}^{J} \left(1 - \beta_i^s\right) \gamma_i^{js} \sum_{n=1}^{N} \frac{X_{in}^s}{t_{in}^s e_{in}^s}. \tag{10}$$

Definition 1 (*Equilibrium*). Given parameters $\left(\theta_j, \psi_j, \alpha_i^j, \beta_i^j, \gamma_i^{sj}; \bar{L}_i, e_{in}^j, t_{in}^j, T_i^j, \tau_{in}^j\right)$, the equilibrium consists of $\left(w_i, L_i^j, P_i^j, X_i^j\right)$ such that

1. Price indices $\left(P_n^j\right)$ are given by Eq. (4).
2. Sectoral labor allocation satisfies Eq. (6).
3. Wage is pinned down by Eq. (7).
4. Sectoral good market clearing holds as in Eq. (10).

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 et al. (2008). We denote the value of any variable Z after change as Z' and $\hat{Z} = Z'/Z$.

Suppose that we have the values of $\left(\alpha_i^j, \beta_i^j, \gamma_i^{sj}, \psi_j, \theta_j\right)$ as well as the data on $\left(X_{in}^j, t_{in}^j, e_{in}^j\right)$. 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 $3NJ + N$ nonlinear equations. The details of the equation system are presented in Online Appendix B.1.[8]

[8] In using the "exact-hat" algebra method we assume balanced trade, which is inconsistent with our data $\left(X_{in}^j\right)$. We follow Ossa (2014) in dealing with this issue. Specifically, we assume that trade imbalances in original data are exogenous international transfers, and use the "exact-hat" algebra method to generate new trade flow data $\left(\tilde{X}_{in}^j\right)$ after eliminating these international transfers. We then treat these after-change trade flows as data in all of our counterfactual analysis.

3.3. Decomposing the welfare effects of policy changes

How does incorporating sectoral economies of scale affect our quantitative analysis on the impacts of trade and industrial policies? Inspired by the sufficient statistics approach developed by Arkolakis et al. (2012), we decompose the welfare effects of policy changes as follows:

Proposition 1 (*Welfare Decomposition*). *The changes in the real income with respect to policy changes are*

$$\log\left(\frac{\hat{Y}_i}{\hat{P}_i}\right) = \underbrace{\sum_{j=1}^{J} \alpha_i^j \left[-\frac{1}{\theta_j}\log\left(\hat{\pi}_{ii}^j\right)\right]}_{\text{Final Goods}} + \underbrace{\sum_{j=1}^{J} \alpha_i^j \left[-\frac{1-\beta_i^j}{\beta_i^j}\left(\log \hat{\Xi}_i^j + \frac{1}{\theta_j}\log\left(\hat{\pi}_{ii}^j\right)\right)\right]}_{\text{Intermediates}} + \underbrace{\sum_{j=1}^{J} \alpha_i^j \frac{\psi_j}{\beta_i^j}\log\left(\hat{L}_i^j\right)}_{\text{Scale Economy}}$$
$$\underbrace{-\sum_{j=1}^{J}\frac{\alpha_i^j}{\beta_i^j}\log\left(\hat{e}_{ii}^j\right)}_{\text{Direct Price Effect}} \underbrace{- \log\left(1-\widehat{\frac{R_i}{Y_i}}\right)}_{\text{Tax Revenue}}, \tag{11}$$

where the sectoral linkages are summarized by

$$\hat{\Xi}_i^j = \prod_{s=1}^{J}\left(\frac{\hat{P}_i^s}{\hat{P}_i^j}\right)^{\gamma_i^{sj}} \tag{12}$$

Proof. See Online Appendix B.2. □

Proposition 1 decomposes the welfare changes led by policy changes into five terms of sufficient statistics. The first two terms, reflecting welfare gains from accessing cheaper final and intermediate goods, are identical with welfare expressions in Caliendo and Parro (2015) under constant-return-to-scale technologies. The third term suggests that, other things equal, a country would benefit from increasing production scale in sectors with higher ψ_j. This term captures welfare gains from reducing misallocation across industries. The fourth term accounts for the direct effect of output taxes on prices, while the last term refers to the welfare effects of tax revenues/subsidy expenses.

3.4. Rationales for import tariffs and industrial policies

In this section, we discuss a country's rationales for import tariffs and industrial policies and how they are affected by other countries' policies. We start from considering the optimal policies enacted by a noncooperative, welfare-maximizing country, as outlined in Lashkaripour and Lugovskyy (2023).

Theorem 1 in Lashkaripour and Lugovskyy (2023) shows that when the full set of trade and industrial policies is feasible, as in their first-best scenario, (i) the optimal import tariff exploits terms-of-trade gains and increases with sectoral trade elasticities; and (ii) the optimal industrial subsidies address misallocation stemming from the cross-industry heterogeneity in scale economies and thereby increase in sectoral scale elasticities. In short, the rationale of import tariffs comes from *terms-of-trade motives*, whereas industrial subsidies aim to address *misallocation across industries*.

Moreover, if the industrial policy is not feasible, as in their second and third-best scenarios, then the optimal approach shifts towards higher import tariffs in sectors with significant scale economies, serving as a partial remedy for the misallocation problem. The key insight here is that while import tariffs can be utilized, they are an inefficient tool for mitigating misallocation due to their impact on import prices. The price increase led by import tariffs decreases consumer welfare, thereby undermining the benefits derived from reducing misallocation.

The aforementioned insights offer justifications for employing import tariffs and industrial policies in a multi-country-multi-sector world in the presence of scale economies. These insights also facilitate a comparative assessment of the effectiveness of these two policies. To what extent do these insights shed light on trade wars and industrial policy competitions across countries? Based on the insights above, we make the following two arguments:

1. A country would experience greater adverse effects from misallocation when other countries subsidize industries with high returns to scale. As a result, it has a stronger incentive to either impose tariffs on imports or offer subsidies to domestic production of these industries to rectify the misallocation issue.
2. When appropriately designed and executed, industrial subsidies tend to be a more efficient response to industrial subsidies implemented by other countries compared to import tariffs. As previously explained, both import tariffs and industrial policies can tackle the misallocation caused by foreign industrial policies. However, import tariffs are less efficient in this regard because they elevate import prices. In contrast, well-implemented industrial policies can effectively address misallocation with considerably fewer distortions, and import tariffs (or subsidies) can be used to address the resulting terms of trade issue.

In sum, inspired by Lashkaripour and Lugovskyy (2023), we argue that a country can leverage terms-of-trade benefits through import tariffs while simultaneously rectifying misallocation across industries via industrial policies. Import tariffs do have the capacity to address misallocation but tend to introduce more distortions compared to industrial policies. These insights provide a rationale for the imposition of tariffs by the Trump administration in response to China's "MIC 2025" industrial subsidies, as well as the subsequent industrial policy proposals set forth by the Biden administration. The insights in this section will guide our quantitative assessments of trade and industrial policies in Section 5.

4. Calibration

We now bring our model to data. The "exact-hat" algebra method requires bilateral trade shares $\left(\pi_{in}^{j}\right)$, sectoral consumption shares $\left(\alpha_{i}^{j}\right)$, sectoral value-added shares $\left(\beta_{i}^{j}\right)$, sectoral expenditure $\left(X_{n}^{j}\right)$, input expenditure shares γ_{i}^{js}, import tariffs $\left(t_{in}^{j}\right)$, production taxes $\left(e_{in}^{j}\right)$, and most importantly, trade elasticities $\left(\theta_{j}\right)$ and scale elasticities $\left(\psi_{j}\right)$. In this section, we first introduce data sources used in model's calibration and counterfactual analysis, and then discuss our calibration of the two sets of elasticities, $\left(\theta_{j},\psi_{j}\right)$.

4.1. Data for calibration and counterfactual analysis

Our quantification exercises consider a world with 6 major economies, the US, China, Japan, EU, Brazil, India, and the rest of world (ROW).[9] We rely on the OECD Inter-Country Input–Output database (ICIO) to extract internationally comparable data on country-sector production, value-added, bilateral trade flows, and input–output linkages. The ICIO table includes 22 tradable sectors and 22 nontradables.[10]

To assess the impacts of the US–China trade war starting from 2018, we need MFN tariffs before the trade war and tariff changes during the trade war. The MFN tariff data come from the World Integrated Trade System (WITS), while the trade war tariffs are hand collected from the announcements by the USTR and China's Ministry of Commerce (MofCom). Both are then aggregated into 22 tradable sectors using a self-constructed crosswalk.

There is no comprehensive database on China's industrial policies across 44 industries covered by the ICIO table. To investigate China's "MIC 2025" industrial subsidies, we employ the following two sources of information.

First, for each of the 22 tradable sectors in ICIO, we identify whether it is supported by the "MIC 2025" project in two steps. We first apply a textual analysis to the descriptions of four-digit HS products (HS4), and match them with the ten high-tech industrial sectors that the "MIC 2025" Project regards as the top priority.[11] We then identify the ICIO sectors that are associated with these HS4 products. We end up with seven sectors that are subject to the "MIC 2025" Project: Chemical, Pharmaceutical, Computer, Electrical equipment, Machinery Nec, Motor vehicles, and Other transport equipment.

Second, we characterize the observed industrial subsidies in China in 2016 and 2018 utilizing two firm-level datasets, the China Stock Market & Accounting Research (CSMAR) Database and China's National Tax Survey (NTS). The details of these databases are introduced in Online Appendix A.3.

Table 1 summarizes sectoral tariff changes during the US–China trade war, linking these tariff changes with whether an industry is supported by the "MIC 2025" project. Table 1 confirms that the Trumpian tariffs (*wave 1*) were concentrated in industries supported by the "MIC 2025" project.

Furthermore, to evaluate how well our model simulations fit the observed changes in China's industry structure, we need information on long-term changes in China's industry structure before and after the US–China trade war and the "MIC 2025" subsidies. We collect the relevant information from the financial statements of China's listed companies, again sourcing from the CSMAR Database. The details of data construction are reported in Online Appendix A.3.

4.2. Calibrating $\left(\theta_{j},\psi_{j}\right)$

As discussed in Section 3.4, trade elasticities $\left(\theta_{j}\right)$ and scale elasticities $\left(\psi_{j}\right)$ are crucial for optimal import tariffs and industrial policies. However, identifying scale economies is challenging since it requires exogenous shocks on sectoral sizes that are uncorrelated with fundamental technology changes. In this paper, we calibrate $\left(\psi_{j},\theta_{j}\right)$ externally from the literature.

Our baseline calibration of $\left(\theta_{j},\psi_{j}\right)$ comes from the recent estimates in Lashkaripour and Lugovskyy (2023). They estimate $\left(\theta_{j},\psi_{j}\right)$ *simultaneously* from firm-level demand parameters, using transaction-level trade data in Colombia and combining exchange rate shocks lagged export sale into a shift-share instrument. The last two columns in Table 1 summarize their estimates of $\left(\theta_{j},\psi_{j}\right)$. The average value of ψ_{j} is 0.23, much larger than the conservative estimate of 0.1 in the literature. Their estimates of ψ_{j} also vary substantially across tradable sectors, leaving considerable room for industrial policies.

We then link the estimates of ψ_{j} with whether an industry is supported by the "MIC 2025" project. We find that industries supported by "MIC 2025" indeed exhibit stronger external economies of scale: the average scale elasticity of industries supported by "MIC 2025" project is 0.28, whereas that of other manufacturing industries is 0.20. As discussed in Section 3.4, the first-best industrial subsidies to these "MIC" industries are higher than these to other industries. This provides a rationale for China's "MIC 2025" industrial subsidies.

As a robustness check, we calibrate $\left(\theta_{j},\psi_{j}\right)$ alternatively from Bartelme et al. (2021). They recover $\left(\psi_{j}\right)$ from the impact of variation in sector size on equilibrium quantities, exploiting variation in countries' population and preferences to construct instruments. They take the values of $\left(\theta_{j}\right)$ from the literature. We report the results of this alternative calibration of $\left(\theta_{j},\psi_{j}\right)$ in Online Appendix Table C.2. Comparing with the estimates in Lashkaripour and Lugovskyy (2023), the estimates of $\left(\psi_{j}\right)$ in Bartelme

9 European Union (EU) consists of 28 countries including the UK.

10 The ICIO has 45 industries. We disregard the last one, which is "Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use" due to a large number of zeros. For details, see OECD. (2021) OECD Inter-Country Input–Output Database, http://oe.cd/icio

11 For a complete list of these ten sectors, see http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm

Table 1
Summary of tradable sectors.

Industry	ICIO code	Description	MFN tariffs (%)		Wave 1 (%)		Wave 5 (%)		MIC 2025	θ_j	ψ_j
			$t_{\mathrm{CN,US}}$	$t_{\mathrm{US,CN}}$	$t_{\mathrm{CN,US}}$	$t_{\mathrm{US,CN}}$	$t_{\mathrm{CN,US}}$	$t_{\mathrm{US,CN}}$			
1	D01T02	Agriculture	1.95	11.04	1.95	16.81	17.56	23.06		6.23	0.14
2	D03	Fishing	0.70	10.59	0.70	13.59	12.90	16.55		6.23	0.14
3	D05T06	Mining, energy	0.00	2.72	0.00	2.72	17.50	24.20		5.28	0.17
4	D07T08	Mining, non-energy	0.27	2.58	0.27	2.58	18.16	20.51		5.28	0.17
5	D09	Mining support	0.25	2.56	0.25	2.56	18.07	20.94		5.28	0.17
6	D10T12	Food	3.84	14.15	3.96	19.78	22.00	30.47		2.30	0.39
7	D13T15	Textiles	7.66	12.71	7.66	12.71	33.36	28.25		3.36	0.22
8	D16	Wood	3.75	12.22	3.75	12.22	26.50	24.92		3.90	0.230
9	D17T18	Paper	2.06	10.19	2.06	10.19	29.92	26.38		2.65	0.32
10	D19	Petroleum	2.96	5.93	3.01	5.93	28.34	20.46		0.64	1.22
11	D20	Chemical	3.17	7.91	4.79	8.01	28.65	22.35	Y	3.97	0.23
12	D21	Pharmaceutical	1.33	4.78	1.53	4.78	5.28	12.84	Y	3.97	0.23
13	D22	Rubber	3.25	12.15	6.67	12.15	27.98	26.75		5.16	0.14
14	D23	Non-metallic	3.24	12.43	3.39	12.43	33.93	23.31		5.28	0.17
15	D24	Basic metals	1.23	5.18	1.29	5.43	18.87	13.08		3.00	0.21
16	D25	Fabricated metal	2.02	11.27	6.40	11.27	28.07	23.13		3.00	0.21
17	D26	Computer	1.90	7.74	10.66	7.74	25.14	17.54	Y	1.24	0.55
18	D27	Electrical equip.	2.14	9.17	15.32	9.17	27.89	19.40	Y	1.24	0.55
19	D28	Machinery nec	1.49	9.36	10.50	9.36	26.37	19.16	Y	7.75	0.12
20	D29	Motor vehicles	1.58	9.76	7.80	10.95	28.57	18.25	Y	2.81	0.13
21	D30	Other transport equip.	1.96	11.04	6.61	11.04	22.30	19.81	Y	2.81	0.13
22	D31T33	Manufacturing nec	2.98	10.06	9.73	10.06	25.22	20.87		6.17	0.15

Notes: $t_{i,n}$ indicates the tariff rate imposed by country n on imports from country i. "Y" in the column "MIC 2025" indicates that the industry is in the MIC2025 project. We calibrate the values of (ψ_j, θ_j) for tradable sectors from Lashkaripour and Lugovskyy (2023). We set $\theta_j = 10$ and $\psi_j = 0$ for non-tradable sectors.

et al. (2021) are much smaller and relatively uniform across industries. Also, according to the estimates in Bartelme et al. (2021), there is no significant difference in average ψ_j between "MIC 2025" industries and other manufacturing industries.

We set (ψ_j, θ_j) from Lashkaripour and Lugovskyy (2023) as our baseline for two reasons. First, Lashkaripour and Lugovskyy (2023) estimate (ψ_j, θ_j) utilizing firm-level variations for identification, whereas Bartelme et al. (2021) calibrate (θ_j) externally. Second, we will show in our counterfactual exercises that China's optimal industrial subsidies under (ψ_j, θ_j) from Lashkaripour and Lugovskyy (2023) can lead to changes in China's industrial structure that correspond closely with the actual transformations observed in the data. The detailed results of this external validity exercise will be shown in Fig. 3 in Section 5.1.3.

5. Counterfactuals

In this section, we conduct three sets of counterfactual exercises. First, we characterize China's subsidies on its high-tech industries. Second, we quantify the interactions of trade wars and industrial policy competitions between the U.S. and China. Third, we characterize the globally cooperative subsidies for high-tech industries.

5.1. China's subsidies to its high-tech industries

Announced in 2015, "MIC 2025" covered 7 industries in the ICIO database. It is challenging to quantify their impacts due to a lack of comprehensive data to uncover all types of subsidies and supporting policies related to this project. We address this challenge through two distinct approaches.

In our first approach, we utilize our model and the data for the economy in 2015 to characterize China's incentives for subsidizing "MIC 2025" industries. In particular, we consider the case in which China imposed a uniform subsidy to "MIC 2025" industries to maximize the Chinese welfare, starting from the economy in 2015. We do not compute the sector-specific optimal subsidies due to high dimensionality of our equilibrium system. However, to allow for sectoral heterogeneity in industrial subsidies, we compute the welfare-maximizing subsidies in China that are proportional to sectoral scale economies. This set of exercises, as a benchmark, provides an *upper bound* characterizing to what extent China would like to subsidize these "MIC 2025" industries.

In our second approach, we approximate actual subsidy rates across sectors in China utilizing various firm-level databases. We regard these observed subsidies as *lower bounds* of actual subsidies since they only cover the direct financial supports that firms report as "subsidies" or "government supports".

5.1.1. China's optimal subsidies to "MIC 2025" industries

We first characterize China's optimal uniform subsidy to its "MIC 2025" industries. The upper panel of Table 2 reports that this optimal uniform subsidy is −7.96%.[12] This large subsidy can be justified by the strong scale economies of these "MIC 2025"

[12] Consistent with our model, we regard subsidy as a negative tax.

Table 2
Welfare effects of china's optimal uniform and observed subsidies to "MIC 2025" industries.

Optimal uniform subsidy: $e^{j*}_{CHN,n} = -7.96\%$ for all n and $j \in$ MIC						
%Δ in:	Welfare	Final	Intermediate	Scale	Direct+Tax	MIC Prod.
China	2.47	−0.02	−2.33	6.07	−1.26	46.43
United States	0.44	0.88	0.38	−0.84	0.02	−12.56
European Union	0.10	0.48	0.66	−1.07	0.03	−11.61
Japan	−0.13	0.58	0.65	−1.35	−0.02	−16.92
India	0.66	1.51	2.97	−3.99	0.17	−15.06
Brazil	0.62	0.57	1.87	−1.95	0.13	−8.48
ROW	0.53	1.37	2.70	−3.66	0.12	−33.33
$e^{a*}_{CHN,n} = -4.04\%$ and $e^{b*}_{CHN,n} = -15.57\%$ for $j = 1, \dots, 22$ and $j \neq 10$						
%Δ in:	Welfare	Final	Intermediate	Scale	Direct+Tax	MIC Prod.
China	3.92	0.18	0.43	8.60	−5.29	48.57
United States	0.40	1.06	0.64	−1.37	0.07	−10.35
European Union	0.05	0.55	0.78	−1.36	0.07	−8.75
Japan	−0.15	0.81	0.95	−1.94	0.03	−13.67
India	−0.06	1.26	2.66	−4.18	0.20	−15.41
Brazil	0.38	0.52	1.63	−1.97	0.20	−6.90
ROW	0.29	1.33	2.49	−3.78	0.25	−26.75
$\left\{e^{j}_{CHN,n}\right\}$ observed in China's National Tax Survey (NTS)						
%Δ in:	Welfare	Final	Intermediate	Scale	Direct+Tax	MIC Prod.
China	0.246	−0.019	−0.095	0.384	−0.025	2.214
United States	0.012	0.026	0.010	−0.025	0.001	−0.382
European Union	0.000	0.014	0.020	−0.035	0.001	−0.366
Japan	−0.010	0.016	0.018	−0.044	0.000	−0.526
India	0.015	0.043	0.089	−0.122	0.004	−0.384
Brazil	0.019	0.016	0.058	−0.060	0.004	−0.217
ROW	0.006	0.041	0.085	−0.125	0.004	−1.188

Notes: We start from the observed world economy in 2015 without any industrial subsidies. "Final", "Intermediates", "Scale", and "Direct+Tax" effects are defined in Eq. (11). In the first panel, $e^{j*}_{CHN,n}$ is the uniform subsidies (or taxes) on $j \in$ MIC that maximize the change in the Chinese welfare. In the second panel, $\left(e^{a*}_{CHN,n}, e^{b*}_{CHN,n}\right)$ results in $e^{j*}_{CHN,n}$ defined by Eq. (13) for $j = 1, \dots, 22$ and $j \neq 10$ that maximize the change in the Chinese welfare. In the last panel, $\left\{e^{j}_{CHN,n}\right\}$ come from China's National Tax Survey Data introduced in Section 4.1.

industries listed in Table 1. Imposing this optimal uniform subsidy in 2015, China would increase the production value of its "MIC 2025" industries by 46.43%, which in turn leads to a 2.47% welfare gain. Moreover, China's optimal uniform subsidy on "MIC 2025" industries would increase the welfare in most of the major economies, except for Japan, mainly through the decline in intermediate prices.

We further decompose the welfare effects of industrial subsidies based on Eq. (11) into effects on final goods, intermediates, scale economies, prices and tax revenues, which are also reported in the upper panel of 2. We find that China gains from subsidizing its "MIC 2025" sectors via scale economies. In Online Appendix, we show that if we impose $\psi_j = 0$ for all j, then China would lose from subsidizing "MIC 2025" sectors but gain from taxing them.[13] In other words, China's industrial subsidies cannot be justified in the absence of scale economies.

Notably, all other major economies lose from the decline in production scale of these high-tech industries, whereas all of them except for Japan are fully compensated by the reduction in their final and, more important, intermediate prices.

We further consider sectoral heterogeneity in optimal industrial subsidies. As discussed in Section 3.4, Lashkaripour and Lugovskyy (2023) have argued that the first-best industrial subsidies are proportional to sectoral economies of scale. Their result is derived under the assumption that other countries' relative wages stay constant. In our quantitative analysis, we do not impose this strong assumption and let the relative wages of other countries change in response to industrial subsidies in general equilibrium. It is therefore still an open question if the optimal subsidies should still be increasing with scale elasticities. To examine this issue, we consider the following scheme of industrial subsidies:[14]

$$e^{j}_{CHN,n} = e^{a}_{CHN,n} + e^{b}_{CHN,n} \times \frac{\psi_j}{1+\psi_j}, \quad j = 1, 2, \dots, 22. \tag{13}$$

We solve for $\left(e^{a}_{CHN,n}, e^{b}_{CHN,n}\right)$ that maximizes the Chinese welfare. The results are shown in the lower panel of Table 2. We find that $e^{a*}_{CHN,n} = -4.04\%$ and $e^{b*}_{CHN,n} = -15.57\%$ for $j = 1, \dots, 22$ and $j \neq 10$. $e^{b*}_{CHN,n} < 0$ confirms the positive relationship between the optimal industrial subsidies and sectoral economies of scale shown in Lashkaripour and Lugovskyy (2023).

13 Please see Online Appendix Figure C.1 for the detailed results.

14 We exclude Petroleum ($j = 10$) whose ψ_j is extremely large.

We conduct two robustness exercises in Online Appendix. First, we re-compute optimal industrial subsidies similar to these in Table 2 under the estimates of (ψ_j, θ_j) in Bartelme et al. (2021), which imply lower scale elasticities for the "MIC 2025" industries. In this case, the optimal uniform subsidy is much lower, $e^{j*}_{CHN,n} = -1.07\%$. The welfare consequences of the optimal subsidies in this case are shown in Online Appendix Table C.3. They are qualitatively in line with those in Table 2. Second, we consider the fact that "MIC 2025" sectors only account for a fraction of production in each ICIO sectors. We thereby divide each ICIO sector supported by "MIC 2025" into two sectors, "MIC 2025" and non-"MIC 2025", aggregated by a Cobb–Douglas function. In this case, the welfare effects of China's optimal uniform subsidy on "MIC 2025" industries shown in Online Appendix Table C.5 are also qualitatively in line with those in Table 2, but with smaller magnitudes.

5.1.2. Observed industrial subsidies in China

We also characterize the observed direct industrial subsidies across sectors in China and their global impacts. To this end, we utilize two firm-level data sources in China: (i) R&D subsides documented in the financial data for Chinese Listed Firms (CSMAR), and (ii) official subsidies reported in the National Tax Survey (NTS) in China. Both data sources are for the year of 2016, one year after the announcement of "MIC 2025" and before the initiation of the "Section 301" investigation. The details of these data sources are presented in Online Appendix A.3.

Fig. 2 summarizes the observed industrial subsidies from the two data sources. We highlight here three observations:

1. We find that the observed subsidies as a share of total revenue are lower than 0.5% in all sectors, much lower than the optimal uniform subsidy we estimated above. In reality, the Chinese governments support specific industries or firms via multiple channels other than explicit "subsidies", such as cheap bank credits, low-priced land, government-sponsored venture capital investments, and subsidies to downstream customers that boos demand, etc. Therefore, we regard the observed subsidies as a lower bound on the actual industrial subsidies.
2. We do find that the industries supported by "MIC 2025" have higher observed subsidy rates than other tradable sectors. In China Listed Firm Data, the average subsidy rate is 0.2% for "MIC 2025" industries but 0.05% for non-"MIC 2025" industries. In China National Tax Survey Data, the average subsidy rate is 0.29% for "MIC 2025" industries but 0.1% for non-"MIC 2025" industries. Therefore, it is evident that the Chinese governments concentrate their industrial subsidies to high-tech industries supported by the "MIC 2025" Project.
3. We link the observed industrial subsidies with the calibrated scale economies in Table 1. Panel (c) and (d) of Fig. 2 show that the observed industrial subsides increase with ψ_j. This result suggests that China's actual industrial subsidies are in line with the insights discussed in Section 3.4.

The last panel in Table 2 summarizes the welfare effects of China's observed industrial subsidies. The results are qualitatively in line with those under optimal uniform subsidies but with much smaller magnitudes. China's observed industrial subsidies increase the Chinese welfare via scale economies and benefit other economies primarily by lowering their intermediate prices.

5.1.3. Model-fit to changes in China's industrial structure

China experienced considerable changes in industrial structure over 2015–2022, associated with the "MIC 2025" industrial subsidies and the US–China trade war starting from 2018. These observed changes give us a chance to assess our model-fit. In particular, is a particular calibration more consistent with the observed changes in China's industry structure?

We gather information regarding changes in China's industrial structure from the financial statements of China's listed firms. We gauge the composition of China's manufacturing sectors based on the sectoral distribution of assets. Our choice to utilize asset-based approximations is driven by the relatively higher data quality associated with this measure. We designate 2015 as our starting point and compute a simple average across the years from 2018 to 2022 as our endpoint.

Our model simulations start from data in 2015. We consider two sets of exogenous shocks: the US–China tariff war (Wave 5) and China's "MIC 2025" industrial subsides. We then generate model-predicted changes in output shares using (1) the optimal industrial subsidies in our baseline calibration reported in the second panel of Table 2, (2) the optimal industrial subsidies in the calibration based on Bartelme et al. (2021), (3) observed industrial subsidies in our baseline calibration, and (4) observed industrial subsidies in the calibration based on Bartelme et al. (2021), respectively. The results are reported in Fig. 3, which shows that only predicted changes in output shares using the optimal industrial subsidies in our baseline calibration are positively correlated with changes in asset shares in the data, whereas other three cases generate changes that are negatively correlated with the observed changes. These results suggest that our benchmark calibration and the assumption of optimal subsidies are partly supported by the Chinese data.

5.2. Trade wars and industrial policy competitions between the U.S. and China

5.2.1. Trumpian tariffs and the "MIC 2025" subsidies

In this subsection, we investigate the impacts of Trumpian tariffs on imports from China and, in particular, how the impacts of Trumpian tariffs depend on the "MIC 2025" industrial subsidies. To this end, we start from the economy in 2017 and assume that China has implemented its optimal uniform subsidy to "MIC 2025" industries (shown in Table 2) in this economy.

Table 3 suggests that Trumpian tariffs (*Wave 1*) decrease the production of "MIC 2025" industries in China by 3.303% and thereby reduce the welfare in China by 0.263%. Correspondingly, these tariffs increase the production of "MIC 2025" industries in the U.S. by 1.448% and increase the welfare in the U.S. by 0.033%.

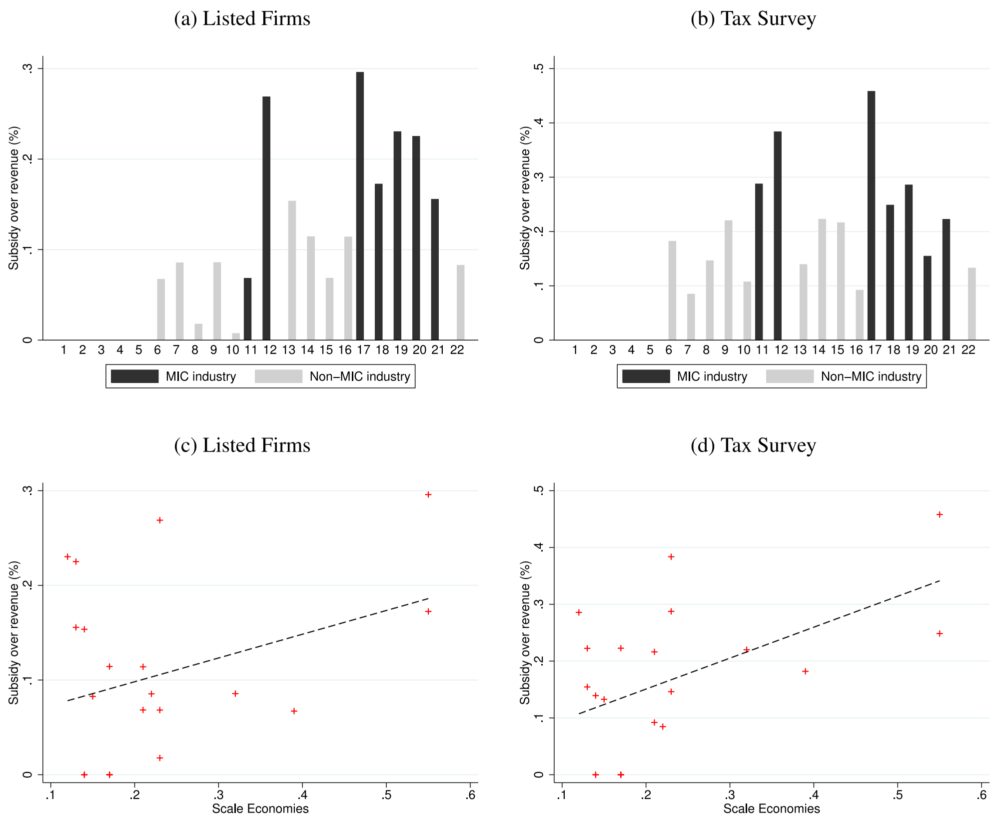

Fig. 2. Observed industrial subsidies in China (2016).
Notes: Sectors are described in Table 1. “Scale economies” refer to (ψ_j) reported in the last two columns of Table 1. In Panel (c) and (d), we exclude Petroleum ($j = 10$) whose ψ_j is extremely large. Moreover, “Listed Firms” refers to the CSMAR database, whereas “Tax Survey” refers to the NTS database (see Section Section 4.1).

Table 3
Trumpian tariffs (*Wave 1*) with and without “MIC 2025”.

	“MIC 2025”					
%Δ in:	Welfare	Final	Intermediate	Scale	Direct+Tax	MIC Prod.
United States	0.033	−0.114	−0.056	0.097	0.106	1.448
China	−0.263	0.012	0.188	−0.605	0.143	−3.303
European Union	−0.009	−0.022	−0.030	0.043	0.000	0.463
Japan	−0.002	−0.023	−0.029	0.049	0.001	0.609
India	−0.009	−0.067	−0.134	0.194	−0.002	0.556
Brazil	−0.043	−0.024	−0.085	0.070	−0.003	0.292
ROW	−0.030	−0.064	−0.138	0.174	−0.002	1.619
	No “MIC 2025”					
%Δ in:	Welfare	Final	Intermediate	Scale	Direct+Tax	MIC Prod.
United States	0.027	−0.040	−0.021	0.038	0.050	0.263
China	−0.253	0.047	0.260	−0.555	−0.004	−1.661
European Union	0.000	−0.002	−0.001	0.003	0.000	0.116
Japan	0.002	0.001	0.003	−0.003	0.000	0.139
India	0.030	−0.008	−0.016	0.054	0.001	0.329
Brazil	−0.014	−0.005	−0.018	0.009	0.000	0.114
ROW	−0.008	−0.010	−0.023	0.026	−0.001	0.370

Notes: In “MIC 2025”, we start from the economy in 2017 in which China subsidizes “MIC 2025” at the rate in the first panel of Table 2. In “No ‘MIC 2025’”, we first eliminate all subsidies in the economy in 2017 and start from this new equilibrium with zero subsidies. “Final”, “Intermediates”, “Scale”, and “Direct+Tax” effects are defined in Eq. (11).

To understand the implications of “MIC 2025” for the incentives of Trumpian tariffs, we eliminate China’s subsidies to “MIC 2025” sectors from the economy in 2017 and re-compute the equilibrium. Starting from this new equilibrium with zero subsidies, we

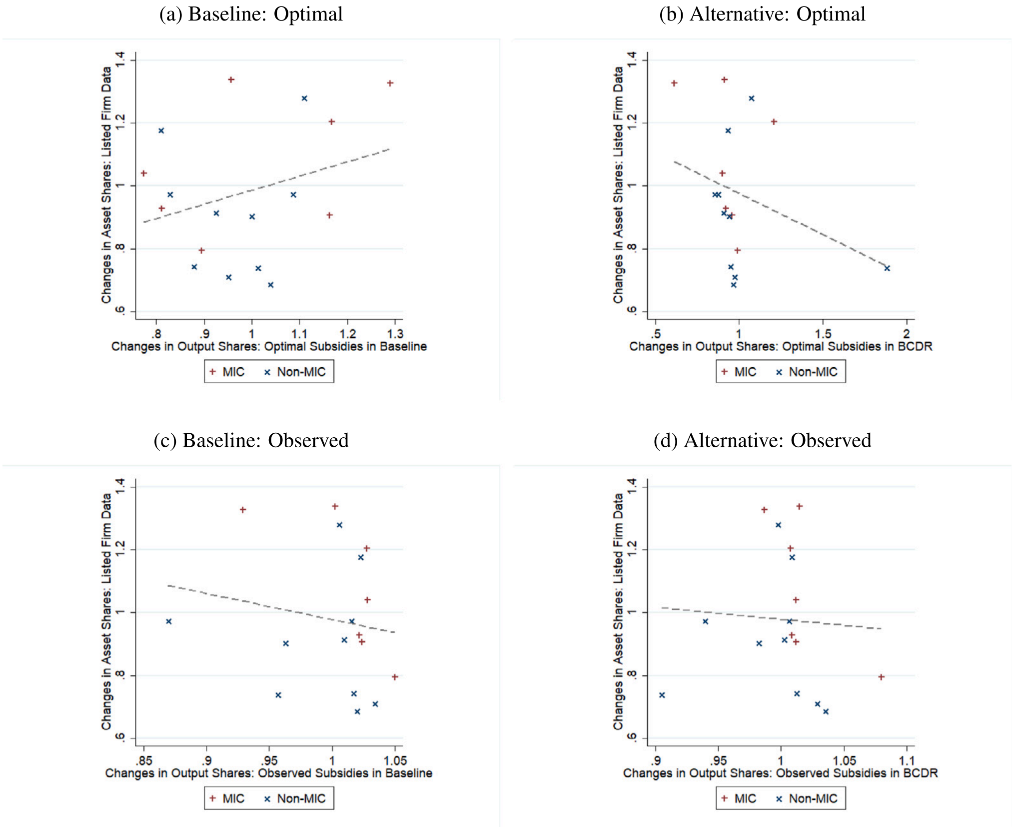

Fig. 3. Observed vs. predicted changes in the structure of Chinese manufacturing.
Notes: In Panel (a), we illustrate the production effects of the optimal subsidies proportional to scale economies (defined by Eq. (13) for $j = 1, \dots, 22$ and $j \neq 10$) in our baseline calibration. In Panel (b), we illustrate the production effects of the analogous optimal subsidies in the calibration based on Bartelme et al. (2021). In Panel (c) and (d), we illustrate the production effects of the observed subsidies (from NTS data) in our baseline calibration and in the calibration based on Bartelme et al. (2021), respectively. The change in the aggregate asset share (end value/initial value) of the MIC sectors is 1.089 in the data. The change in the aggregate production share (end value/initial value) of the MIC sector is 1.072 under optimal subsidies in our baseline model, 0.901 under optimal subsidies in the alternative calibration, 0.999 under observed subsidies in our baseline model, and 1.006 under observed subsidies in the alternative calibration.

re-compute the welfare impacts of Trumpian tariffs (*Wave 1*). Comparing with the baseline case with “MIC 2025” subsidies, the U.S. gains less from the first wave of Trumpian tariffs (0.027%) in the alternative case without “MIC 2025” subsidies. Notably, Caliendo and Parro (2021) find that the Trumpian tariffs in 2018 (without China’s retaliation) increase the U.S. real income by 0.024%. This result is close to our estimate without the “MIC 2025” subsidies but lower than that in our baseline case with the “MIC 2025” subsidies. It is consistent with our argument in Section 3.4 that China’s subsidies to high-return-to-scale industries could lead to more cross-sector misallocation in the U.S. and thereby increase the U.S. gains from imposing tariffs on imports from China.

We also look at the welfare effects of Trumpian tariffs (*Wave 1*) on other major economies and how these effects depend on the “MIC 2025” subsidies. In the baseline case with the “MIC 2025” subsidies, Trumpian tariffs (*Wave 1*) concentrated in China’s “MIC 2025” sectors significantly increase the global intermediate prices of these sectors and thereby decrease the welfare in most of the other major economies. In contrast, without the “MIC 2025” subsidies, the intermediate price effect is overwhelmed by the trade diversion effect. In this case, Trumpian tariffs (*Wave 1*) would increase the welfare in most of the other major economies.

We conduct a robustness exercise by dividing each ICIO sector supported by “MIC 2025” into two sectors, “MIC 2025” and non-“MIC 2025”. All results above hold qualitatively. The details of this robust exercise are reported in Online Appendix Table C.6.

Finally, we quantify the interactions of the US–China trade wars (wave 1&5) and the optimal “MIC 2025” subsidy. Table 4 suggests that China loses considerably from both rounds of trade wars, whereas the U.S. gains slightly from wave 1 but loses from wave 5. In addition, the U.S. gains more (loses less) from trade wars in our baseline case with the optimal “MIC 2025” subsidy than in those without the subsidy. Moreover, most of the other major economies lose from the US–China trade wars, particularly in the case with the “MIC 2025” subsidy.

5.2.2. The U.S. and China’s Nash tariffs on high-tech industries

In this section, we characterize the Nash tariffs on “MIC 2025” industries in the U.S. and China. This exercise sheds light on the incentives of the U.S. and China to compete in these high-tech industries via import tariffs. In our baseline case, we start from the economy in 2017 and assume that the optimal uniform subsidy of China in Table 2 has been implemented.

Table 4
The US–China trade wars (Wave 1&5) with and without "MIC 2025".

	Wave 1		Wave 5	
%Δ in Welfare:	"MIC 2025"	No "MIC 2025"	"MIC 2025"	No "MIC 2025"
United States	0.020	0.018	−0.031	−0.050
China	−0.266	−0.257	−0.720	−0.700
European Union	−0.008	0.000	−0.010	0.001
Japan	−0.001	0.002	−0.005	−0.017
India	−0.012	0.029	0.027	0.109
Brazil	−0.042	−0.013	−0.085	−0.036
ROW	−0.030	−0.007	−0.039	−0.005

Notes: "Wave 1" refers to Trumpian tariffs (*Wave 1*) and China's corresponding retaliation tariffs. "Wave 5" is defined analogously. In "MIC 2025", we start from the economy in 2017 in which China subsidizes "MIC 2025" at the rate in the first panel of Table 2. In "No 'MIC 2025'", we first eliminate all subsidies in the economy in 2017 and start from this new equilibrium with zero subsidies.

Table 5
Nash tariffs on "MIC 2025" industries in the U.S. and China.

	Nash Tariffs (%)			
	"MIC 2025"		No "MIC 2025"	
	United States	China	United States	China
Nash	13.23	20.42	18.81	27.77
Wave 1	6.23	0.18	–	–
Wave 5	21.52	9.94	–	–
	Effects of Nash tariffs			
	"MIC 2025"		No "MIC 2025"	
%Δ in:	Welfare	MIC Prod.	Welfare	MIC Prod.
United States	−0.017	0.671	−0.077	−2.706
China	−0.251	−3.802	−0.249	−1.766
European Union	−0.004	0.714	0.018	0.595
Japan	0.006	0.863	0.025	0.686
India	−0.047	0.570	−0.012	0.176
Brazil	−0.038	0.431	0.005	0.283
ROW	−0.025	2.426	0.025	1.610

Notes: In "MIC 2025", we start from the economy in 2017 in which China subsidizes "MIC 2025" at the rate in the first panel of Table 2. In "No 'MIC 2025'", we first eliminate all subsidies in the economy in 2017 and start from this new equilibrium with zero subsidies. In each case, we compute the Nash uniform tariffs on $j \in$ MIC in the U.S. and China. Moreover, "Wave 1" refers to the simple averaged tariffs on "MIC 2025" industries in the first wave of the US–China trade war, whereas "Wave 5" refers to the analogous tariffs in the fifth wave of the US–China trade war.

We consider the Nash game in which each country chooses a uniform tariff rate on imports of "MIC 2025" industries from the other country. The Nash tariffs are shown in the first two columns in the upper panel of Table 5. In the Nash equilibrium, the U.S. tariff on "MIC 2025" industries is 13.23%, whereas the Chinese tariff is 20.42%. Notice that the U.S. Nash tariff is in the middle of Trumpian wave 1 and wave 5 tariffs, whereas the Chinese Nash tariff is much higher than the actual levels.

The first two columns in the lower panel of Table 5 show that Nash tariffs lead to considerable welfare losses in both U.S. and China. China suffers more in this Nash game, both in terms of welfare and the production of "MIC 2025" industries. This result indicates the importance of these high-tech industries in China. Moreover, most of the other major economies loses from the Nash tariffs, primarily due to the increases in intermediate prices.

We also compute the Nash tariffs in the world without the optimal uniform subsidy to "MIC 2025" industries by China. The last two columns in the upper panel of Table 5 suggest that the Nash tariffs in this world are much higher than those in our baseline case: 18.81% in the U.S. and 27.77% in China. We find that the U.S. loses more from the Nash tariffs in this case than in the case with China's optimal uniform subsidy to "MIC 2025" industries.

To understand the role of scale economies and terms of trade in shaping tariff wars, we compute Nash tariffs on "MIC 2025" industries between U.S. and China under $\psi_j = 0$ for all j. We find that Nash tariffs are much lower in this case than in our baseline case. Moreover, the welfare losses in the U.S. and China led by tariff wars are much smaller. As a result, while terms-of-trade manipulation could rationalize tariff wars, scale economies are important in understanding prohibitive tariffs and their severe disruptions during trade wars. The detailed results of this case are presented in Online Appendix Table C.1.

We finally conduct a robustness exercise by dividing each ICIO sector supported by "MIC 2025" into two sectors, "MIC 2025" and non-"MIC 2025". All results in this subsection hold qualitatively in this robustness exercises. The detailed results are reported in Online Appendix Table C.7.

Table 6
Nash tariffs and subsidies on "MIC 2025" industries in the U.S. and China.

	Nash Equilibrium			
	"MIC 2025"		No "MIC 2025"	
	United States	China	United States	China
Tariffs (%)	5.57	21.23	11.27	10.61
Subsidies (%)	−9.59	–	−9.44	−12.77
	Changes under Nash Equilibrium			
	"MIC 2025"		No "MIC 2025"	
%Δ in:	Welfare	MIC Prod.	Welfare	MIC Prod.
United States	0.260	61.556	0.435	−14.250
China	−0.155	−2.688	2.510	138.810
European Union	−0.268	−11.377	0.007	−15.556
Japan	−0.257	−7.981	−0.395	−22.457
India	−0.007	−3.627	0.953	−15.812
Brazil	−0.143	−8.256	0.740	−9.225
ROW	−0.117	−20.403	0.322	−38.845

Notes: In "MIC 2025", we start from the economy in 2017 in which China subsidizes "MIC 2025" at the rate in the first panel of Table 2. In this case, we compute the Nash uniform tariff and subsidy on $j \in$ MIC in the U.S. and the Nash uniform tariff on $j \in$ MIC in China. In "No 'MIC 2025'", we first eliminate all subsidies in the economy in 2017 and start from this new equilibrium with zero subsidies. In this case, we compute the Nash uniform tariffs and subsidies on $j \in$ MIC in the U.S. and China.

5.2.3. Industrial policy competitions between the U.S. and China

In this section, we consider the case in which the U.S. can not only impose protectionist tariffs, but also subsidize its own high-tech industries as China did. The key question is: in this case, would the U.S. still impose high tariffs on the imports of "MIC 2025" industries from China? In our baseline case, we start from the economy in 2017 and assume that the optimal uniform subsidy in Table 2 has been implemented.

We consider the Nash game in which the U.S. chooses a uniform subsidy on "MIC 2025" industries and a uniform tariff on imports of these industries from China, whereas China chooses a uniform tariff on imports of "MIC 2025" industries from the U.S. The first two columns of the upper panel of Table 6 show that when the U.S. can also subsidize its "MIC 2025" industries, it will implement a 9.59% subsidy on the production in these industries and, simultaneously, reduce its protectionism tariffs on these industries to 5.57%, much lower than its Nash tariff 13.23% and even lower than the average Trumpian tariff (*Wave 1*) 6.23% (see Table 5).

What are the welfare effects of the Nash game in which the U.S. can choose both tariffs and industrial subsidies? The first two columns in the lower panel of Table 6 show that, comparing with the Nash tariff game, allowing the U.S. to implement industrial subsidies lead to much larger welfare gains to the U.S. and, correspondingly, smaller welfare losses in China. This result is consistent with our argument in Section 3.4 that both import tariffs and industrial subsidies can increase the domestic production scale as a response to other countries' industrial subsidies, but industrial subsidies, if properly specified and implemented, can do so without distorting the import prices.

We also consider the Nash game in which the U.S. and China simultaneously choose their tariffs and subsidies on "MIC 2025" industries. To this end, we start from the economy in 2017 without any industrial subsidies. The last two columns of the upper panel of Table 6 show that, comparing with the unilateral optimal subsidies, China would implement a higher uniform subsidy, 12.77%, in this Nash game. In the meanwhile, China's equilibrium tariff in this Nash game is much lower than those in the Nash tariff game in Table 5. The last two columns of the lower panel of Table 6 suggest that both the U.S. and China gain substantially from this Nash game and most of the major economies, except for Japan, gain as well.

Again, we conduct a robustness exercise by dividing each ICIO sector supported by "MIC 2025" into two sectors, "MIC 2025" and non-"MIC 2025". All results in this subsection hold qualitatively in this robustness exercises. The detailed results are reported in Online Appendix C.8.

5.3. Global cooperation in industrial policies

International competitions via trade and industrial polices, as quantified in Section 5.2, tend to result in considerable welfare losses in major economies. If we turn international policy conflicts and competitions into global cooperation, what is the scope for welfare improvements? In particular, can globally coordinated industrial policies address misallocation in a way that benefits all countries? In this section, we utilize our model to quantify the welfare gains from global cooperation in industrial policies.

We first start from the calibrated economy in 2015, without trade war and industrial policies, and consider a global social planner choosing, for each country i, a uniform industrial subsidy $e_i^j \equiv e_{in}^j$ for all n and $j \in$ MIC. The objective is to maximize the *minimum* of changes in welfare across countries, i.e. $\max\min\{\hat{W}_i\}$. The results are shown in the first panel of Table 7. We find that all major economies impose substantial subsidies to their "MIC 2025" high-tech industries to maximize the minimum of welfare changes across countries. These subsidies result in considerable welfare gains for all major economies, particularly for developing

Table 7
Globally cooperative industrial policies.

Maximizing the minimum of changes in welfare							
	Subsidy (%)	%ΔWelfare	Final	Intermediate	Scale	Direct+Tax	%ΔMIC Prod.
Brazil	−8.94	2.39	0.60	−0.38	0.38	1.78	9.92
China	−13.28	0.42	0.23	−2.80	8.31	−5.32	64.68
European Union	−3.33	0.43	0.96	0.96	−1.88	0.39	−26.07
India	−8.77	2.99	2.15	1.93	−3.51	2.41	7.10
Japan	−7.65	0.42	0.91	0.80	−0.92	−0.36	−6.75
ROW	−2.08	1.67	3.65	6.76	−9.50	0.76	−67.88
United States	−3.35	1.20	1.80	0.61	−1.70	0.49	−28.87
Maximizing the equally distributed welfare gains							
	Subsidy (%)	%ΔWelfare	Final	Intermediate	Scale	Direct+Tax	%ΔMIC Prod.
Brazil	−1.18	0.17	0.07	−0.05	−0.17	0.32	−4.42
China	−1.23	0.17	0.03	−0.18	0.08	0.25	−0.67
European Union	−3.56	0.17	−0.02	−0.32	0.40	0.11	8.96
India	−1.54	0.17	0.12	−0.18	−0.24	0.48	−3.43
Japan	−5.69	0.17	−0.01	−0.06	0.85	−0.60	18.31
ROW	−1.57	0.17	0.18	0.14	−0.46	0.31	−8.88
United States	−2.31	0.17	0.04	−0.14	0.02	0.24	−0.82
Zero import tariffs + cooperative industrial subsidies							
	e_i^{b*}	%ΔWelfare	Final	Intermediate	Scale	Direct+Tax	%ΔMIC Prod.
Brazil	−0.85	2.06	1.46	−11.51	8.26	3.85	1.26
China	−0.43	1.78	0.34	0.50	5.01	−4.07	−2.33
European Union	−0.60	1.78	0.80	−1.70	0.95	1.74	−29.17
India	−0.42	2.81	4.23	4.59	−9.74	3.72	−44.50
Japan	−0.59	1.88	1.02	2.03	0.17	−1.34	−14.22
ROW	−0.69	1.78	0.48	−2.58	3.97	−0.09	6.02
United States	−1.01	1.78	0.44	−2.17	4.93	−1.42	22.78

Notes: We eliminate all subsidies in the economy in 2017 and start from this new equilibrium with zero subsidies. "Final", "Intermediates", "Scale", and "Direct+Tax" effects are defined in Eq. (11). "Maximizing the Minimum of Changes in Welfare" refers to maximizing $\min_{i=1,\dots,N} \hat{W}_i$. "Maximizing the Equally Distributed Welfare Gains" refers to maximizing $\hat{W}_1$ subject to $\hat{W}_i = \hat{W}_1$ for all $i = 1,\dots,N$. In the last panel, We let $\tilde{t}_{in}^j = 0$ for all (i,n,j) and solve for $\left(e_i^b\right)_{i=1}^N$ in Eq. (14) that maximizes the minimum of $\left(\hat{W}_i\right)_{i=1}^N$.

countries such as Brazil and India. Moreover, these cooperative subsidies tend to concentrate the production of "MIC 2025" high-tech industries to China. Consequently, China mainly gains from this industrial policy competition through scale effects, whereas other major economies primarily gain through the decline in final and intermediate prices.

We then consider an alternative scenario in global cooperation, inspired by cooperative tariffs in Ossa (2014). In this scenario, a global social planner still chooses a uniform industrial subsidy e_i^j for all $j \in$ MIC and for each i. The objective of the social planner is to increase the welfare in all countries by an equal amount (in percentage) and to maximize this equal amount, *i.e.* $\max \hat{W}_1$, s.t. $\hat{W}_i = \hat{W}_1$ for all $i = 1,\dots,N$. The results are shown in the second panel of Table 7. We find moderate welfare gains for all major economies in this scenario. Moreover, to ensure equal gains from industrial policy cooperation, Japan and European Union have to impose relatively larger subsidies to the "MIC 2025" industries. Therefore, in this cooperation scenario, production of the "MIC 2025" high-tech industries would be shifted from China towards Japan and European Union.

Finally, we quantify the consequences of zeros tariffs plus industrial subsidies proportional to sectoral scale economies, inspired by the globally first-best policies in Lashkaripour and Lugovskyy (2023). In particular, we start from the calibrated economy in 2015, setting $\tilde{t}_{in}^j = 0$ for all (i,n,j) and computing the following shifter of industrial subsidies in each country i

$$e_i^j = e_i^b \times \frac{\psi_j}{1+\psi_j}, \quad j = 1,2,\dots,22 \quad j \neq 10, \tag{14}$$

that maximize the *minimum* of changes in welfare across countries. The results are shown in the last panel of Table 7. We find that $e_i^{b*} < 0$ for all i, suggesting that it is globally optimal to impose higher subsidies to high-return-to-scale industries. Moreover, all countries, particularly Brazil and India, gain substantially in this scenario. Interestingly, zeros tariffs and cooperative industrial subsidies proportional to scale economies tend to shift the production of the "MIC 2025" high-tech industries towards the U.S. This result indicates that if the U.S. wants to induce high-tech manufacturing moving back home, it should abandon the Trumpian tariffs and negotiate cooperative industrial policies with other countries.

6. Conclusion

This paper provides the first quantitative assessment of the interactions of import tariffs and industrial policies in the context of the US–China trade war. We incorporate sectoral scale economies into the multi-country-multi-sector general equilibrium model developed by Caliendo and Parro (2015) and quantify the impacts of tariff wars and industrial policy competitions between the U.S. and China. Our counterfactual exercises (i) provide a rationale for China's subsidies on the "MIC 2025" industries and the Trumpian tariffs targeting on these high-tech industries and (ii) suggest that industrial policies generate less distortion than import tariffs as a means of competition between the U.S. and China.

In evaluating the role of industrial policies, we have assumed in this paper that subsidies are financed by lump sum taxes and there is no distortion in the implementation of these subsidies. An important future research question is how the impacts of industrial policies would change if the financing and implementation of these policies are subject to distortions.

We have provided evidence that the US–China economic conflicts starting from 2018 are essentially a technology competition. Our model in this paper characterizes the technology competition by assuming that the productivity of a sector is endogenously determined by its production scale. In this sense, our model is isomorphic to the steady state of standard endogenous growth models. To characterize rich dynamics in technology competitions and understand the dynamic impacts of trade and industrial policies, we need a multi-country-multi-sector dynamic general equilibrium models with endogenous technology progress. We also leave this for the future work.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jmoneco.2023.10.012.

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