China's Trade Retaliation:
Factuals vs. Counterfactuals

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Abstract

Throughout the past century, opportunities to analyze and understand trade wars have been limited. Building on China's *eye for an eye* retaliation in the 2018-2019 US-China trade war, this paper introduces a quantitative framework designed to (i) estimate the welfare consequences of retaliatory tariffs varying by policy motives, (ii) assess the relevance of multiple trade policy theories to actual retaliatory actions, (iii) identify the policy intentions behind the observed retaliation, and (iv) gauge the lower bound of welfare deterioration resulting from trade retaliation. The incorporation of counterfactual tariffs as controls provides various insights into the infrequent occurrence of trade wars.

Key words: Trade wars, retaliatory tariffs, industrial policy
JEL codes: F13, O24

1   Introduction

International trade theories illustrate why and how countries should avoid trade wars. Thanks to these theories and the global trade policies that adhere to them, trade wars have been a rare occurrence since the 1950s. Nevertheless, situations that can be avoided do not always get avoided. The recent US-China trade war serves as a prime example. The world's two largest economies, both reaping substantial benefits from trade liberalization, engaged in a large-scale trade conflict during 2018-2019. For trade theory practitioners, academics, and policymakers, it is crucial to uncover the motives underlying these actions. Trade theories recognize various motives that drive countries to impose tariffs on one another. By examining these motives within the context of an actual trade war, we can comprehend why trade wars still occur, their impact on welfare, and how to avert similar conflicts in the future.

In this study, we examine the factual and counterfactual motives of China's trade retaliation against the US. Reacting to the punitive tariffs imposed by the Trump administration, China countered by reflecting the taxable value and rate structure of the US, as depicted in Figure 1. Take

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Tranche 1 of the two countries, for example. The US specified a 34 billion USD taxable value and a 25 percent tariff rate, followed by China which set precisely the same taxable value and tariff rate. Conceivably, if China retaliated based on its domestic economic needs, it would have been unlikely to set identical terms as the US. In reality, not only did China set the same terms, it even selected the same effective date of July 6, 2018. This date was selected by the US because its tariff proposal had been posted in the Federal Register three months in advance on April 6 (as required by law). Given that China has unique political and policymaking systems that differ markedly from those in the US, a likely, and perhaps the sole, reason for China to counter US trade policies using identical terms was to convey a demonstration of strength. The power struggle started from Tranche 1, lasting until the two countries signed a trade ceasefire (known as the "Phase One Deal") in January 2020.

Figure 1: Timeline of the US-China Trade War

The US side	The Chinese side
6-15-2018:	6-15-2018:
• Tranche 1: **effective 7-6-2018, 34bn USD, rate: 25%**	• Tranche 1: **effective 7-6-2018, 34bn USD, rate: 25%**
• Tranche 2: **effective 8-23-2018, 16bn USD, rate: 25%**	• Tranche 2: **effective 8-23-2018, 16bn USD, rate: 25%**
7-10-2018:	9-18-2018:
• Tranche 3: **effective 9-24-2018**, 200bn USD, rate: **10%**	• Tranche 3: **effective 9-24-2018**, 60bn USD, rate: **up to 10%**
5-9-2019:	5-13-2019:
• Tranche 3 continued: **rate raised to 25%**, effective 5-10-2019	• Tranche 3 continued: **rate raised up to 25%**, effective 6-1-2019
8-13-2019: 300bn USD	8-23-2019: 75bn
• Tranche 4 (half): **effective 9-1-2019**, rate: 15%	• Tranche 4 (half): **effective 9-1-2019**, rate: 10%

October to December 2019: both sides disclosed ongoing negotiation
1-15-2020: the two sides signed "Phase One Deal"

Notes: Only actions that became effective as announced are included in the figure. US dollar values are taxable values officially announced by the two governments. Actions of the two sides mirroring each other are **in bold**.

China's *eye for an eye* (EFAE) retaliation provides an unprecedented opportunity to study re-taliatory motives in a trade war by simplifying the enormous policy space of an antagonist into product selection. Since the taxable values and tariff rates had largely been fixed by the trade

sanctions set forth by the US, the margin of control remaining for Chinese policymakers was the selection of products to penalize. The selection of penalized products therefore reflects the retaliatory motives involved. We are thus able to uncover China's retaliatory motive from the factual product list in a forensic manner, and also simulate alternative tariff motives noted in trade theories by building counterfactual product lists. Retaliation based on different tariff motives would prioritize product-level penalties differently, leading to distinct rankings of products. Along each such ranking, going from the top product downward delivers a set of products matching the factual taxable values (such as the 34 billion USD mentioned above) and corresponding tariff rates (such as the 25 percent above). These counterfactual retaliatory tariff schedules are observationally equivalent to the factual schedule in total taxable value and tariff rate structure, and thereby comparable with each other and with the factual schedule, both positively and normatively.

We consider four theory-based retaliatory motives. The first motive aims to exploit terms-of-trade gains. Since tariffs create a tax incidence between domestic consumers and foreign producers, taxing foreign products with low elasticities may improve domestic consumers' welfare at the cost of foreign producers. This is a classic motive behind tariffs, explained by the optimal tariff theory (e.g., Bickerdike, 1907; Johnson, 1953; Broda et al., 2008). The second motive aims to shield domestic interest groups from import competition, known as the protection-for-sale theory (e.g., Grossman and Helpman, 1994; Goldberg and Maggi, 1999; Gawande and Bandyopadhyay, 2000). Despite not having Western-style lobbies, China has state-owned enterprises that directly contribute to its government revenue and thus constitute interest groups lobbying for protection. The third motive involves targeting foreign products produced in electorally competitive regions (e.g., Mayer, 1984; Dutt and Mitra, 2002; Muûls and Petropoulou, 2013; Ma and McLaren, 2018). Swing states were crucial for Trump's electoral success in 2016 and were a central focus of his reelection campaign in 2020. Therefore, targeting those swing states that supported Trump in 2016 was a natural strategic response from China. The fourth motive stems from the theory of international economic sanctions. Sanctioning a foreign country by cutting major imports from the country is a common practice in cross-country conflicts. This practice, although controversial in its effectiveness, has been rationalized by economists with various mechanisms such as coercion, alienation, and signaling (e.g., Mayer, 1977; Kaempfer and Lowenberg, 1988, 2007; Verdier, 2009). Hence, we posit that Chinese policymakers might target the products in which the US has comparative advantages.

All four retaliatory motives have corresponding product-level measures and thereby generate distinct product rankings. These product rankings (a "free" margin), combined with the total taxable value and tariff rate structure (the two "fixed" margins) dictated by the EFAE retaliation, produce four alternative tariff schedules. These counterfactual schedules, denoted by *optimal tariff*, *state owned enterprise (SOE) protecting*, *swing state (SS) targeting*, and *comparative advantage (CA) sanctioning*, are observationally equivalent to the factual tariff schedule but penalize different products with different rates. They depict how China would have retaliated if its policy-

makers had each of the four motives in mind, serving as the foundation of our welfare analysis. We measure welfare using the inverse import price index of China because it is the only welfare metric applicable across the four retaliatory motives. In this regard, our welfare analysis follows the optimal tariff tradition of using partial equilibrium analysis, but can account for cross-sector, cross-product, and cross-variety substitution.

Our welfare analysis of the tariff schedules, both factual and counterfactual, produce five primary findings.

First, among the four counterfactual schedules, the consequential tariff-ridden welfare ranks as: *SOE protecting < SS targeting < optimal tariff < CA sanctioning*. We also simulate the process of welfare deterioration as the total taxable value rises, starting from no retaliation up to the factual strength, and construct four distinct trajectories of welfare deterioration. The speed of welfare deterioration follows the same ranking.

Second, the *SS targeting* schedule generates a welfare loss most similar to the factual retaliation (approximately 0.37 percentage points lower than the pre-retaliation level). In addition, we conduct a regression analysis to explain the factual retaliatory tariffs with the four motive measures, and find that only the *SS targeting* motive has a significant power in explaining the factual retaliatory tariffs. That is, both the normative and positive findings in our study corroborate the *SS targeting* motive behind the factual retaliation.

Third, the *optimal tariff* schedule offers only modest gains relative to the factual schedule. Our estimation indicates a short-run horizontal foreign supply curve for China, resembling what the extant studies found for the US (Amiti et al., 2019; Fajgelbaum et al., 2020; Flaaen et al., 2020). Nonetheless, according to our estimates, even with upward-sloping US supply curves, the gain from retaliating with optimal tariffs remains limited and the net welfare effect is still negative.

Fourth, the *CA sanctioning* schedule exhibits the slowest welfare deterioration among the four motives. Comparative advantages, coming ultimately from low costs and thus low prices, provide a cushion that partially offsets trade costs including retaliatory tariffs. This finding indicates that the US product varieties in which the US has comparative advantages have a potent price position in China's market relative to alternative product varieties imported by China from other countries. As a result, taxing these product varieties appears less costly in welfare terms relative to taxing other US product varieties.

Lastly, the *SOE protecting* schedule has the worst welfare consequence among the four counterfactual schedules, and is the only counterfactual schedule offering lower welfare than the factual schedule. The production inefficiency of SOEs has long been known, such that it is reasonable to expect that shielding SOEs from competition with tariffs would cause a double jeopardy for domestic welfare. Our finding confirms this expectation.

This study also includes two extensions that complement the above factual and counterfac-

tual analyses. The first extension concerns the worst welfare consequence of China's EFAE retaliation. We solve a welfare minimization problem that customizes a retaliatory tariff rate for each US product variety, subject to a tariff-ridden trade volume equivalent to the factual retaliation. Such flexible, universal tariffs turn out to be nearly ten times worse in welfare terms than the factual retaliation, representing the lower bound welfare of an observationally equivalent retaliation. The second extension takes a reduced-form approach to estimating welfare losses. The welfare analysis described so far is structural, drawing on an assumed CES demand system. We construct a reduced-form welfare measure to assess the factual and four counterfactual retaliations. It shows similar absolute and relative welfare losses as the structural approach.

The recent trade wars between the US and its trade partners are exceptional in three respects. First, their initiation was unusually political. The executive branch of the US government, compared to its legislative branch, is overall more friendly towards free trade, a pattern that has held ever since the 1930s; moreover, the Republican Party has been the party more supportive of free trade in American politics for half a century (see Irwin (1998) and Baldwin (2009) for reviews). However, Donald Trump, as a Republican president, mobilized his executive power to launch six parallel battles against multiple trade partners on the grounds that the US suffers huge losses in international trade. In response, nearly all these trade partners, irrespective of being traditional allies or adversaries of the US, retaliated against the US with higher tariffs (see Bown and Kolb (2021) and Fetzer and Schwarz (2021) for reviews). Second, China challenged the US in the international trade policy arena for the first time and in an unexpected "eye for an eye" (EFAE) fashion. China, whose economic prosperity heavily relies on its trade performance, did not have an obvious motive to restrict trade. In particular, it had a large trade surplus against the US and thus was not expected to apply tariffs with comparable sizes as the US. The actual motive for its retaliation was never disclosed officially. Third, antagonists of these trade wars appeared not to garner terms-of-trade (TOT) gains. The canonical explanation of trade wars is through a prisoner's dilemma: antagonists launch tariffs on each other in order to exploit TOT gains, ending up with a lose-lose scenario. The use of trade agreements as a remedy has been shown theoretically, empirically, and quantitatively effective and efficient.[1] In fact, both Fajgelbaum et al. (2020) and Amiti et al. (2019) find that the new tariffs launched by the US were fully borne by US consumers. Chang et al. (2020) and Ma et al. (2021), replicating Fajgelbaum et al. (2020) and Amiti et al. (2019) respectively, reach similar findings for the Chinese side (see Fajgelbaum and Khandelwal (2021) for a review).

We combine the political economy of tariffs with welfare analysis in this study. Politically motivated tariffs arise from various specific motives, leading to distinct welfare consequences. To our knowledge, there has been no study comparing the welfare consequences of tariffs across

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[1]For literature reviews, see Bhagwati, Krishna, and Panagariya (1999) and Bagwell and Staiger (2010) focusing on theoretical development, Goldberg and Pavcnik (2016) on empirical evidence, and Ossa (2016) and Caliendo and Parro (2021) on quantitative evaluation.

tariff motives. We examine multiple theoretical rationales for China to retaliate against the US with equal strength. According to our results, what happened on the Chinese side turns out to be targeting products from Trump-supporting swing states. This political motivation of the retaliation explains China's fast and forceful restriction of trade without TOT gains. When economic rationality yields to political needs, free trade is usually the first principle to be sacrificed because protectionism caters to populism (even though domestic consumers pay the price) and domestic producers may benefit from protectionism. Such losses from politicized protectionism also applied to the US side of the trade war. As estimated by Fajgelbaum et al. (2020), the US lost 7.2 billion US dollars in the trade war. A global return of protectionism not only renders trade policies more distortive, but also makes them more uncertain and precarious. Our paper particularly sheds light on what could have happened for China if it engaged in the trade war differently. For instance, as we show, protecting SOE sales would have caused an even heavier welfare loss. Similarly, even if TOT gains existed, the net welfare effect would still be negative. Moreover, retaliating with flexible universal tariffs could be nearly ten times more costly in terms of welfare. That is, at least on the Chinese side, the welfare consequence of retaliation could actually have been worse.

The rest of the paper is organized as follows. Section 2 describes China's retaliation against the US during the US-China trade war, serving as the background of our study. Section 3 presents our analytical framework, including parameter estimation and theory-based retaliatory motives. Section 4 reports the results of our factual and counterfactual welfare analyses. Section 5 and Section 6 discuss two extensions of the previous analyses. Section 7 concludes.

2 Background

The US-China trade war had four rounds, each concluding with new tariffs levied on both sides. In each round, the Trump administration took actions first and received immediate retaliation from China's central government. The previous Figure 1 presents a timetable of the trade war. This section elaborates on the key elements of the trade war, with a focus on China's retaliation.

On June 15, 2018, the Office of the United States Trade Representative (henceforth, USTR), following directives given by President Trump, released two lists of Chinese products to be levied with 25 percent additional tariffs.[2] These two lists were officially called the 34 billion list (or Tranche 1) and the 16 billion list (or Tranche 2), since the taxable Chinese products in the two lists, if denominated in terms of 2017 US imports from China, were worth 34 billion and 16 billion

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[2] President Trump instructed the USTR on August 14, 2017 to investigate whether China "implemented laws, policies, and practices and has taken actions related to intellectual property, innovation, and technology that may encourage or require the transfer of American technology and intellectual property to enterprises in China or that may otherwise negatively affect American economic interests" under Section 301 of the Trade Act of 1974. Having completed an eight-month investigation, the USTR issued a report on March 22, 2018. On the same day, Trump signed a presidential memorandum to announce that punitive tariffs would be applied to Chinese products. The lists were publicized by the USTR on April 3, 2018, revised afterwards, and finally released on June 15, 2018.

US dollars, respectively. Tranche 1 was announced to take effect on July 6, 2018, and Tranche 2 on August 23, 2018. In response, the Customs Tariff Commission of the Chinese State Council (henceforth, CTC), which is the Chinese counterpart of the USTR, announced its own Tranches 1 and 2 with the same tariff rates (an additional 25 percent), the same taxable value (34 billion and 16 billion US dollars, denominated in terms of China's 2017 imports from the US), and the same effective dates (July 6 and August 23) on the same day as the US announcement (June 15). Subsequently, the two tranches of both countries took effect as announced.

It is fairly clear that China's retaliation intentionally mirrored the US sanction. The two countries have no economic reason to design identical policies (taxable values and tariff rates) against each other. In addition, as mentioned in the introduction, China selected the same dates as the US for the new tariffs to take effect, even though those dates were selected by the US to address domestic review and hearing requirements that do not apply to China. In fact, China's practice of dividing the tariffs into two tranches was also copied from the US. The product lists of the US side were initially published as one single proposal, but some of those products needed a second round of review and hearing, so that the products in the proposal were divided into two tranches bearing separate effective dates.[3] Thus, there was actually no reason for Chinese policymakers to divide their tariffs into two tranches, except an intention to match the US move precisely. Taken together, China's response, which cannot be explained by coincidence, expresses an unambiguous "eye for an eye" stance.

On July 10, the USTR announced its Tranche 3 tariffs, worth 200 billion US dollars, with a 10 percent rate, to become effective on September 24, 2018. One week before that effective date, the CTC announced a Chinese Tranche 3, worth 60 billion US dollars, with rates of up to 10 percent, to become effective on September 24 as well. The Chinese Tranche 3 was weaker than the US Tranche 3, indicating a lack of ammunition on the Chinese side. The third tranche for both sides took effect as announced.

Between September 2018 and May 2019, trade negotiations were conducted between the two countries. The details of those negotiations were not disclosed by either side. There was an informal meeting between presidents of the two countries when they attended a G20 summit in Argentina in December 2018. Neither the negotiation nor the meeting was productive in terms of resolving the trade war. On May 9, 2019, the USTR raised the rate of its Tranche 3 from 10 percent to 25 percent (effective May 10), and in the following week, the CTC revised the rate of its Tranche 3 from up to 10 percent to up to 25 percent (effective June 1).

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[3]See "Notice of Action and Request for Public Comment Concerning Proposed Determination of Action Pursuant to Section 301: China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation" (Docket number USTR-2018-0018 in the Federal Register).

Table 1: China's Pre- and Post-retaliation Tariffs on US Products

	Pre-retaliation	Post-retaliation			
	2017	Tranche 1	Tranche 2	Tranche 3	Tranche 4
Simple average	6.98	8.58	9.55	20.88	21.39
(standard deviation)	(5.20)	(8.85)	(10.19)	(12.36)	(12.04)
Increase relative to pre-retaliation		1.59	2.57	13.90	21.39
[p-value]		[0.00]	[0.00]	[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 1			0.97	12.31	12.81
[p-value]			[0.00]	[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 2				11.33	11.84
[p-value]				[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 3					0.51
[p-value]					[0.00]
Weighted average	4.18	8.66	10.54	15.66	15.82
(standard deviation)	(4.75)	(12.72)	(13.58)	(13.35)	(13.20)
Increase relative to pre-retaliation		4.48	6.36	11.49	11.64
[p-value]		[0.00]	[0.00]	[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 1			1.875	7.00	7.16
[p-value]			[0.00]	[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 2				5.13	5.28
[p-value]				[0.00]	[0.00]
Increase relative to post-retaliation, Tranche 3					0.15
[p-value]					[0.00]

Notes: This table compares post-retaliation average tariff rates with pre-retaliation average tariff rates. All tariff rates are at the HS8 level. Pre-retaliation rates refer to those effective by the end of 2017. Post-retaliation rates are effective rates, which have three tranches. Each tranche in the table has included all previous tranches. Simple average tariff rates are arithmetic means. Weighted average tariff rates are computed using 2017 imports values as weights. All t-tests are paired tests. The t-tests for weighted average tariffs first use 2017 imports values to compute weighted means and then compute the point estimates of the linear combination (post-retaliation weighted average − pre-retaliation weighted average).

The twelve months from July 2018 to June 2019, as detailed above, were the prime period of the US-China trade war. On both sides, the first effective date was July 6, 2018 and the last June 1, 2019. In the months prior to July in 2018, despite having bilateral tensions on trade issues, there was no policy confrontation between the two countries.[4] Two months after June 2019, a fourth tranche was announced by both sides, which was substantially lighter than each country's Tranches 1 to 3. Both sides chose lower rates than previous tranches (10 percent set by China, and 15 percent set by the US), as a result of ammunition shortage on both sides. The ammunition shortage was particularly salient on the Chinese side, whose Tranche 4 had a product overlap with its previous tranches 1 to 3 (i.e., the same product lines were included but with revised rates). Moreover, on both sides, only half of Tranche 4 took effect. The two governments canceled scheduled effective dates as a gesture of good faith before their negotiations held in December 2019.[5] This round of negotiation concluded with a "Phase One Deal" in January 2020.

Table 1 demonstrates the impacts of China's retaliatory rates on the cumulative tariff rates levied on its imported US products. The simple average of total tariff rates rose from 6.98 to 21.39 percentage points, while the weighted average rose from 4.18 percentage points to 15.82 percentage points. All tranches generated statistically significant rate increases. However, the economic significance of the tariff increases was predominantly driven by Tranches 1 to 3, as Tranche 4 generated only 0.51 (0.15 if weighted) percentage points of increase on average. The contrast is salient in Figure 2, where monthly average tariff rates are plotted against time. Figure 2 also includes the two sets of exemptions made by China for certain products during the trade war, one for automobile products in January 2019 and the other for multiple products with no specific focus (including whey, shrimp, lubricating oils, and nucleic acids) in October 2019. The exemptions, as shown in the figure, have minimal impacts on the average tariff rates. Further details on the data are provided in Appendix A.

## 3 Analytical Framework

In this section, our analytical framework is presented in four steps. We provide a theoretical setup in Section 3.1 and parameterize it in Section 3.2. Our setup and parameters are a variant of those used in Fajgelbaum, Goldberg, Kennedy, and Khandelwal (2020) (henceforth, FGKK). Then, in Section 3.3, we construct counterfactual retaliatory tariffs that are observationally equivalent to "eye for an eye" (EFAE) retaliatory tariffs, such as those used by China in 2018 and 2019. Our setting can be applied to various tariff motives, including the four common ones acknowledged

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[4]In 2018, the Trump administration also initiated trade wars pertaining to solar panels, washing machines, steel, aluminum and so on, which targeted multiple trade partners in addition to China. These concurrent trade wars are not examined in this study.

[5]In August 2019, each side announced a Tranche 4 of tariffs that were explicitly divided into two halves, one scheduled to take effect on September 1, 2019 and the other on December 15, 2019. In late 2019, both sides decided to maintain the first half and cancel the second half. The Tranche 4 in Figure 1 refers to the first half scheduled for the September.

Figure 2: China's Tariffs on US Products, 2018-2019
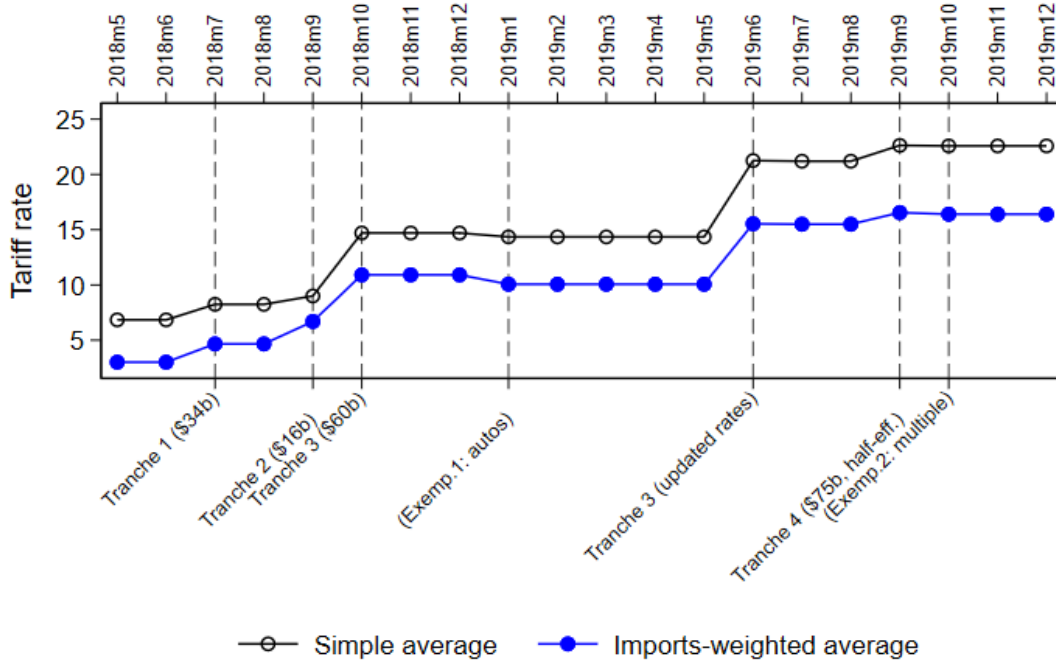
Notes: Unit of tariff rate is percentage point. Tariff rates are at the HS8 level. The time span is May 2018 (2018m5) to December 2019 (2019m12). Tariff rates in month *t* refer to those in effect starting from the 15th day of month *t*-1 and ending on the 14th day of month *t*. The 2017 imported values are used to compute imports-weighted average rates.

in the literature, as we illustrate in Section 3.4.

3.1 Setup

Since Chinese imports serve both consumption and production purposes, we refer to the bearer of the economic interests in China's imports as *importers*. The economic interests of importers are represented by the utility of a nationally aggregated importer:

$$U = \prod_s \left(\frac{C_s}{\gamma_s}\right)^{\gamma_s}, C_s \equiv \left(\sum_{g \in s} m_g^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}, \text{ and } m_g = \left(\sum_i m_{gi}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

Here $\gamma_s \in (0,1)$ is expenditure share of sector s and $\sum_s \gamma_s = 1$. Consumption C_s is an aggregate of imported foreign products in sector s. Consumption m_g is an aggregate of product line g that consists of multiple varieties differentiated by origin country i. The elasticity of substitution is

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$\eta > 1$ at the product line level, and $\sigma > 1$ at the variety level. Notice that each "US product" is technically a variety, denoted by $gi = gUS$, made by US producers, and imported to China under product line g. Henceforth, we refer to product lines simply as products.

Price indexes can then be derived:

$$P = \prod_s (P_s)^{\gamma_s}, P_s = \left(\sum_{g \in s} P_g^{1-\eta} \right)^{\frac{1}{1-\eta}}, \text{ and } P_g = \left(\sum_i p_{gi}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \quad (2)$$

where P, P_s, and P_g represent import price indexes at the national, sector, and product levels, respectively. The tariff-ridden price of an imported variety is

$$p_{gi} = (1 + t_{gi}) p_{gi}^*, \quad (3)$$

where p_{gi}^* is the CIF price paid to foreign suppliers. The inverse supply function of foreign suppliers is

$$p_{gi}^* = z_{gi} m_{gi}^\omega, \quad (4)$$

where z_{gi} is a foreign marginal cost shifter and ω is the inverse foreign supply elasticity.

The t_{gi} in equation (3) is an ad valorem tariff rate. Denote the pre-retaliatory tariff rate by t_{gi}^0, then we have

$$t_{gi} = \begin{cases} t_{gUS}^0 + T_g, & \text{if } i = US, \\ t_{gi}^0, & \text{if } i \neq US, \end{cases} \quad (5)$$

since the retaliation was only against US varieties. The T_g in equation (5) is the retaliatory tariff added on the pre-retaliation rate t_{gUS}^0. Notice that $T_g = 0$ for some g's, because China did not retaliate against all US varieties. China's full post-retaliation tariff schedule can be written as set $\{t_{gi}\}_{\forall g,i}$, composed by an unaffected set and an affected set:

$$\{t_{gi}\}_{\forall g,i} = \{t_{gi}^0\}_{\forall g,i \neq US} \bigcup \{t_{gi}^0 + T_g\}_{\forall g,i=US} = \{t_{gi}^0\}_{\forall g,i} \bigcup \{T_g\}. \quad (6)$$

These set notations are convenient. In particular, $\{T_g\}$, which applies only to US varieties, reflects all new tariff changes due to the retaliation. Henceforth, we refer to $\{T_g\}$ as a *retaliatory schedule*.

Welfare in this study (W) is measured by import prices, namely $W = 1/P$. Among various welfare aspects of tariffs, import prices are the only one comparable across tariff motives in our setting. Tariffs are essentially taxes such that alternative retaliatory tariff schedules have no difference beyond different product lists and tax rates. Regardless of the tariff motives considered, trade policy models unanimously recognize this particular nature of tariffs. The relationship between tariff motives and other welfare aspects of tariffs is significantly more involved. For instance, policymakers who prioritize domestic economy and who prioritize foreign politics are expected to launch different retaliatory tariffs. Without modeling the entire political structure of a country,

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we would not be able to endogenize tariff motives and the resulting redistribution of tariff revenue and labor income.[6] To avoid endless modeling choices and conundrums, we do not pursue general equilibrium effects in this study. The theoretical setup presented so far is a self-contained partial equilibrium model, whose welfare calculation collapses to the analysis of P thanks to the nested CES structure.

3.2 Parameters

The sector-level expenditure shares $\{\gamma_s\}$, as Cobb-Douglas parameters, can be directly computed using China's imports data (see Table A1 in Appendix A). Our estimation of σ, ω, and η follows the FGKK method. That is, to estimate σ and ω, we use

$$\Delta \ln m_{git} = \pi_{gt} + \pi_{it} + \pi_{si} - \sigma \Delta \ln p_{git} + \epsilon_{git}, \tag{7a}$$

$$\Delta \ln p_{git}^* = \pi_{gt}^* + \pi_{it}^* + \pi_{si}^* + \omega \Delta \ln m_{git} + \epsilon_{git}^*, \tag{7b}$$

where t indexes month. Following FGKK, σ and ω are identified by instrumenting $\Delta \ln p_{git}$ and $\Delta \ln m_{git}$ with[7]

$$\tilde{T}_{gt} = \begin{cases} T_{gt}, & \text{if } i = US, \\ 0, & \text{if } i \neq US. \end{cases}$$

Here, T_{gt} is a monthly varying version of the previous T_g. That is, product lines are assigned varying retaliatory tariff rates over time, following the time frame described in Section 2.

Likewise, to estimate η, we use

$$\Delta \ln S_{gt} = \chi_{st} + (1 - \eta) \Delta \ln p_{gt} + \epsilon_{gt}^S, \tag{8}$$

where $S_{gt} \equiv \frac{p_{gt} m_{gt}}{P_{st} M_{st}}$ is the import share of product g in sector s. η is identified by instrumenting $\Delta \ln p_{gt}$ with its tariff-ridden counterpart $\Delta \ln H_{gt} \equiv \ln \left(\sum_i \exp(\Delta \ln(1 + t_{git})) / N_{gt} \right)$, where N_{gt} is the set of continuing varieties into the next period, and Feenstra-style variety correction is applied to both $\Delta \ln p_{gt}$ and $\Delta \ln H_{gt}$.[8]

The estimation results are reported in Table 2. Our sample begins in January 2017 and ends in December 2019. Our full-sample results are reported in Panel A, which serve as our main estimates. Their robustness is checked in Panels B to C using various subsamples. Considering

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[6] As an example of the challenges in such political modeling, consider labor who serves as workforce, lobbyists, and voters simultaneously. Introducing labor income into the welfare calculation would necessitate ad hoc assumptions on the overlapped roles of labor, and moreover those assumptions would directly influence welfare calculation (e.g., how lobbies and voters jointly decide the redistribution of tariff revenue).

[7] This instrumental strategy of FGKK, following Romalis (2007) and Zoutman et al. (2018), rests on the fact that tariffs shift down (up) the demand (supply) curve to make the segment of the supply (demand) curve around the equilibrium identifiable.

[8] See Appendix A for other details of our estimation.

Table 2: Estimation of Structural Parameters

	(1)	(2)	(3)	(4)
Countries	All	All	US	All
Unit of observation	Country-HS8-month	Country-HS8-month	HS8-month	HS8-month
Parameter identified	$-\sigma$	ω	ω	η
Dependent variable	$\Delta\ln$(quantity)	$\Delta\ln$(exporter price)	$\Delta\ln$(exporter price)	$\Delta\ln$(S)
Panel A: Main results (the full sample)				
$\Delta\ln$(tariff-ridden price, variety level)	-1.453***			
	(0.547)			
$\Delta\ln$(quantity, variety level)		0.521	0.270	
		(0.430)	(0.211)	
$\Delta\ln$(price, product level)				1.892***
				(0.751)
Fixed effects	Product × time, Country × time, Product × sector	Product × time, Country × time, Product × sector	Sector, time†	Sector × time
N	2,109,798	2,109,798	133,931	205,492
Panel B: Post-Tranche 3 months excluded (the January 2017 to August 2019 subsample)				
Coefficient§	-1.635**	0.502	0.243	2.089***
	(0.623)	(0.363)	(0.175)	(1.507)
N	1,858,060	1,858,060	118,838	181,117
Panel C: Pre-Tranche 1 months excluded (the July 2018 to December 2019 subsample)				
Coefficient§	-1.483**	0.576	0.289	1.891***
	(0.599)	(0.476)	(0.222)	(0.750)
N	1,188,855	1,188,855	73,962	115,246
Panel D: Tranches 1 to 3 (the July 2018 to August 2019 subsample)				
Coefficient§	-1.656**	0.586	0.273	2.089***
	(0.699)	(0.433)	(0.193)	(1.507)
N	937,115	937,115	58,868	90,871

Notes: The 2SLS estimation of parameters σ, ω, and η follows the identification strategy in Fajgelbaum et al. (2020) (see text for details). † Column (3) applies the specification of column (2) to the US-only subsample. The US-only subsample has only product and time dimensions, so that the product × time and country × time fixed effects collapse to the time fixed effects while the product × sector fixed effects collapse to the sector fixed effects. Using sector × time fixed effects instead of the two separate fixed effects gives similar results. § The four coefficients correspond respectively to $-\sigma$, ω, ω (US sample only), and η. Their regression specifications are identical with those used in Panel A but pertain to different time periods. Robust standard errors in parentheses, clustered by HS2. ** $p<0.05$, *** $p<0.01$.

that only half of Tranche 4 took effect (lasting from September 2019 to December 2019), we exclude those four months in Panel B. Panel C excludes the pre-retaliation periods, lasting from January 2017 to June 2018 (recall that Tranche 1 took effect in July 2018). Panel D uses the intersection of the subsamples used in Panels B and C, keeping only the months when Tranches 1 to 3 were effective. The estimated coefficients show high stability across panels within each column, all remaining within one standard error of each other.

Four observations emerge from Table 2. First, $\hat{\sigma} = 1.453$ (s.e. 0.547). Notice that σ is the

elasticity of substitution across origin-differentiated varieties within a product line. To our knowledge, the only counterpart estimate in the literature is the one in FGKK, which is 2.53 (s.e. 0.26). Our elasticity is smaller in magnitude than theirs. The two estimates for two countries respectively are not strictly comparable. That being said, we speculate that the difference between them is at least partly related to the foreign supply chains that ship certain product varieties to China for further processing, final assembly, and other manufacturing activities that aggregate the values of imported parts. For that reason, the quantity demanded of single varieties may respond inactively or modestly to price variations.

Second, $\hat{\eta} = 1.892$ (s.e. 0.751), which resembles the FGKK estimate 1.53 (s.e. 0.27). Our $\hat{\eta}$ is greater than our $\hat{\sigma}$, suggesting that imported varieties within product lines are less substitutable than product lines within a sector. This is also in line with the fact that a large fraction of foreign varieties imported to China are for processing and assembly.[9] The first and second observations, taken together, indicate (i) a similar substitutability across products in the Chinese case and the US case, which is explained by both countries being large and comprehensive importers, and meanwhile (ii) a smaller substitutability across varieties in the Chinese case than in the US case, which is explained by China's role in the global manufacturing network.

Third, $\hat{\omega}$ does not have a statistically significant difference from zero, a finding that resembles the findings on the US side made by FGKK, Amiti et al. (2019) and Flaaen et al. (2020). Given that a horizontal foreign supply curve cannot be rejected, the tariff burdens all fall on the importers. Notice that we also estimate $\hat{\omega}$ using only US products (column (3), Table 2) and reach the same finding. In our view, the similarity in this estimated parameter between US and China is not a coincidence. The estimates for both countries, covering only one to three recent consecutive years, are short-run estimates. Amiti et al. (2019) note that the found horizontal supply curves may stem from policy uncertainties. The US-China trade war was accompanied by various strategic maneuvers and tentative confrontation undertaken by both sides. Therefore, Chinese producers, as well as US producers, might maintain their original prices before they ascertained the final tariff rates applicable to their products. In our context, the supply chain complexity mentioned above might exacerbate the stickiness in export prices.

Fourth, according to our estimates, the average change in import values of targeted varieties is -17.5%, while the average change in import values of targeted products is -1.2%. The two averages changes are -31.7% and -2.5%, respectively, in the FGKK study on the US side.[10] The average changes are expected to be somewhat smaller in our context, possibly owing to global

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[9]Since our (FGKK) setup is different from the conventional nested CES functions, our $\hat{\eta} > \hat{\sigma}$ is unrelated to, and thus not contradicting, the conventional assumption that varieties are more substitutable than products in the previous trade literature.

[10]Our calculation of the two average changes follows the FGKK formulas. For the average change of targeted varieties, the formula is $\overline{\Delta \ln p^*_{git} m_{git}} = -\hat{\sigma} \frac{1+\hat{\omega}^*}{1+\hat{\omega}^*\hat{\sigma}} \overline{\Delta \ln(1 + \tau_{git})}$. It is the solution to the system of equations (7a) and (7b). For the average change of targeted products, the formula is $\Delta \ln p_{gt} m_{gt} = -(\hat{\eta} - 1)\Delta \ln H_{gt}$.

supply chains as discussed above.

3.3 Factual and counterfactual analysis

Using the set notations defined in Section 3.1, we refer to the retaliatory tariffs used by China on its imports from the US as a factual (F) retaliatory schedule $\{T_g^F\}$. That is, every US product variety $gi = gUS$ imported by China receives an additional rate $T_g^F \geq 0$, and those appearing in Tranches 1 to 3 each receive a positive additional rate $T_g^F > 0$. We leave Tranche 4 out because as noted in Section 2, Tranche 4 has (i) a product overlap with Tranches 1 to 3, (ii) an effectiveness of only half the tranche, and (iii) a short duration of three months.[11] Section 3.2 has estimated $\{\gamma_s\}, \sigma, \eta$, and ω (i.e., a horizontal foreign supply curve). Thus, with data on $\{T_g^F\}$ (US only), pre-retaliation tariffs $\{t_{gi}^0\}$ (all foreign countries), and CIF prices $\{p_{gi}^*\}$ (all foreign countries), we are ready to compute the welfare level W^F associated with the factual retaliatory schedule through the previous price indexes P^F, P_s^F, and P_g^F constructed following equation (2).

The strength of China's retaliation is manifested by two margins of $\{T_g^F\}$. First, $\{T_g^F\}$ was applied to a basket of US products imported by China that were, in total, worth 108 billion US dollars in 2017, or

$$\sum_{g \in \{T_g^F > 0\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$108\text{bn} \equiv Q^F. \tag{9}$$

Equation (9), or the *total taxable margin*, stems from the fact that both countries announced the sizes of their tariffs in USD values, officially referencing them in 2017 import prices and quantities (i.e., $p_{gUS}^{2017} m_{gUS}^{2017}$).[12] Second, $\{T_g^F\}$ has a rate structure:

$$T_g^F = \begin{cases} 25\%, & \text{if } Q \leq \$58\text{bn}, \\ 20\%, & \text{if } \$58\text{bn} < Q \leq \$73\text{bn}, \\ 10\%, & \text{if } \$73\text{bn} < Q \leq \$89\text{bn}, \\ 5\%, & \text{if } \$89\text{bn} < Q \leq \$108\text{bn}(= Q^F), \end{cases} \tag{10}$$

that assigns a penalty to each product g. Specifically, Tranches 1 and 2 use a rate of 25% while Tranche 3 has rates of 5%, 10%, 20%, and 25%. We build those brackets into piecewise function (10), or the *rate structure margin* of $\{T_g^F\}$. Notice that the rate pattern decreasing with Q in the piecewise function coincides with the chronological order of tranches. That is, 25% is placed at the top not only for technical clarity, but also because it was the earliest rate used by Chinese policymakers. Products penalized earlier were also penalized heavier, indicating their level of priority in China's retaliation.[13] We maintain this observed decreasing rate pattern throughout

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[11]The short duration of three months overlapped with Quarter 4 of 2019 including the holiday season.

[12]The taxable values in China's official announcements in Figure 1 (34 billion, 16 billion, and 60 billion) amount to 110 billion (USD). Those three values were rounded before being announced. For accuracy, we compute the total taxable value and find it to be 108 billion (USD).

[13]Tranches 1 and 2 of China's retaliatory tariffs bore the rate of 25%, and Tranche 4 the rate of 10%. The effective

our welfare analysis.

The two margins (9) and (10) establish the strength of $\{T_g^F\}$ and enable us to construct counterfactual retaliatory schedules $\{T_g^{CF}\}$ that are observationally equivalent to $\{T_g^F\}$. Consider an arbitrary counterfactual retaliatory schedule $\{T_g^{CF}\}$. So long as $\{T_g^{CF}\}$ meets the two margin conditions, it can be compared with $\{T_g^F\}$ in product composition and welfare consequence. The two retaliatory schedules are comparable since they have the same strength in terms of taxable value and rate structure.

We let policy motives motivate counterfactual retaliatory schedules. We consider policy motives that can rank imported US product varieties in product characteristic Λ. Such motives, namely preferences of policymakers, can be represented by a monotonic ranking function:

$$\Phi : \Lambda_g \to \phi_g, \tag{11}$$

which ranks imported US varieties $\{g\}$ according to product characteristic Λ_g and assigns ranking value ϕ_g.[14] Without loss of generality, we assume $\Phi(\Lambda_g)$ to be positive monotonic: a greater Λ_g corresponds to a greater ϕ_g, representing a higher ranking in the to-be-penalized product list. Intuitively, $\Phi(\cdot)$ acts as Chinese policymakers who favor US varieties differentially and thus rank them discriminately.

The ranking function $\Phi(\Lambda_g)$ works with conditions (9) and (10) to assign counterfactual tariff rate T_g to each imported US variety according to its characteristic Λ_g. The algorithm works as follows. First, solve ϕ^{25}, ϕ^{20}, ϕ^{10} and ϕ^5 such that

$$\sum_{g \in \{\Phi(\Lambda_g) \geq \phi^{25}\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$58\text{bn}, \tag{12a}$$

$$\sum_{g \in \{\Phi(\Lambda_g) \geq \phi^{20}\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$73\text{bn}, \tag{12b}$$

$$\sum_{g \in \{\Phi(\Lambda_g) \geq \phi^{10}\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$89\text{bn}, \tag{12c}$$

$$\sum_{g \in \{\Phi(\Lambda_g) \geq \phi^5\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$108\text{bn}, \tag{12d}$$

rates of Tranche 3 rose from *up to 10%* (effective September 24, 2018) to *up to 25%* (effective June 1, 2019). Either before or after Tranche 3's rate increase, a decreasing rate pattern is continually observed across tranches. That is, Tranche 3's rates were above-bounded by the rate of Tranches 1–2 (i.e., 25%) after the rate increase, and above-bounded by the rate of Tranche 4 before the rate increase. Tranche 4 is not examined in our welfare analysis for reasons noted earlier (product overlap, half effectiveness, and short duration overlapping with Quarter-4 seasonality).

[14]Mathematically, each policy motive is a strict total ordering (i.e., any two varieties can be strictly compared). Then, given that imported varieties are a finite set, an unambiguous ranking among the varieties always exists.

and then assign T_g^{CF} according to

$$
T_g^{CF} = \begin{cases}
25\%, & \text{if } \Phi(\Lambda_g) \geq \phi^{25}, \\
20\%, & \text{if } \phi^{25} > \Phi(\Lambda_g) \geq \phi^{20}, \\
10\%, & \text{if } \phi^{20} > \Phi(\Lambda_g) \geq \phi^{10}, \\
5\%, & \text{if } \phi^{10} > \Phi(\Lambda_g) \geq \phi^{5}, \\
0, & \text{if } \phi^{5} > \Phi(\Lambda_g).
\end{cases}
\tag{10'}
$$

This algorithm ensures $\{T_g^{CF}\}$ have the same rate structure margin (now, condition (10′)) and total taxable margin

$$
\sum_{g \in \{T_g^{CF} > 0\}} p_{gUS}^{2017} m_{gUS}^{2017} = \$108\text{bn} = Q^F,
\tag{9'}
$$

as $\{T_g^F\}$. Thus, $\{T_g^{CF}\}$ and $\{T_g^F\}$ are observationally equivalent.

The above algorithm can generate a counterfactual schedule $\{T_g^{CF}\}$ based on any product characteristic Λ_g that is rankable and without ties. It provides a mapping from a set of product characteristic $\{\Lambda_g\}$ to a set of tariffs $\{T_g^{CF}\}$ through equations (11) to (9′), henceforth represented by

$$
T_g^{CF} = \Xi\left(\Lambda_g\right).
\tag{13}
$$

Without loss of generality, we assume $\Xi(\cdot)$ to be positive monotonic. Through $\Xi(\cdot)$, variety g with a greater Λ_g receives a greater tariff rate T_g^{CF}. The tariff rates $\{T_g^{CF}\}$ are observationally equivalent to the factual retaliatory schedule $\{T_g^F\}$ à la margins (9′) and (10′). When different types of characteristic Λ_g are used, different counterfactual schedules are generated. As a toy example showing how the algorithm works, consider fictional policymakers who favor physically lightweight varieties (i.e., Λ_g is weight per unit). Suppose that the 102 heaviest US varieties happen to be worth 58 billion dollars. Then, by equations (12a) and (10′), the tariff rate of 25% is assigned to those 102 heaviest varieties and the tariff rate of 20% to the 103rd heaviest US variety. The assignment continues until condition (9′) is met and thus the set $\{T_g^{CF} | T_g^{CF} > 0\}$ settles. The rest of US varieties (i.e., the even lighter ones) are assigned $T_g^{CF} = 0$ to complete the set $\{T_g^{CF}\}$.

3.4 Retaliatory motives

Section 3.3 has provided a generic counterfactual retaliatory tariff schedule m, $\{T_g^{CF,m}\}$, observationally equivalent to the factual retaliatory tariff schedule $\{T_g^F\}$ in taxable value and rate structure. Every such schedule $\{T_g^{CF,m}\}$ rests on a product characteristic Λ_g^m. We consider four alternative product characteristics to generate four counterfactual schedules for our later welfare analysis. Each of the four characteristics represents a theory-based policy motive for retaliation.

The first policy motive stems from optimal tariffs (henceforth, *optimal tariff*). According to

17

the optimal tariff theory (Bickerdike (1907), Johnson (1953), and Broda et al. (2008) among others), tariffs set by an importing country may force foreign suppliers to lower their prices, thereby generating terms-of-trade gains for the importing country. At the core of this motive is tax incidence. That is, the burden of a tax is shared between the demand side and the supply side, and the side with a lower price elasticity bears relatively more of the burden. Thus, the optimal tariff rate for the importing country is in inverse proportion to the supply elasticity of foreign exporters. As per this motive, Chinese policymakers observed long-term inverse export elasticities of US products in the prewar era and retaliated by setting

$$T_g^{CF,1} = \Xi \left(\Lambda_g^1 \equiv \left[\frac{dm_{gUS}}{dp_{gUS}^*} \cdot \frac{p_{gUS}^*}{m_{gUS}} \right]^{-1} \right).$$ (14)

We follow Feenstra (1994) and Broda and Weinstein (2006) to estimate the inverse supply elasticity for each US product variety (the details of estimation for all four motives are reported in Appendix B).

The ranked characteristic Λ_g^1 in equation (14) is the inverse supply elasticity of US exporters pertaining to product g. It is reminiscent of ω in equation (4), estimated in regression (7b) for exporters in the rest of the world and the US respectively, which can also be interpreted as an inverse export elasticity. However, ω is a short-run elasticity. Moreover, it does not vary by product, but treats the rest of the world or the US as a single aggregated exporter. The ω estimated in Table 2, for both China's foreign exporters as a whole and US exporters only, are statistically indifferent from zero, which does not mean that China has no market power in the long run.[15] Λ_g^1, as a long-run product-level parameter estimated using prewar US exports, is unequal to ω and has no particular reason to be zero across the board.[16]

The second policy motive stems from sale protection (henceforth, *SOE protecting*). According to the protection-for-sale theory (Grossman and Helpman, 1994; Goldberg and Maggi, 1999; Gawande and Bandyopadhyay, 2000), policymakers make a tradeoff between domestic consumption and political contributions from interest groups. A higher tariff levied on a given product harms consumers but meanwhile benefits a domestic interest group who competes with foreign exporters on the product. As per this motive,

$$T_g^{CF,2} = \Xi \left(\Lambda_g^2 \equiv \frac{I_g - \alpha}{a + \alpha} \cdot \frac{R_g}{\sigma_g} \right),$$ (15)

where a is the weight of consideration given by policymakers to domestic consumption, I_g is a lobby indicator for product g, α represents overall prevalence of lobbies, and R_g captures import

---

[15] The same argument applies to the US, which also has an estimated ω statistically indifferent from zero (Amiti et al., 2019; Fajgelbaum et al., 2020; Flaaen et al., 2020) but holds considerable power in the world market.

[16] In theory, Chinese policymakers could not observe or estimate contemporaneous foreign supply elasticities $1/\omega$ at the time of retaliation, because their retaliation influenced the import data.

penetration (domestic production divided by imports). That is, products guarded by lobbies (i.e., a greater $I_g - \alpha$) tend to have higher tariff rates. China does not have Western-style lobbies but instead has state-owned enterprises (SOEs) that directly contribute to government revenue. We customize the ranked characteristic Λ_g^2 to the Chinese context by letting it vary by cross-product presence of SOEs.

The third policy motive is to sanction the US products in which the US has comparative advantages (henceforth, *CA sanctioning*). Penalizing the core exports of a foreign country with tariffs, embargoes, and other trade barriers is a common practice in international politics. Although the effectiveness of trade sanctions is controversial, economists find the economic mechanisms of trade sanctions reasonable in one way or another, including coercion, alienation, and signaling (e.g., Mayer, 1977; Kaempfer and Lowenberg, 1988, 2007; Verdier, 2009). China is a user of economic sanctions and has been using them frequently in recent years (for instance, China sanctioned Australia in 2020 and Lithuania in 2021). Thus, retaliating against the US by taxing its comparative advantage products is a plausible potential motive. By retaliating this way, Chinese policymakers might maximize the loss on the US side and thereby obtain better terms in future trade negotiations. As per this motive,

$$ T_g^{CF,3} = \Xi\left(\Lambda_g^3 \equiv \frac{Z_{gUS}/Z_{g^0 US}}{Z_{gi^0}/Z_{g^0 i^0}} \right), \tag{16} $$

where i^0 denotes a reference country, g^0 denotes a reference product, and Z_{gi} represents the productivity of country i in producing product g. The micro-foundation for using $\frac{Z_{gj}/Z_{g^0 j}}{Z_{gi^0}/Z_{g^0 i^0}}$ to measure country j's revealed comparative advantage in product g is discussed in Costinot et al. (2012) and French (2017), and we follow their method to estimate $\frac{Z_{gUS}/Z_{g^0 US}}{Z_{gi^0}/Z_{g^0 i^0}}$ for each US product variety gUS.

The fourth policy motive is to target US products associated with US swing-state voters (henceforth, *SS targeting*). The importance of median/swing voters has long been explored in the theoretical trade literature (Mayer, 1984; Muûls and Petropoulou, 2013; Ma and McLaren, 2018). As per this motive

$$ T_g^{CF,4} = \Xi\left(\Lambda_g^4 \equiv \sum_{h \in Swing} \frac{L_{gh}}{L_h} \cdot VotingTrump_h \right), \tag{17} $$

where $h \in Swing$ represents a county in a swing state that voted for Trump in the 2016 US presidential election. $\frac{L_{gh}}{L_h}$ is the share of labor related to US product g. US employment data are only available by industry, so we resort to the product-industry concordance compiled by Pierce and Schott (2012). Consider a swing state county h that voted for Trump ($VotingTrump_h = 1$). The county has its labor employed for producing different products, and we use the share of employment related to product g (L_{gh}) in its total employment (L_h) to weight $VotingTrump_h = 1$ and aggregate such weighted Trump-voting indicators $VotingTrump_h$ for each product g to be its product characteristic Λ_g^4. In short, Λ_g^4 is a product-level employment-weighted count of Trump-voting

swing state counties.[17]

To conclude this section, with price indexes (P, P_s, P_g), estimated parameters $(\gamma_s, \sigma, \omega, \eta)$, and observationally equivalent $\{T_g^F\}$ and $\{T_g^{CF,m}\}$ where $m = 1$ to 4, we are ready to compare the welfare consequences of factual and counterfactual retaliations.

4 Main Results

4.1 Baseline findings

Five schedules. Table 3 summarizes the counterfactual retaliatory tariff schedules $\{T_g^{CF,1}\}$ to $\{T_g^{CF,4}\}$ with each other and against the factual schedule $\{T_g^F\}$. Each g corresponds to an HS8 product imported by China from the US in 2018. The first and second columns reproduce the elevation of factual tariff rates shown in the previous Table 1. Compared with the pre-war (2017) tariff rates, the post-war tariff rates elevated threefold (unweighted, from 6.98 percent to 20.88 percent) to fourfold (2017-imports weighted, from 4.18 to 15.66). The elevations generated by the four counterfactual schedules are comparable in economic and statistical significance to the factual elevations. Among the four counterfactual schedules, the *CA sanctioning* schedule penalizes the smallest number of products (12.2 percent of the 6,726 US product lines imported by China). Because the US products with revealed comparative advantages to China have large import volumes, the simple average post-retaliation tariff rate of the CA-sanctioning schedule (8.27) is far lower than the factual schedule and the other three counterfactual schedules, while its weighted average rate (16.09) is on par with them.

Recall that $\{T_g^{CF,1}\}$ to $\{T_g^{CF,4}\}$, unlike the unordered $\{T_g^F\}$, rank imported US varieties in ways distinct from each other. Depending on which motive is at play, the least (most) favored US products are prioritized (deprioritized) to be penalized. To provide an overview of the ranking orders, we report in Table 4 the top-five and bottom-five unrepeated HS2 chapters according to the rankings used by each $\{T_g^{CF,m}\}$. The most prioritized products as per the *optimal tariff* motive ($m = 1$) are concentrated in transportation and infrastructure, a sector in which China has a large market power due to its large infrastructure investment. In contrast, China has relatively small influence in homogeneous products such as straw, meat, cereals, and fruits. In the metallurgical industries of China, SOEs have considerable influences owing to the role of metals in industrialization and their large scales in fixed assets and employment. China's SOEs are also major players in its sectors related to national defense. These sectors are associated with the most prioritized products following the *SOE protecting* motive ($m = 2$). As expected, the most prioritized products following the *CA sanctioning* motive ($m = 3$) are China's major imports from the US, and those following

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[17] Λ_g^4 is different from Bartik-style measures in the literature (e.g., Autor et al. (2013)) in that the summation is across counties rather than products. Bartik-style measures concern the product composition of each county, whereas Λ_g^4 concerns the county composition of each product.

Table 3: Counterfactual Retaliatory Schedules: Rates

	Pre-retaliation	Post-retaliation				
		Factual*	Counterfactual			
	2017*		Optimal tariff	SOE protecting	CA sanctioning	SS targeting
Simple average	6.98	20.88	12.80	17.19	8.27	19.77
(standard deviation)	(5.20)	(12.36)	(10.21)	(11.74)	(6.71)	(12.36)
Relative to pre-retaliation		+13.90	+5.82	+10.20	+1.29	+12.79
[p-value]		[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Weighted average	4.18	15.66	16.90	17.95	16.09	16.27
(standard deviation)	(4.75)	(13.35)	(10.47)	(12.06)	(11.95)	(11.90)
Relative to pre-retaliation		+11.49	+12.72	+13.78	+11.91	+12.10
[p-value]		[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Penalized products		6,085	3,051	4,551	823	5,412
Share§		90.5%	45.4%	67.7%	12.2%	80.5%

Notes: This table compares post-retaliation average tariff rates (factual and counterfactual) with pre-retaliation average tariff rates. All tariff rates are at the HS8 level. Pre-retaliation rates refer to those effective by the end of 2017. Simple average tariff rates are arithmetic means. Weighted average tariff rates are computed using 2017 imports values as weights. *t*-tests are pairted tests. The *t*-tests for weighted average tariffs first use 2017 imports values to compute weighted means and then compute the point estimates of the linear combination (post-retaliation weighted average − pre-retaliation weighted average). * Same values as in Table 1. § The share refers to the share of the number of products penalized under each motive out of 6,726 imported US products.

the *SS targeting* motive ($m = 4$) come from traditional manufacturing sectors whose producers expected protection or other forms of assistance from the Trump administration.[18]

Comparing products across columns, one can observe different patterns of prioritization and deprioritization varying by motive. The four top-five product lists have little in common. Straw and silk make two bottom-five lists. Some products listed as bottom-five following one motive are listed as top-five following another motive (e.g., cereals, fabrics, and mineral products). Overall, there exist distinct variations across counterfactual schedules to be used in our welfare analysis.

Factual welfare. With price indexes (P, P_s, P_g), estimated parameters $(\gamma_s, \sigma, \omega, \eta)$, and factual schedule $\{T_g^F\}$, we compute factual welfare level W^F resulting from China's retaliation and compare it with the welfare level if there were no retaliation at all. The latter welfare level, denoted by W^O, is computed using $\{T_g = 0, \forall g\}$. We use China's December 2017 tariff rates for t_{gi}^0, and 2018 average CIF prices for $\{p_{gi}^*\}$. China's CTC issues tariff rates for the coming year every De-

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[18]The article by Eavis (2018) in *The New York Times* discusses the political importance of the US lumber industry to the Trump administration. The US glass industry was heavily impacted by China's retaliatory tariffs (see their response to the US-China "Phase One Deal" in Thompson (2019)).

Table 4: Counterfactual Retaliatory Schedules: Products

	Optimal tariff	SOE protecting	CA sanctioning	SS targeting
Top-5 HS2:				
1	89. Ships, boats and floating structures	72. Iron and steel	88. Aircraft, spacecraft and parts thereof	82. Tools, implements, cutlery, spoons and forks, of base metal
2	60. Fabrics	36. Explosives; etc.	27. Mineral fuels, mineral oils and products of their distillation	70. Glass and glassware
3	71. Natural, cultured pearls; precious, semi-precious stones; etc.	81. Metals; n.e.c., cermets and articles thereof	89. Ships, boats and floating structures	64. Footwear; gaiters and the like; parts of such articles
4	87. Vehicles; etc.	78. Lead and articles thereof	10. Cereals	47. Pulp of wood or other fibrous cellulosic material; recovered paper or paperboard
5	84. Nuclear reactors, boilers, machinery and mechanical appliances; etc.	93. Arms and ammunition; parts and accessories thereof	87. Vehicles	31. Fertilizers
Bottom-5 HS2:				
1	46. Straw, esparto or other plaiting materials	29. Organic chemicals	53. Vegetable textile fibres; etc.	60. Fabrics
2	16. Meat, fish or crustaceans, molluscs or other aquatic invertebrates	27. Mineral fuels, mineral oils and products of their distillation; etc.	46. Straw, esparto or plaiting materials	01. Live animals
3	10. Cereals	85. Electrical machinery and equipment and parts thereof; etc.	51. Wool, fine or coarse animal hair; etc.	18. Cocoa and cocoa preparations
4	50. Silk	7. Edible vegetables and certain roots and tubers.	45. Cork and articles of cork	24. Tobacco and manufactured tobacco substitutes
5	8. Fruit and nuts	31. Fertilizers	50. Silk	69. Ceramic products

Notes: The four columns correspond to the four counterfactual retaliatory schedules (optimal-tariff, SOE-protecting, CA-sanctioning, and SS-targeting) respectively. Each column shows top-five and bottom-five unrepeated HS chapters (HS2).

cember, so that the 2017 tariff rates are the default import tariff rates for the year 2018. The welfare deterioration turns out to be 0.37 percentage points, namely $\ln W^O - \ln W^F = 0.37$.

The estimated welfare deterioration above accords with what China's contemporaneous consumer price index (*CPI*) suggests. As a macroeconomic index constructed with completely different data and method from our import price index P, *CPI* displays clear rises as China's retaliation proceeded tranche after tranche. In the upper panel of Figure 3, we reproduce the imports-

Figure 3: China's CPI and PPI during the US-China Trade War
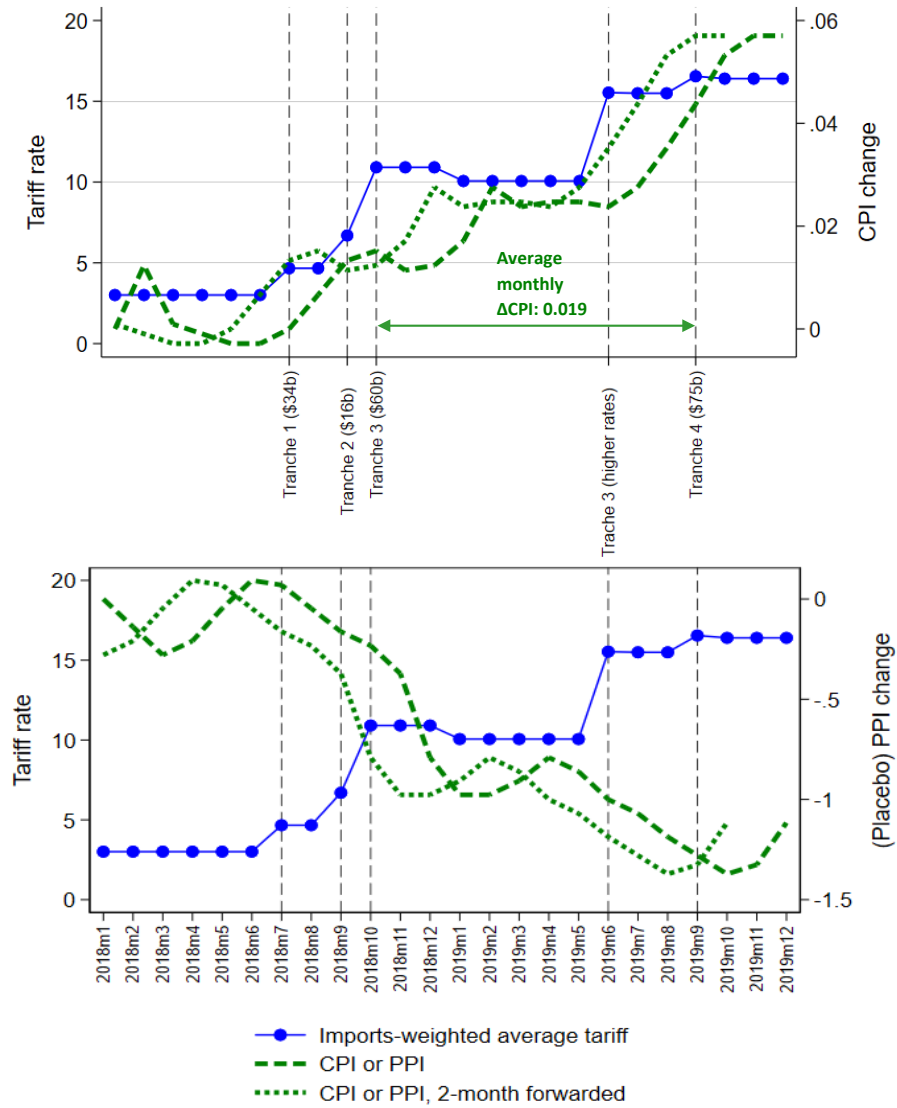
Notes: The solid line represents monthly imports-weighted tariff changes (same as the solid line in Figure 2 but extending backward to January 2018). Monthly consumer price index (CPI in the upper panel) and producer price index (PPI in the lower panel) are displayed as dashed lines for the period (January 2018 to December 2019). CPI and PPI forwarded by two months, which concern delayed impacts of retaliatory tariffs, are displayed as dotted lines. Month t's forwarded CPI and PPI take their month $t + 2$'s values.

weighted retaliatory tariffs displayed in Figure 2 (solid line), extend the time span to the 24 months of 2018 and 2019, and incorporate contemporary *CPI* changes (dashed line; January 2018 is the

base period).[19] As shown, *CPI* significantly rose from July 2018 onward. The average ΔCPI between July 2018 (Tranche 1's effective month) and August 2019 (the last month before Tranche 4 became half-effective) is 0.019. In addition, considering that the passthrough of import tariffs into consumption prices took time, we forward ΔCPI by two months so that month t takes month $t + 2$'s ΔCPI value. The forwarded ΔCPI series (dotted line) traces the tariff locus even more closely.[20]

In the lower panel of Figure 3, we compare the contemporary producer price index (*PPI*), as a placebo for *CPI*, against the backdrop of retaliatory tariffs. The *PPI* locus (dashed line) actually declined from June 2018 onward. The decline might relate to the contemporaneous US tariffs on Chinese products and to macroeconomic factors such as a weaker domestic aggregate demand. Pertaining to our research interest, two observations are in order. First, the association between retaliatory tariffs and *CPI* shown above is not spuriously driven by an all-around inflation, as the production respect appears deflationary. Second, the import price index we use to measure welfare covaries with consumer prices rather than producer prices, supporting our practice to treat imports primarily as a consumption-side phenomenon.

Counterfactual welfare.   We next construct welfare measures for counterfactual retaliatory tariff schedules $\{T_g^{CF,1}\}$ to $\{T_g^{CF,4}\}$. Each counterfactual schedule m has its own $W^{CF,m}(Q)$, which quantifies the welfare level when the total taxable value is Q billion USD. We increase Q product by product rather than dollar by dollar. That is, following the rankings associated with each $\{T_g^{CF,m}\}$, we include one additional HS8 product line each time to increase Q. As Q increases, $W^{CF,m}(Q)$ displays the locus of welfare deterioration. The four $W^{CF}(Q)$ loci can be compared with one another, and also with the factual welfare loss estimated earlier.
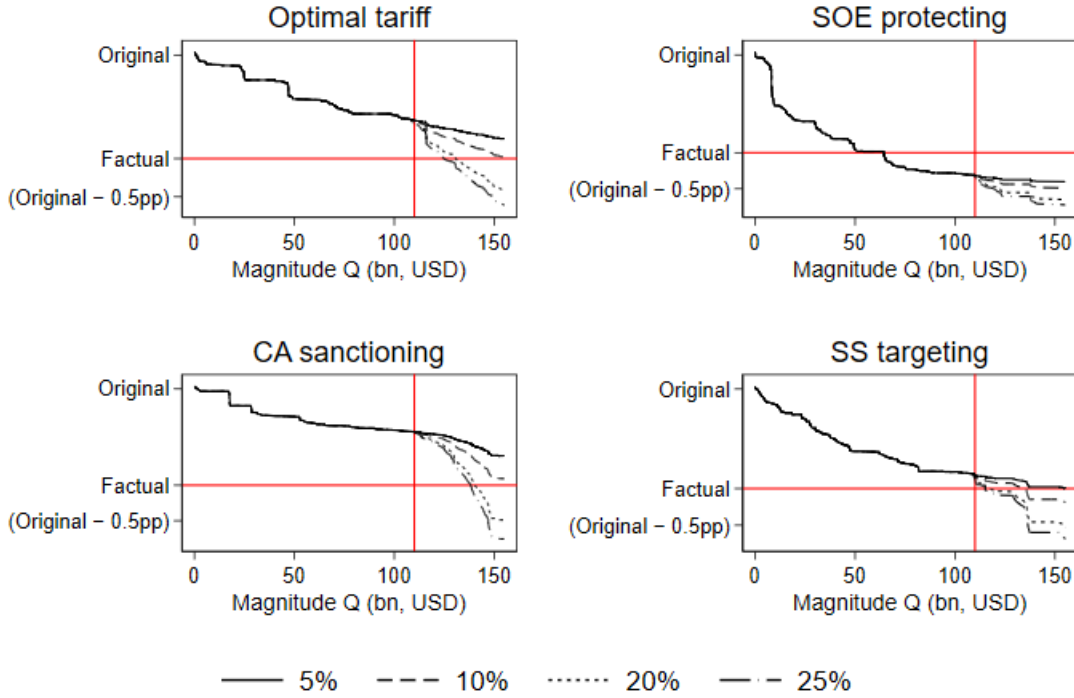
The comparisons are demonstrated in Figure 4. In all four plots of the figure, we mark the previously estimated welfare levels W^F (generated by factual schedule $\{T_g^F\}$) and W^O (assuming no retaliation) with horizontal red lines. We also annotate the welfare level lower than W^O by 0.5 percentage points on the vertical axis as a reference level. In addition, a horizontal line (factual welfare after retaliation) and a vertical line (factual magnitude of retaliation, $Q = Q^F \equiv \$108bn$) divide each plot into four quadrants. The intersection of the horizontal and vertical red lines signify the factual scenario ($Q = Q^F, W = W^F$). We also extend total taxable value Q beyond $\$108bn$ by assuming each of the four existing brackets 5%, 10%, 20% and 25%, and graph the resulting welfare consequences as four separate tails.

As shown, the *optimal tariff* motivated schedule ($m = 1$) generates moderate welfare deterio-

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[19]For example, ΔCPI=0.02 implies a two-percent increase in monthly *CPI* relative to January 2018.

[20]We are not aware of any academic research on the causal effect of China's retaliation on its *CPI*. Macroeconomic research reports published by financial institutions find price-level changes similar to our estimates. For example, Morgan Stanley (2018) estimates the fraction of *CPI* increase attributed to the US-China trade war to be 0.2 to 0.3 percentage points, while Huachuang Securities (2019) estimates it to be 0.3 percentage points.

Figure 4: Factual vs. Counterfactual Welfare: Baseline

Notes: The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff, SOE-protecting, CA-sanctioning,* and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with four hypothetical rates (5%, 10%, 20%, and 25%) in each plot.

ration as Q rises. When Q reaches $Q = Q^F$, the welfare level is higher than W^F. If all remaining Chinese imports from the US are also imposed a tariff rate of 5 to 10 percent, the welfare would still be higher than W^F. This finding also applies to the *CA sanctioning* schedule ($m = 3$), which gives even slower welfare deterioration. In a CES setting such as ours, a potent price position does not necessarily mean low prices but reflects the lack of alternatives. That is, the products in which the US has comparative advantages have a strong market standing, and thus a retaliatory schedule targeting them turns out to be less detrimental in welfare terms.

The *SOE protecting* motivated schedule ($m = 2$) is the only one outperformed by the factual

schedule. The production inefficiency of SOEs has long been known (e.g., Hsieh and Klenow (2009)), such that shielding SOEs from competition with tariffs is expected to cause a double jeopardy for domestic consumer welfare. As a result, $W^{CF,2}(Q)$ decreases to the factual level as early as Q reaches 50 billion US dollars (that is, right after the counterfactual Tranche 2 became effective). Afterwards, $W^{CF}(Q)$ is outperformed by W^F.

The *SS targeting* motivated schedule ($m = 4$) generates a $W^{CF,4}(Q)$ locus approaching W^F when Q reaches Q^F. Notice that if the rest of Chinese imports from the US continue to be imposed a tariff rate of 5 to 10 percent—10 percent is indeed the rate used by China for the half of Tranche 4 that took effect—the welfare level would further approach the factual level. Considering the high similarity in welfare consequence, we conjecture that targeting the swing states important to Trump's reelection largely explains the design of China's factual schedule $\{T_g^F\}$. The next subsection is an econometric investigation into this conjecture.

4.2 Factual motive forensics

The policy motive underpinning China's factual retaliatory schedule $\{T_g^F\}$ is not directly observable. In order to infer that motive, we econometrically examine how the previous motive measures $\{\Lambda_g^1\}$ to $\{\Lambda_g^4\}$ fit the observed $\{T_g^F\}$. Our regression is specified as

$$T_g^F = \sum_{m=1}^{4} \beta_k \Lambda_g^m + M_g \Gamma + \delta_{g2} + \epsilon_g, \tag{18}$$

where g is defined as an HS6 product line and T_g^F is averaged to the HS6 level. δ_{g2} is an HS2 fixed effect and control variables M_g include pre-retaliation tariff rate t_{gUS}^0, a Rauch classification dummy (=1 if product g is a differentiated product), and a Made-in-China 2025 dummy (=1 if product g is covered by the industry policy).[21] These control variables hold constant other policy-related product characteristics that may covary with the retaliatory tariffs. Our parameters of interest are the β's, which isolate the effect of each motive measure Λ_g^m with other motives and product characteristics held the same.

Figure 5 demonstrates pairwise correlations among the four motive measures $\{\Lambda_g^1\}$ to $\{\Lambda_g^4\}$. The motive measures turn out to have their own variations, collaborating the distinct variations indicated by the previous Table 4. The regression results are reported in Table 5. Panel A shows that only the coefficient of the SS-targeting motive measure is statistically significant. That is, all else held equal, products with a greater relevance to Trumps' swing-state support base are taxed at a higher retaliatory rate. The significance holds when the dependent variable is converted to a binary indicator $\mathbb{I}[T_g > 0]$ (Panel B) and when different combinations of control variables are used (Panel C). Products related to China's Made-in-China 2025 Initiative turn out to have lower

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[21] Details of China's Made-in-China 2025 Initiative are provided in Appendix B.

Figure 5: Pairwise Correlation among Motives
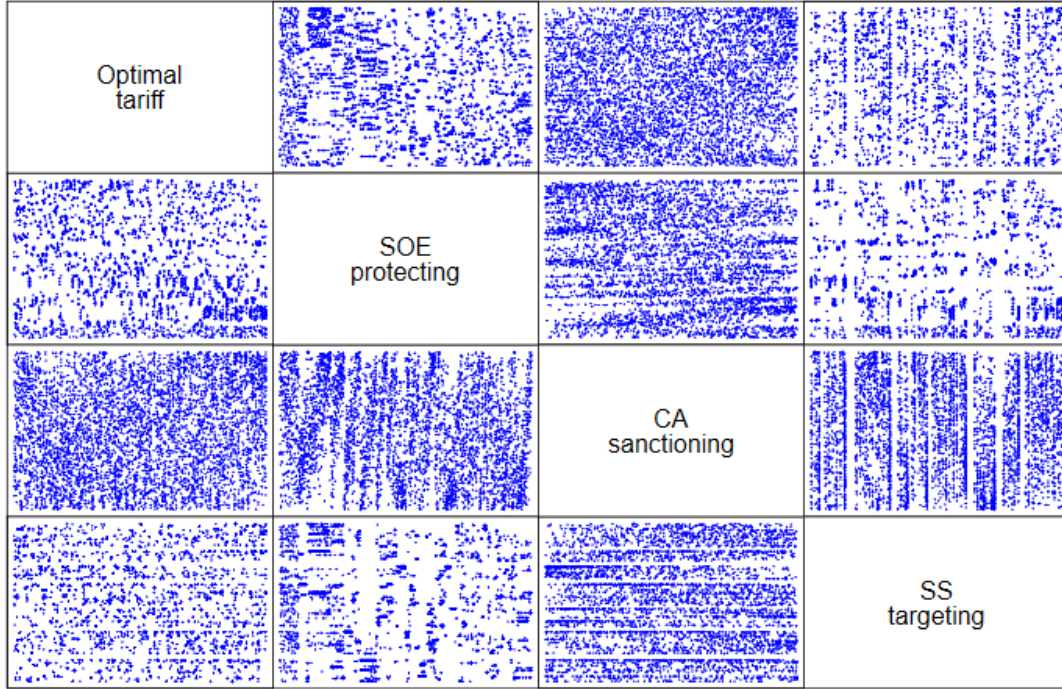
Notes: Pairwise correlations among the four motive measures (*optimal-tariff, SOE-protecting, CA-sanctioning,* and *SS-targeting*) are presented in the figure.

retaliatory tariffs, which is likely due to China's strategic use of high-technology parts and components produced by the US. As a placebo check, we replace the dependent variable with the pre-retaliation tariff rates $\{t^0_{gUS}\}$ (Panel D). Then the statistical significance of the SS-targeting motive measure disappears. Meanwhile, in contrast, the coefficient of the CA-sanctioning motive measure (i.e., a measure of the revealed comparative advantage of US products) becomes statistically significant. That is, prior to the trade war, China actually applied lower tariffs to the products in which the US has comparative advantages.

Table 5: Retaliatory Motive: Forensic Regressions

Panel A: Benchmark results

Dep. Variable: retaliatory tariff rate (unit: percentage point)

	(1)	(2)	(3)	(4)	(5)	(6)
Optimal tariff	0.008				0.008	0.008
	(0.113)				(0.111)	(0.111)
SOE protecting		0.960			0.925	0.921
		(5.241)			(5.264)	(5.277)
CA sanctioning			0.002		0.003	0.003
			(0.006)		(0.006)	(0.006)
SS targeting				0.057**	0.058**	0.058**
				(0.025)	(0.025)	(0.025)
Control variables:						
Pre-war tariff rate	1.068***	1.068***	1.068***	1.066***	1.067***	1.067***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Rauch classification dummy§	0.077	0.084	0.081	0.023	0.030	0.030
	(0.539)	(0.533)	(0.540)	(0.530)	(0.519)	(0.519)
Made-in-China 2025 dummy	-1.423***	-1.429***	-1.429***	-1.350***	-1.363***	-1.365***
	(0.452)	(0.448)	(0.440)	(0.446)	(0.434)	(0.440)
Observations	4,267	4,267	4,267	4,267	4,267	4,267
R-squared	0.530	0.530	0.530	0.530	0.530	0.529

Panel B: Binary dependent variable

Dep. Variable: Indicator[retaliatory tariff rate>0]

	(1)	(2)	(3)	(4)	(5)	(6)
Optimal tariff	-0.000				-0.000	-0.000
	(0.007)				(0.008)	(0.008)
SOE protecting		0.148			0.150	0.150
		(0.218)			(0.218)	(0.218)
CA sanctioning			0.000		0.000	0.000
			(0.000)		(0.000)	(0.000)
SS targeting				0.003***	0.003***	0.003***
				(0.001)	(0.001)	(0.001)
Control variables:						
Pre-war tariff rate	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rauch classification dummy§	0.028	0.027	0.029	0.027	0.029	0.028
	(0.021)	(0.022)	(0.022)	(0.022)	(0.022)	(0.021)
Made-in-China 2025 dummy	-0.068***	-0.067***	-0.071***	-0.067***	-0.071***	-0.068***
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Observations	4,267	4,267	4,267	4,267	4,267	4,267
R-squared	0.169	0.170	0.170	0.169	0.170	0.171

Panel C: Different control variable combinations

Dep. Variable: retaliatory tariff rate (unit: percentage point)

	(1)	(2)	(3)	(4)	(5)	(6)
Optimal tariff	0.008	0.007	0.008	0.008	-0.000	0.000
	(0.097)	(0.097)	(0.111)	(0.111)	(0.008)	(0.007)
SOE protecting	0.741	0.753	0.921	0.925	0.139	0.144
	(5.377)	(5.365)	(5.277)	(5.277)	(0.224)	(0.218)
CA sanctioning	0.002	0.002	0.003	0.003	0.000	0.000
	(0.006)	(0.006)	(0.006)	(0.006)	(0.000)	(0.000)
SS targeting	0.065**	0.065**	0.058**	0.058**	0.003***	0.003***
	(0.027)	(0.027)	(0.025)	(0.025)	(0.001)	(0.001)
Control variables:						
Pre-war tariff rate	1.069***	1.068***	1.067***	1.067***	0.001	0.001
	(0.033)	(0.033)	(0.033)	(0.033)	(0.001)	(0.001)
Rauch classification dummy§	0.082	0.082	0.031			
	(0.524)	(0.524)	(0.022)			
Made-in-China 2025 dummy	-1.365***	-1.429***	-0.070***			
	(0.440)	(0.440)	(0.023)			
Observations	4,267	4,267	4,267	4,267	4,267	4,267
R-squared	0.529	0.530	0.530	0.530	0.167	0.171

Panel D: Pre-war tariffs

Dep. Variable: pre-war tariff rate (unit: percentage point)

	(1)	(2)	(3)	(4)	(5)	(6)
Optimal tariff	-0.188				-0.188	-0.188
	(0.182)				(0.183)	(0.182)
SOE protecting		-0.354			-0.371	
		(0.421)			(0.475)	
CA sanctioning			-0.010**		-0.011**	
			(0.005)		(0.005)	
SS targeting				0.045	0.048	
				(0.043)	(0.043)	
Control variables:						
Pre-war tariff rate						
Rauch classification dummy§	1.397***	1.377***	1.410***	1.423***	1.461***	
	(0.434)	(0.418)	(0.430)	(0.431)	(0.446)	
Made-in-China 2025 dummy	-0.434	-0.464	-0.498	-0.524	-0.522	
	(0.458)	(0.474)	(0.523)	(0.520)	(0.491)	
Observations	4,267	4,267	4,267	4,267	4,267	
R-squared	0.468	0.467	0.467	0.466	0.467	

Notes: HS2 fixed effects are included in all regressions. § Rauch classification dummy: 1 for differentiated products and 0 otherwise. Robust standard errors in parentheses, clustered by HS2. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The findings from Table 5, resulting from a reduced-form forensic analysis, are consistent with the structural normative analysis reported earlier. Evidently, the factual schedule $\{T_g^F\}$ targeted products related to the swing states important to Trump. There have been anecdotes (e.g., Arends (2019) and Helmore (2018)) and studies (e.g., Kim and Margalit (2021) and Fetzer and Schwarz (2021)) claiming that China penalized US swing voters who voted for Trump in the 2016 presidential election and thus might have been likely to vote for him again in the 2020 presidential election. Our product-level analysis supports this thesis. All else held equal, a one standard deviation in the SS-targeting index (6.01) is associated with a 0.35 percentage points higher (i.e., $0.058 \times 6.01 = 0.349$) additional tariff.[22]

4.3 Counterfactual factuals

In this subsection, our interest remains on the factual retaliatory schedule $\{T_g^F\}$ though we return to welfare analysis. We ask the following question: how would the factual retaliatory schedule be implemented if policymakers followed the four theory-based retaliatory motives? The factual schedule does not have a directly observed motive, such that we could not prioritize its products to build its welfare locus against $Q \in [0, Q^F]$ in Figure 4 as we did for counterfactual schedules. Now, suppose that $\{T_g^F\}$ were implemented by a fictional policymaker who reasoned with the four hypothetical motives respectively. Then she could "rehearse" each of the four counterfactual ways to prioritize US varieties to be penalized. This thought experiment helps illustrate how trade theories may affect policy-implementation when policy-making (here, $\{T_g^F\}$) is taken as given.

The results are reported in Figure 6, where all four welfare loci share the same beginning W^O and ending W^F. The upper envelope of the four loci is primarily composed by the locus associated with the SS-targeting motive, a finding that corroborates the retaliatory motive we inferred from Table 5. That is, the SS-targeting motive not only explains the product composition of $\{T_g^F\}$ but also provides a relatively slow reducing path of welfare when it is used to prioritize the factually taxed products. In practical terms, this way of implementation is the most flexible among the four: if $\{T_g^F\}$ were implemented in a continuous fashion—for instance, product after product, or (billion) dollar by (billion) dollar—the implementation following the SS-targeting motive could then stop any time in response to external changes such as negotiations and keep caused welfare losses limited.

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[22]Our estimates are not directly comparable with those in Kim and Margalit (2021) or Fetzer and Schwarz (2021). Kim and Margalit (2021) use an interaction term to identify whether swing congressional districts have a larger employment in industries targeted by China. They find that swing districts displayed 0.59 percentage points higher of that type of employment. Fetzer and Schwarz (2021) use individual-level data to identify whether voters who switched from Obama in 2012 to Trump in 2016 had a higher exposure to China's retaliation. They find that those areas most exposed to retaliatory tariffs of China exhibited an up to 5 percent greater swing to Trump relative to the performance of the 2012 Republican candidate. Unlike in both studies, the relevance to Trump's swing voters in our study is a product characteristic. Our interest is directly in Chinese policymakers' selection of products when they decided to retaliate.

Figure 6: Factual Schedule Implemented in Counterfactual Ways
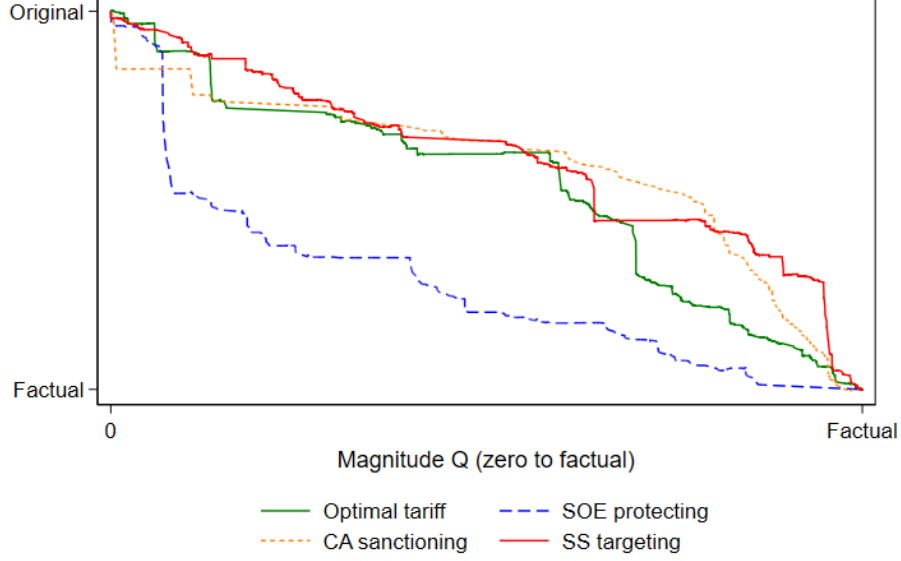
Notes: The four lines are all based on the factual retaliatory tariff schedule. The products in the schedule are ranked according to four different retaliatory motives (*optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting*), and then subsequentially taxed with their factual tariff rates. Since the products and rates come from the factual retaliatory tariff schedule, the maximal Q here is equal to the factual Q (i.e., Q^F), and the lowest welfare level in this figure coincides with the factual welfare level in Figure 4.

4.4 Potential terms-of-trade effects

Our welfare analysis in Section 4.1 does not consider terms-of-trade (TOT) effects, since the short-run ω estimated in Section 3.2 is not statistically different from zero. In other words, according to our estimates, TOT effects are absent in the particular short run we examine. In this subsection, we examine how our previous welfare analysis would change if TOT effects existed. We refer to such *potential* TOT effects as PTOT effects.

In theory, given a retaliatory tariff rate T_g, the burden falling on importers equals

$$\check{T}_g = \frac{1/\omega}{\sigma + 1/\omega} T_g. \tag{19}$$

$1/\omega$ is known as the optimal tariff. When ω approaches zero (as estimated in Section 3.2), $\check{T}_g$ approximates T_g and therefore, the tariff burden all falls on importers. Otherwise, $\check{T}_g$ is smaller than T_g, indicating that the tariff burden is shared by Chinese importers and foreign exporters.

That is, the new $\check{T}_g$ carries only part of the retaliatory tariff burden T_g, alleviating the welfare losses. The delivery price then equals

$$\check{p}_{gUS}(T_g, 1/\omega, p^*_{gUS}, t^0_{gUS}) = \left(1 + \frac{1/\omega}{\sigma + 1/\omega}(t^0_{gUS} + T_g)\right) \underbrace{\left(1 - \frac{\sigma}{\sigma + 1/\omega}(t^0_{gUS} + T_g)\right) p^*_{gUS}}_{\text{observed CIF price}}, \quad (20)$$

where CIF prices observed in the data now correspond to the entire second term rather than merely p^*_{gUS} in the term. In other words, the observed CIF price has two alternative interpretations: (i) p^*_{gUS} if TOT effects are absent, and (ii) $\left(1 - \frac{\sigma}{\sigma + 1/\omega}(t^0_{gUS} + T_g)\right) p^*_{gUS}$ if TOT effects are present. Our previous welfare analysis is based on interpretation (i), whereas we now switch to interpretation (ii). The term $\left(1 - \frac{\sigma}{\sigma + 1/\omega}(t^0_{gUS} + T_g)\right)$ in equation (20), which is less than or equal to one, represents the PTOT effect. Premised on interpretation (ii), the observed US producer prices have already been reduced by the PTOT effect, as the tariff burden has partly fallen on exporters.

We now compute the above $\check{p}_{gUS}(T_g, 1/\omega, p^*_{gUS}, t^0_{gUS})$ for US products imported by China and use them in the welfare analysis, where $1/\omega$ is replaced by our previous optimal-tariff motive measure Λ^1_g, a product-level long-run parameter that we estimated following Feenstra (1994) and Broda and Weinstein (2006) (see Section 3.4 and Appendix B). Here, T_g can be either a factual T^F_g or a counterfactual T^{CF}_g. In theory, $\check{p}_{gUS}(T_g, \Lambda^1_g, p^*_{gUS}, t^0_{gUS})$ can be lower than p^*_{gUS}. Thus, with price $\check{p}_{gUS}(T_g, \Lambda^1_g, p^*_{gUS}, t^0_{gUS})$ instead of p^*_{gUS} used as the price in welfare analysis, the post-retaliation welfare decreases less and may even be higher than the pre-retaliation level.

Figure 7 demonstrates both the factual and counterfactual welfare consequences of retaliation with PTOT effects. Three observations emerge. First, as expected, the W^F with PTOT effects is higher than the previous W^F without PTOT effects (both marked in the figure). Second, the ranking order of the four counterfactual schedules and their comparison with the factual schedule remain the same as before, except that the optimal-tariff schedule now outperforms the CA-sanctioning schedule. Third and most importantly, even with PTOT effects taken into account, China's retaliation does not generate welfare gains. That is, the PTOT effects are outweighed by the consumers' losses such that the net welfare effect continues being negative.

It should be noted that the TOT adjustments in equation (20) consider only the tax incidence related to US products (i.e., $gi = gUS$). In theory, the tax incidence related to product varieties made by other countries should also be taken into account. We are unable to conduct Feenstra-Broda-Weinstein estimation for those numerous country-specific varieties (gi duplets) as we did for US products. However, the welfare consequence of the third-country tax incidence omission, if having a significant magnitude, would appear in the market share of US varieties within their product-level market shares: $\lambda_{gUS} = p^{1-\sigma}_{gUS}/P^{1-\sigma}_g$. Technically, we decompose the price index of

Figure 7: Factual vs Counterfactual Welfare: With PTOT Effects
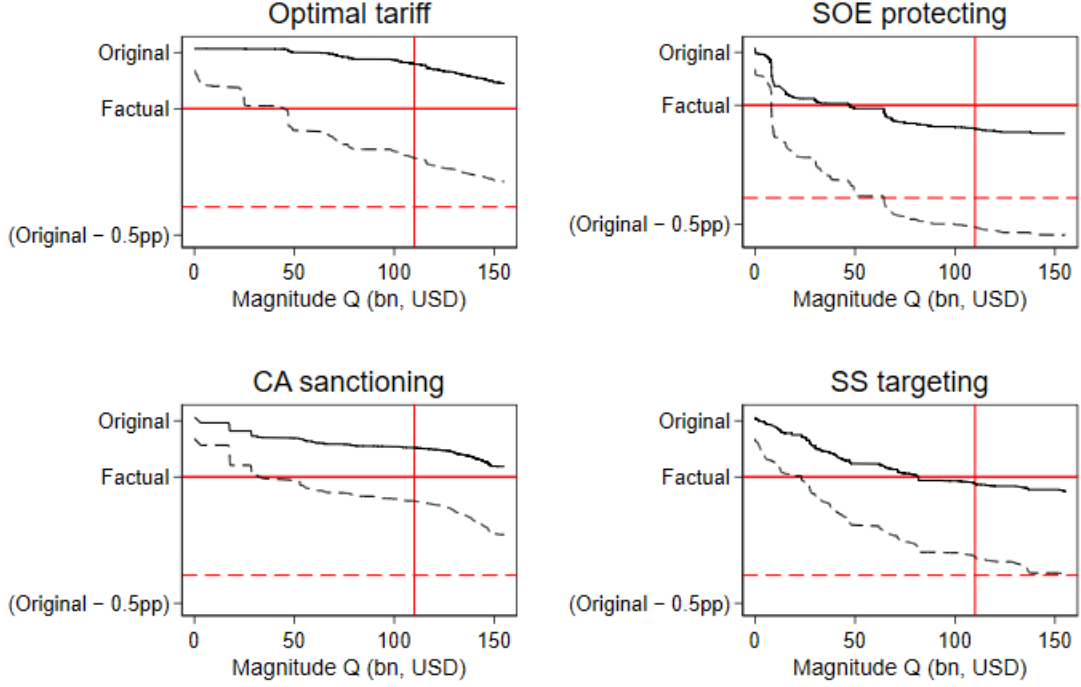
Dashed lines reproduce the results in Figure 4 (i.e., without PTOT effects)

Notes: The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff, SOE-protecting, CA-sanctioning,* and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot. Factual and counterfactual welfare levels have all included PTOT effects, except the dashed lines as noted above.

each given product g containing a US variety into two terms:

$$d \ln P_g = \frac{1}{\sigma - 1} d \ln \lambda_{gUS} + \Omega_{gUS}, \tag{21}$$

where Ω_{gUS} refers to the welfare implications with PTOT effects displayed in the above Figure 7.[23] That is, with Ω_{gUS} partialled out, the market shares $\{\lambda_{gUS}\}$ serve as a sufficient statistic for all the omitted tax incidence. We compare $\{\lambda_{gUS}\}$ of US products between the pre-retaliation setting

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[23]The derivation of equation (21) follows Arkolakis, Costinot, and Rodriguez-Clare (2012). See Appendix C for details.

Figure 8: Market Shares: Pre-retaliation and Post-retaliation
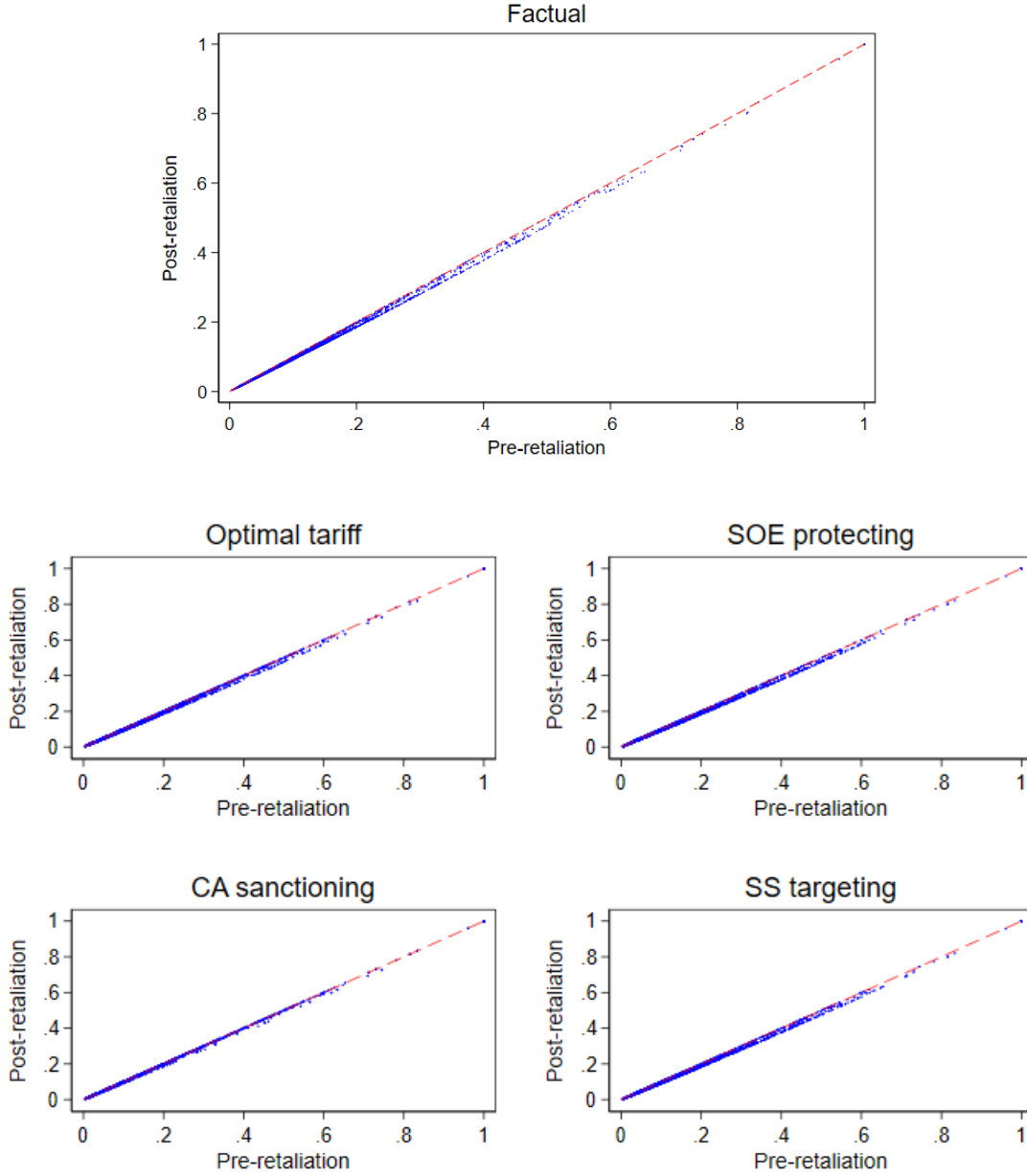
Notes: The market share of US varieties within their HS8 product lines is compared between the pre-retaliation schedule and the post-retaliation schedule. The post-war schedule includes retaliatory tariffs, which come from either the factual schedule (upper panel) or counterfactual schedules (lower panel). The four counterfactual retaliatory schedules correspond to *optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting* motives, respectively. Each dot represents an HS8 product line. The diagonal (dashed) represents no change in market share.

(i.e., $p_{gUS} = (1 + t^0_{gUS})p^*_{gUS}$) and the post-retaliation setting, the latter of which includes the fac-

tual $\breve{p}_{gUS}(T_g^F, \Lambda_g^1, p_{gUS}^*, t_{gUS}^0)$ and the counterfactual $\breve{p}_{gUS}(T_g^{CF}, \Lambda_g^1, p_{gUS}^*, t_{gUS}^0)$. The results from the comparison are displayed in Figure 8, where the diagonals represent no difference between the pre-retaliation market share and the post-retaliation market share of a given product g. As shown, the market share changes are minor, whether factual or counterfactual retaliatory schedules are considered. Thus, we find it safe to say that the omission of third-country tax incidence has minimal impacts on our findings from Figure 7.

4.5 Additional robustness checks

We conduct two additional robustness checks on the welfare analysis reported in Section 4.1. First, average CIF import prices from the year 2018 are used as $\{p_{gi}^*\}$ therein, and we now experiment with alternative 12-month prices.[24] As the retaliation continued until the end of 2019, we use average CIF import prices from (i) the year 2019 and (ii) the year from July 2017 to June 2018. The year 2019 is distant from the pre-trade war base year 2017, and the year from July 2017 to June 2018 overlaps with the base year. Nevertheless, they remain useful since the former accounts for the half-effective Tranche 4 while the latter is a more "immediate" preceding year before the trade war broke out. The results, reported in Appendix D, are in line with what we find in Section 4.1.

Second, the raw import data provide no information on the intended use of imported products. As noted in Section 3.1, the bearer of welfare in our welfare analysis is a nationally aggregated importer. The proportions of Chinese imports being used for consumption, production, processing-then-consumption, processing-then-production, and so forth do not affect our welfare analysis. Nonetheless, for robustness, we check whether these findings (both factual and counterfactual ones) vary by trade regime, and find no remarkable difference across trade regimes. The results of these checks are reported in Appendix E.

5 The Worst-welfare Scenario

In this section, we examine the worst welfare consequence of China's retaliation. The worst welfare consequence arises from the following hypothetical tariff-setting problem. A fictional policymaker maximizes the increase in import price index P subject to a V dollar worth of tariff-ridden imports from the US by setting retaliatory tariff rate T_{gUS} on each US variety of product g. To obtain the retaliatory tariff rates, she solves the following constrained optimization problem:

$$
\begin{aligned}
&\underset{\{T_{gUS}\}}{\text{maximize}} && \ln P \\
&\text{subject to} && \sum_s \sum_{g \in s} (1 + t_{gUS}^0 + T_{gUS}) p_{gUS}^0 m_{gUS} = V.
\end{aligned}
\tag{22}
$$

[24]Full-year (12 months) averages are used, in order to address seasonality in product composition and prices.

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Here $m_{gUS} = [(1 + t^0_{gUS} + T_{gUS})p^0_{gUS}]^{-\sigma} X_g / P_g^{1-\sigma}$, representing the counterfactual demand for US product variety g in sector s when tariff T_{gUS} is applied to the variety.[25] Intuitively, the fictional policymaker should equalize the marginal increase in China's import price index P across US varieties when tariff-ridden total imports from the US rise by one dollar. In the end, she ends up with a set of flexible tariff rates, henceforth denoted by $\{T^+_{gUS}\}$.

The tariff-ridden import value V in problem (22) can be linked to the total taxable value Q used in the previous welfare analysis. Recall that Q is denominated in terms of 2017 prices and quantities $p^{2017}_{gUS} m^{2017}_{gUS}$ to match official descriptions of the retaliatory actions. The sum of any Q-value and its corresponding tariffs can serve as a V-value, which later enables us to compare schedule $\{T^+_{gUS}\}$ with schedule $\{T^F_{gUS}\}$ in welfare.[26]

We solve the optimization problem (22) in Appendix F. A key step in the solving process is

$$\gamma_s \frac{\left(\frac{P_g}{P_s}\right)^{1-\eta}}{\left[1 - \left(\frac{(1+t^0_{gUS}+T^+_{gUS})p^0_{gUS}}{P_g}\right)^{1-\sigma}\right]X_g} = \gamma_k \frac{\left(\frac{P_h}{P_k}\right)^{1-\eta}}{\left[1 - \left(\frac{(1+t^0_{hUS}+T^+_{hUS})p^0_{hUS}}{P_h}\right)^{1-\sigma}\right]X_h}, \quad (23)$$

a condition that must hold for any two US varieties g in sector s and h in sector k. Here X_g and X_h represent product-level expenditures. Intuitively, in order to maximize the upward pressure on the national import price index P, an additional unit of tariff-ridden US import value should keep the marginal index increases through product g and product h equal to each other. The intuition can be further illustrated with a thought experiment. Consider two products h and g in the same sector (i.e., set k to s) and assume that the two products have the same price index and expenditure (i.e., set P_h to P_g and X_h to X_g). Then,

$$(1 + t^0_{gUS} + T^+_{gUS})p^0_{gUS} = (1 + t^0_{hUS} + T^+_{hUS})p^0_{hUS}. \quad (24)$$

That is, the US variety with a lower producer price or initial tariff rate should be given a higher retaliatory tariff rate. In essence, because of the CES demand structure, the solved tariffs are conducive to a relatively symmetric consumption pattern.

The solution to problem (22) is

$$p^0_{gUS} T^\triangle_{gUS} = \frac{V}{X} \left[\sum_i \left((1 + t^0_{gi}) T^\triangle_{gi} p^0_{gi}\right)^{1-\sigma} \right], \quad (25)$$

---

[25]Informed by the ω-estimate in Section 3.2, a horizontal foreign supply curve is assumed here.

[26]The constraint and V in problem (22) have to be tariff-ridden; otherwise, the problem is not a convex optimization problem.

for US product variety g, where X is China's total expenditure on imports, and

$$
T_{gi}^{\triangle} = \begin{cases} 1 + \dfrac{T_{gUS}^+}{1 + t_{gUS}^0}, & \text{if } i = US, \\[2mm] 1, & \text{if } i \neq US. \end{cases}
$$

When $T_{gi}^{\triangle}$ is solved, the flexible tariff rate T_{gUS}^+ can be recovered. As the right side of equation (25) also contains $T_{gi}^{\triangle}$, $T_{gi}^{\triangle}$ does not have a closed-form solution. Intuitively, a higher $T_{gUS}^{\triangle}$ departing from the optimal level reduces the market share of US variety gUS, thereby forming a force to push $T_{gUS}^{\triangle}$ back to the optimal level. Because of the pushback force, an optimal $T_{gUS}^{\triangle}$ exists. Notice that the absence of a closed-form solution to $T_{gi}^{\triangle}$ is not caused by the power $1 - \sigma$, but stems from the presence of third-country varieties. If the US variety gUS is the only variety of product g, the solution (25) collapses to

$$
T_{gUS}^{\triangle} = \frac{1}{p_{gUS}^0} \left(\frac{V}{X} \right)^{1/\sigma}. \tag{26}
$$

Unsurprisingly, $T_{gUS}^{\triangle}$ (and thus T_{gUS}^+) would be higher if either the US variety has a lower price, or V/X rises (i.e., a larger magnitude of retaliation).

With data on $\{p_{gUS}^{2017}\}$, $\{t_{gUS}^0\}$, and selected V-values, we numerically solve for $\{T_{gi}^{\triangle}\}$ and thus $\{T_{gUS}^+\}$. Our selected V-values are \$45bn, \$63bn, and \$131bn, each of which is a tariff-ridden Q analyzed earlier. For example, the cumulative Q by Tranche 3 (i.e., $Q_F \equiv \$108$bn in equation (9)), when tariff-ridden, equals

$$
\sum_{g \in \{T_g^F > 0\}} (1 + t_{gUS}^0 + T_g^F) p_{gUS}^{2017} m_{gUS}^{2017} = \$131\text{b}. \tag{27}
$$

With each of the three V-values, we graph the solved T_{gUS}^+ against T_{gUS}^F as a plot in the first column of Figure 9. As expected, a higher V translates to higher T_{gUS}^+ rates. This pattern is salient if one reads from the top row of plots to the bottom row. Intuitively, since the CES structure is homothetic, a larger given tariff-ridden import value has to be realized by raising all retaliatory tariffs proportionately. The solved T_{gUS}^+ have rates as high as 60,000 percentage points, potentially driven by small unit values (equation (26) illustrates the mechanism), small market shares, the solving algorithm, and combinations thereof. To address outliers, we exclude the top-5 (top-25) percent T_{gUS}^+ rates in the second (third) column of the plots. Excluding the top quarter of T_{gUS}^+ rates reduces the highest rates to be in a realistic range between 20 to 60 percentage points.

In Figure 10, we plot the post-retaliation welfare level resulting from the flexible schedule, along with the welfare level resulting from the factual schedule, tranche after tranche against tariff-ridden imports from the US (i.e., V, or equivalently, tariff-ridden Q). The flexible schedule turns out to perform far worse than the factual schedule. The cumulative welfare loss by Tranche 3 is 3.5 percentage points lower than the no-retaliation level, which is nearly ten times worse than

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Figure 9: Flexible Rates vs. Factual Rates: Composition
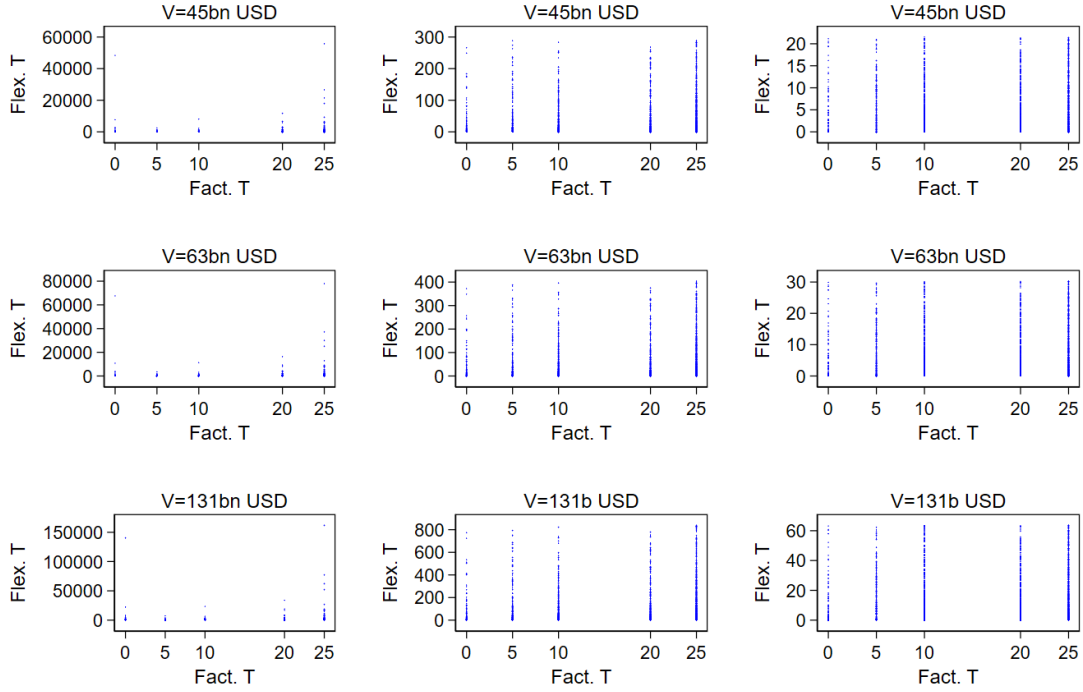
Notes: The three rows of plots correspond to three different V-values (46bn, 63bn, and 131bn, unit: USD). The V-value noted above each plot is the one used to solve T_{gUS}^{+}. In each graph, flexible rate T_{gUS}^{+} is graphed against factual rate T_{gUS}^{F} across US product varieties. Each dot represents one US product variety. The left column of plots includes all values of T_{gUS}^{+}, the middle column excludes top 5% rates, and the right column excludes top 25% rates. Unit of the rates is 1 (e.g., a rate of 20 means a 20 percent ad valorem retaliatory tariff).

the factual retaliation (0.37 percentage points lower).

6   Reduced-form Welfare Analysis

Our welfare analysis has so far been conducted in a structural approach. In this section, we use a reduced-form welfare measure (henceforth, RFM) to conduct both factual and counterfactual welfare analysis. The measure takes the following form:

$$RFM = -\mathbf{m^0} \cdot \mathbf{p^*} \cdot \mathbf{T}. \tag{28}$$

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Figure 10: Flexible Rates vs. Factual Rates: Welfare
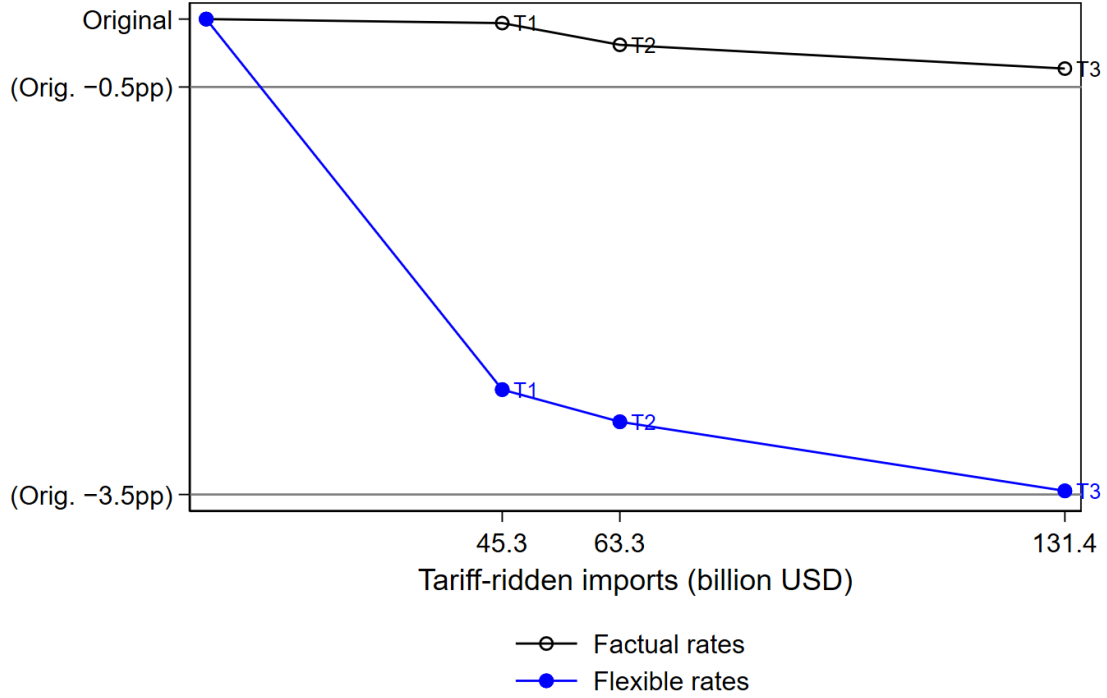
Notes: The horizontal axis shows tariff-ridden import value (V). The V-values 45.3, 63.3, and 131.4 are tariff-ridden equivalents of the Q-values 34, 16, and 108 respectively in the previous welfare analysis. Each of the three V-values (Q-values) pertains to the conclusion of one tranche of retaliation. The resulting welfare levels are graphed as lines: black (hollow-circle connected) for the factual schedule $\{T_g^F\}$ and blue (solid-circle connected) for the flexible schedule $\{T_g^+\}$.

Here, $\mathbf{m^0}$ is the vector of pre-retaliation import quantities, namely $\{m_{git^0}\}$ (in our case, the 2017 quantities of imports by China from the US). $\mathbf{p}^*$ is the vector of post-retaliation observed CIF prices, namely $\{p_{gi}^*\}$. $\mathbf{T}$ is the vector of retaliatory tariffs, namely $\{T_{gi}\}$, where

$$T_{gi} = \begin{cases} 0, & \text{if } i \neq US, \\ T_g, & \text{if } i = US. \end{cases} \tag{29}$$

Here, $\{T_g\}$ can be either factual $\{T_g^F\}$ or counterfactual $\{T_g^{CF}\}$.

RFM represents the hypothetical income change needed to reach the pre-retaliation importers' welfare level anchored by pre-retaliation import quantities. Its value is in pecuniary terms (US dollars) and implies that the importers would be equally worse off as they would from losing

RFM dollars if the retaliatory tariffs were applied on importers as a lump-sum tax rather than on imports as sales taxes. It is equal to the first term in FGKK's aggregate equivalent variation (EV).

RFM has two notable merits in our context. First, it entails only pre-retaliation quantity and post-retaliation prices. The previous equation (5), combined with data and estimated $\hat{\omega} = 0$, gives counterfactual post-retaliation prices but no counterfactual post-retaliation quantities. Thus, *RFM* meets our need to estimate post-retaliation welfare without post-retaliation quantities. Second, it is a plain accounting measure that does not rely on any theoretical structure. The only element we borrow from the previous welfare analysis is the four counterfactual retaliatory schedules (including product lists and tariff rates).

Table 6: Reduced-form Welfare Reduction

	Factual	Counterfactual			
		Optimal tariff	SOE protecting	CA sanctioning	SS targeting
Value, billion USD	-62.8	-30.4	-63.0	-27.5	-27.9
(s.e.)	(27.2)	(5.9)	(23.4)	(7.8)	(4.7)
[95% c.i.]	[-116.1, -9.5]	[-42.0, -18.9]	[-108.9, -17.0]	[-42.8, -12.2]	[-37.2, -18.7]
% points of GDP*	-0.51	-0.25	-0.51	-0.22	-0.23
[95% c.i.]	[-0.94, -0.08]	[-0.34, -0.15]	[-0.88, -0.14]	[-0.35 -0.10]	[-0.30, -0.15]

Notes: The four columns under "Counterfactual" correspond to the four counterfactual retaliatory schedules (optimal-tariff, SOE-protecting, CA-sanctioning, and SS-targeting) respectively. Standard errors (s.e.) and confidence intervals [95% c.i.] are based on boostrapped product lists (1,000 times). * Points and interval estimates are based on the values above divided by China's 2017 GDP (12.31 trillion US dollars).

Our *RFM* estimates are reported in Table 6. The factual welfare loss is estimated to be 62.8 billion US dollars (s.e. 27.2), accounting for 0.51 percent of China's pre-retaliation (2017) GDP. The factual estimates are comparable with FGKK's import-only estimates for the US (-50.9 billion US dollars and a reduction of the US GDP by 0.27 percent).[27] The ranking order of the factual and counterfactual schedules follows the one we obtained from the structural approach. The only exception is that the SS-targeting schedule now performs better than the optimal-tariff schedule, though their estimates remain in each other's one standard error and 95% confidence interval. As

---

[27]FGKK provide equivalent variation (EV) estimates for imports and exports separately. The sum of the two EVs and the change in tariff revenue is their total EV (see their equation (27) and Table VIII). Our *RFM* is most similar to their EV for imports (EV^M).

before, the factual retaliation is still worse than three out of the four counterfactual retaliations and only better than the SOE-protecting schedule. However, the magnitude of the measured welfare deterioration is now close to that of the SOE-protecting schedule rather than the other three. Notice that the magnitude hinges on the quantity data $\mathbf{m^0}$, which come from the year 2017 (that is, when the trade war was fermented). We employ and present this reduced form approach only for the purposes of comparison and completion.

7   Concluding Discussion

Trade theories have long shown why and how to avoid trade wars but have said relatively little about how to fight a trade war that has unfortunately begun. The recent US-China trade war, in some sense, caught trade economists off guard. However, it does provide an opportunity to observe trade wars and reflect on trade policy theories. During the major rounds of China's retaliation, Chinese policymakers fought in an "eye for an eye" (EFAE) fashion, matching the US terms of total taxable value and tariff rates while leaving the product dimension open to decision-making. We simulate four different trade policy theories that could motivate retaliation and compare them against China's factual retaliation. Conditional on the same total taxable and rate structure, two of the counterfactual retaliations (with optimal-tariff and CA-sanctioning motives, respectively) perform better than China's factual retaliation, and one of them (with SOE-protecting motive) performs worse. Retaliating against Trump's swing state voters, as the fourth hypothetical motive, is closest to the welfare loss caused by factual retaliation. This welfare implication is also in line with our regression-based forensic study of China's retaliatory tariffs.

A notable merit of our approach is that it can be applied to any EFAE retaliation. As long as the second party in a trade war chooses the same taxable value and tariff rates as the first party, our approach can be used to simulate the welfare consequence of various retaliatory motives. The resulting retaliatory schedules, either theoretically motivated (such as the four theory-backed motives we consider) or ad hoc designed (such as the worst-welfare scenario we construct), are observationally equivalent to the factual retaliation and thus can be compared both side by side with the factual retaliation and compared among themselves.

We would like to note three unaddressed areas in this study. First, domestic production is not included here. Our welfare analysis builds on FGKK's CES structure but departs from their study in most other respects. In the variant of their CES structure we build, imports are intentionally separated from domestic products. We take the perspective of a representative Chinese importer, who is neither a pure consumer nor a pure producer. China's imports serve as both consumption goods and intermediate inputs. The use of an importer's perspective exempts us from modeling the anatomy of global supply chains. Chinese producers in the global value chains are, first of all, importers. In a study examining Chinese import tariffs, designating the stakeholders as importers is a compromise we made between tractability and reality.

Second, ours is a partial equilibrium framework. General equilibrium analysis in our setting would entail, at a minimum, assumptions on the political structure and labor market. Policy-makers who prioritize one motive would redistribute tariff revenue differently from those who prioritize another. More broadly, how they shape the economy differently depends on how we assume the institutions of the country work. We maintain our study, an empirical one aiming to inform future policy modeling choices, in a partial equilibrium fashion such that its findings are not driven by the modeling choices that it aims to inform.

Third, our study, just as other studies in the literature, focuses on the short runs of trade wars. The welfare implications may or may not apply to the long run. China's considerable market size can pull the foreign supply curves of many products upward. In the meantime, recent studies such as Besedes et al. (2020) show that tariff burdens fall on US consumers even in the long run. China's market power is smaller than the US market power, leaving still smaller room for terms-of-trade manipulation. The trade war was China's first instance in recent decades of raising import tariffs extensively. Time will tell what effects these tariffs may have in the long run.

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"China's Trade Retaliation: Factuals vs. Counterfactuals" Online Appendices

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May 6, 2023

Table of Contents

Online data sources in the appendices are <u>hyperlinked</u>

A Data and Parameters

Data sources. China's import tariff rates of 2017 were extracted from *The Customs Import and Export Tariff of the People's Republic of China* published by the Customs Tariff Commission of the Chinese State Council (henceforth, CTC). The CTC publishes tariff rates by HS code and country on the website of the Ministry of Finance in .pdf format (web link) and on the website of the Ministry of Commerce (Mofcom) in web-form format (web link). During the US-China trade war, the CTC published retaliatory tariffs as follows:

- Tranches 1 and 2: See web link (Announcement Number: Mofcom-2018-55) for announcements, product lists, and tariff rates.

- Tranche 3: See web link (Announcement Number: Mofcom-2018-69) for the announcement. The product list and tariff rates are provided as attachments at web link (original version, September 18, 2018) and web link (escalated version, May 13, 2019).

- Tranche 4: See web link (Announcement Number: CTC-2019-4) for announcements, product lists, and tariff rates.

Two exemptions are mentioned in the main text of this paper. One was for automobile products, announced in December 2018 (see web link for both announcement and product list, Announcement Number: CTC-2018-10), effective January 1, 2019. This exemption was announced in August 2019 to end on December 15, 2019 (see web link, Announcement Number: CTC-2019-5). The other was for a list of products with no specific focus, announced in August 2019 (see web link for both announcement and product list, Announcement Number: CTC-2019-6), effective September 17, 2018. Import price and quantity data can be purchased from the Data Services Department of the Hong Kong Trade Development Council (HKTDC, web link).

Estimates of γ_s. The estimates of γ_s mentioned in the main text are reported in Table A1, with the descriptions of the HS2 codes having maximal and minimal γ-values.

Preexisting trends. The parameter estimation through regressions (7a) and (7b) assumes the absence of preexisting trends. That is, tariff changes must be uncorrelated with import demand and export supply shocks. Following Fajgelbaum et al. (2020), we test for preexisting trends using

$$\overline{\Delta \ln y_{gi,2017}} = \zeta_g + \zeta_{is} + \rho \Delta \ln(1 + t_{ig}) + \epsilon_{gi}, \tag{A.1}$$

where the dependent variable is average monthly change in imported values, quantities, exporter prices, or import prices in 2017. Each of these average monthly changes, denoted by y, is regressed against the changes in the import tariff rates between 2017 and 2018. ζ_g and ζ_{is} are (HS8) product fixed effects and country-sector fixed effects, respectively. As shown in Table A2, no statistically significant relationship is found between these import outcomes and the import tariff changes,

indicating that targeted product varieties were not driven by preexisting trends that differ from non-targeted product varieties.[1] When the sample is limited to US product varieties, the same finding applies.

Feenstra-style variety correction. The Feenstra-style variety correction refers to a method developed by Feenstra (1994) for adjusting variety changes in price index construction. Our demand system follows Fajgelbaum et al. (2020), who derived

$$\Delta \ln p_{gt} = \frac{1}{1-\sigma} \ln \left(\sum_{i \in \mathcal{C}_{gt}} s_{git} e^{(1-\sigma)\Delta \ln \left(p^*_{git}\left(1+t_{git}\right)\right)+\Delta \ln \hat{\varepsilon}_{git}} \right) - \frac{1}{1-\sigma} \ln \left(\frac{S_{g,t+1}\left(\mathcal{C}_{gt}\right)}{S_{g,t}\left(\mathcal{C}_{gt}\right)} \right). \qquad \text{(A.2)}$$

The last term in equation (A.2) is a Feenstra-style variety correction that addresses the changes in the composition of varieties between time t and time $t+1$. Here $s_{git} \equiv \frac{p_{git}m_{git}}{\sum_{i' \in \mathcal{C}_{gt}} p_{gi't}m_{gi't}}$ is the share of continuing variety i among all continuing varieties, $\mathcal{C}_{gt}$ is the set of continuing imported varieties in product g between the two periods, and $S_{g,t}(\mathcal{C}) \equiv \frac{\sum_{i' \in \mathcal{C}} p_{i'gt}m_{i'gt}}{\sum_{i' \in \mathcal{I}} p_{i'gt}m_{i'gt}}$ is the share of the varieties in set $\mathcal{C}$ within the imports of all product g varieties (set $\mathcal{I}$) at time t. σ and $\hat{\varepsilon}_{git}$ are estimated from equation (7a). The instrumental variable for $\Delta \ln p_{gt}$ is

$$\Delta \ln H_{gt} = \ln \left(\frac{1}{N_{gt}} \sum_{i \in \mathcal{C}_{gt}} e^{\Delta \ln \left(1+t_{git}\right)} \right), \qquad \text{(A.3)}$$

where N_{gt} is the set of continuing varieties from the previous period.

Made in China 2025. We include a *Made in China 2025* dummy (HS4) indicator in Table 5 as a control variable. The dummy variable was constructed by us. The Made-in-China 2025 Initiative (henceforth, MIC2025) was released by the State Council of China on May 19, 2015. The full text of the MIC2025 document is publicly available on the Chinese Central Government's website (web link). The initiative aims to transform China into a global manufacturing leader in the production of high-technology products. It encourages the use of private and state funds to conduct research and development (R&D) and purchase global firms. We manually match the initiative to product lines through the similarities between the industry descriptions in the MIC2025 document and the product descriptions of the four-digit HS codes (publicly available on the UN Statistics Division's website, web link).

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[1]The last two columns display the same coefficients because their dependent variables, when written in first-order differences, are equivalent to each other. The same finding was made in FGKK (see columns (3) and (4) in their Table III).

Table A1: Estimates of γ_s

Variable	Obs	Mean	Std. Dev.	Median	Min*	Max**
γ	96	0.010	0.030	0.016	3.99E-06	0.221

* γ-min: HS2=93

Arms and ammunition; parts and accessories thereof.

** γ-max: HS2=85

Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles.

Table A2: Testing for Pretrends

	(1) $\Delta\ln(p_{gi}^* m_{gi})$	(2) $\Delta\ln(m_{gi})$	(3) $\Delta\ln(p_{gi}^*)$	(4) $\Delta\ln(p_{gi})$
Panel A: All Imports				
$\Delta\ln(1+\tau_{ig})$	0.983	0.259	0.724	0.724
	(0.689)	(0.825)	(0.457)	(0.457)
Country-sector fixed effect	Yes	Yes	Yes	Yes
Product fixed effect	Yes	Yes	Yes	Yes
N	85,002	85,002	85,002	85,002
R-squared	0.239	0.232	0.238	0.238
Panel B: Imports from the US only				
$\Delta\ln(1+\tau_{ig})$	0.623	-0.370	0.994	0.994
	(1.096)	(1.112)	(0.622)	(0.622)
Sector fixed effect	Yes	Yes	Yes	Yes
N	4,846	4,846	4,846	4,846
R-squared	0.064	0.064	0.055	0.055

Notes: Standard errors in parentheses, clustered by country and HS8 in Panel A and by HS8 in Panel B. None of the coefficients in the table is statistically significant at conventional significance levels.

B Auxiliary Estimation Details

The estimation details of Λ_g^1 to Λ_g^4 are provided in this section. We keep notations consistent with those in their original studies whenever confusion does not arise. Thus, notations used in the estimation of one Λ_g (such as X or Y) may not apply to another Λ_g.

Optimal tariffs. We follow Feenstra (1994) and Broda and Weinstein (2006) to estimate the inverse supply elasticity

$$\Lambda_g^1 \equiv \left[\frac{dm_{gUS}}{dp_{gUS}^*} \cdot \frac{p_{gUS}^*}{m_{gUS}} \right]^{-1}.$$

Notice that currently available data and methods do not allow an estimation of US product supply elasticities specifically perceived by China as an importer. The supply elasticities we estimate are in the eyes of the rest of the world (i.e., an aggregate importer of US products). Below is a concise description of their method, without entailing its micro-foundation. First, estimate the following model over a period of time:

$$\bar{Y}_{ngi} = \theta_{ng1}\bar{X}_{1,ngi} + \theta_{ng2}\bar{X}_{2,ngi} + \bar{u}_{ngi}, \tag{B.1}$$

where the overbars denote averages and the variables are defined as follows:

$$Y_{ngit} = \left(\Delta^* \ln p_{ngit} \right)^2, \tag{B.2}$$

$$X_{1,ngit} = \left(\Delta^* \ln s_{ngit} \right)^2, \tag{B.3}$$

$$X_{2,ngit} = \left(\Delta^* \ln p_{ngit} \Delta^* \ln s_{ngit} \right). \tag{B.4}$$

Here, n is the importer, while g, i, and t index product, exporter, and time, respectively, as in the main text. s_{ngit} is the share of variety gi within product g in country n. Δ^* denotes a time-difference operation specific to duplet ng: $\Delta^* x_{ngit} = \Delta x_{ngit} - \Delta x_{ngk_{ng}^*t}$ for any variable x_{ngit}, where k_{ng}^* is a reference product g imported by n. By estimating equations (B.1), we obtain $(\hat{\theta}_{ng1}, \hat{\theta}_{ng2})$, which is in turn informed by structural parameters

$$\hat{\theta}_{ng1} = \frac{w_{ng}}{(1 + w_{ng})(o_{ng} - 1)}, \tag{B.5}$$

$$\hat{\theta}_{ng2} = \frac{w_{ng}(o_{ng} - 2) - 1}{(1 + w_{ng})(o_{ng} - 1)}. \tag{B.6}$$

As solutions to the system of equations (B.5)-(B.6), w_{ng}^* and o_{ng}^* have theoretical interpretations in the background. w_{ng}^* is inverse export elasticity perceived by importer n, while o_{ng}^* is import demand elasticity of importer n.[2]

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[2]The system of equations (B.5)-(B.6) is not linear. We follow Broda et al. (2008) to conduct grid searches to ensure $w_{ng}^* > 0$ and $o_{ng}^* > 1$.

As noted above, in our setting, the importer is the entire world except the US. We downloaded the import data of 227 countries from COMTRADE for the years 2012-2017, covering 1,224 HS4 products. By setting n as the aggregate of all 227 countries, we estimate equation (B.1) and solve $w^*_{China,g}$ as our estimate of Λ^1_g for US product g. Λ^1_g is at the HS4 level. Notice that the algorithmic operation of margins (9′) and (10′) does not hinge on the (dis)aggregatedness of product line g. Policymakers can assign counterfactual tariffs at the HS4, HS6, or HS8 level, depending on the HS-level of product line g or estimated Λ_g.

Protection for sale (SOE protecting).   We follow Goldberg and Maggi (1999) to construct

$$\Lambda^2_g \equiv \frac{I_g - \alpha}{a + \alpha} \cdot \frac{R_g}{\sigma_g},$$

where, for a given product g, I is a dummy variable reflecting whether lobbies are organized ($= 1$ if they are), import penetration R is equal to the domestic output divided by imports EX/IM, and σ is the long-run import demand elasticity. The data on IM and EX come from the Annual Industrial Surveys of China (AISC). Their original data are at the industry level (four-digit industry code), which we convert to HS6 codes using the concordance table in Upward et al. (2013). To construct I_g for industry g, we employ the enterprise list published by the State-owned Assets Supervision and Administration Commission (SASAC) of the Chinese State Council. Industries with (without) SOEs mentioned by the SASAC are given $I_g = 1$ ($I_g = 0$).[3] σ_g is estimated using the method of Feenstra (1994) and Broda and Weinstein (2006), as described above, for estimating optimal tariffs—recall o^*_{ng} as a solution to the system of equations (B.5)-(B.6). When the method is applied to Chinese imports from the rest of the world, o^*_{ng} implies China's long-run product-specific import demand elasticity and can be estimated following the same procedure as we conducted for w^*_{ng}. We extract Chinese imports data from COMTRADE (2012-2017, 217 countries, 5,042 HS4 products) to estimate o^*_{ng} as the value of σ_g.

In the formula for Λ^2_g, α refers to the share of employment related to organized lobbies (SOE in our context). It is a constant scalar appearing in both the numerator and the denominator. We do not normalize it but estimate it using the aggregated AISC data ($\hat{\alpha} = 0.179$). a as a constant scalar appearing only in the denominator is normalized to zero.

Revealed comparative advantage (CA sanctioning).   Costinot et al. (2012) and French (2017) propose a parametric system $\{Z_{gi}\}$ that can characterize product-level comparative advantages of countries in a micro-founded fashion.[4] Z_{gi} is a technology parameter in inverse proportion to the cost of producing product g in country i. By definition, country j has a comparative advantage in

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[3]Only SOEs controlled by the central government are considered. The list of enterprises is provided on the SASAC website (web link).

[4]French (2017) shows that the underlying micro-foundation can be an Eaton-Kortum, Armington, Bertrand competition, or monopolistic competition (with and without free entry and firm heterogeneity) trade model.

product g if

$$\frac{Z_{gj}}{Z_{gi}} > \frac{Z_{g'j}}{Z_{g'i}}, \tag{B.7}$$

for any country i and product g'. Define bilateral trade flows $X_{ngi} = p^*_{ngi} m_{ngi}$ in product g between countries n (destination) and i (origin). French (2017) shows that

$$\frac{X_{ngj}}{X_{ngi}} > \frac{X_{ng'j}}{X_{ng'i}} \text{ if and only if } \frac{Z_{gj}}{Z_{gi}} > \frac{Z_{g'j}}{Z_{g'i}}, \tag{B.8}$$

for any destination country n. Thus, with reference country i^0 and reference product g^0 given, $\frac{Z_{gj}/Z_{g^0 j}}{Z_{g i^0}/Z_{g^0 i^0}}$ is a measure of country j's comparative advantage in producing product g. This comparative advantage measure can be constructed using trade flow data. Both Costinot et al. (2012) and French (2017) note that this measure can be estimated using the fixed effect δ_{gj} in the following regression

$$\ln X_{n,gj} = \delta_{nj} + \delta_{gn} + \delta_{gj} + \epsilon_{n,gj}. \tag{B.9}$$

In our context, $j = US$. We use US exports to 222 countries to run regression (B.9).[5] The estimated $\hat{\delta}_{gj}$ is our motive measure Λ^3_g in equation (16). Our Λ^3_g is at the HS6 level.

Trump swing state index (SS targeting). As noted in the text, the Trump swing state index was constructed as

$$\Lambda^4_g \equiv \sum_{h \in Swing} \frac{L_{gh}}{L_h} \cdot VotingTrump_h,$$

where $h \in Swing$ represents a county in a swing state that voted for Trump in the 2016 US presidential election. The swing states in 2016 were the 11 states (Colorado, Florida, Iowa, Michigan, Nevada, New Hampshire, North Carolina, Ohio, Pennsylvania, Virginia and Wisconsin) designated by Politico (web link). Among them, Florida, Iowa, Michigan, North Carolina, Ohio, Pennsylvania, and Wisconsin voted for Trump. The county-level voting data were purchased from *Dave Leip's Atlas of U.S. Presidential Elections* https://uselectionatlas.org). $\frac{L_{gh}}{L_g}$ is the share of labor employment related to US product g. The data on employment across counties were downloaded from the County Business Patterns (CBP) database maintained by the US Census Bureau. The latest data available for downloading are for the year 2016. The CBP data are published by the US Census Bureau at the county-industry level. Notice that CBP reports industry (NAICS) level data. To convert the CBP data to the HS6 level, we followed the steps taken by Autor et al. (2013), available on this page (https://www.ddorn.net/data.htm) of David Dorn's website. Our Λ^4_g is at the HS6 level.

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[5]The US exports data were downloaded from COMTRADE for the year 2017, covering 5,131 products.

C Derivation of Equation (21)

The tariff-ridden delivery price of an imported variety in China can be generally written as

$$p_{gi} = Y_{gi} p_{gi}^X. \tag{C.1}$$

When TOT effects are absent, $Y_{gi} = 1 + t_{gi}$ and $p_{gi}^X = p_{gi}^*$. When TOT effects are present, $Y_{gi} = 1 + \frac{1/\Lambda_{gi}^1}{\sigma + 1/\Lambda_{gi}^1}(t_{gi}^0 + T_{gi})$ and $p_{gi}^X = [1 - \frac{\sigma}{\sigma + 1/\Lambda_g^1}(t_{gi}^0 + T_g)]p_{gi}^*$. The latter case is an application of equation (20), with $T_{gi} = 0$ if $i \neq US$. The derivation below holds whether TOT effects exist or not.

Define $\lambda_{gi} = p_{gi}^{1-\sigma}/P_g^{1-\sigma}$. The CES demand m_{gi} equals $\lambda_{gi} X_g$, where X_g is China's expenditure on imported product g. By equations (C.1),

$$d \ln \lambda_{gi} - d \ln \lambda_{gUS} = (1 - \sigma) \left((d \ln Y_{gi} + d \ln p_{gi}^X) - \underbrace{(d \ln Y_{gUS} + d \ln p_{gUS}^X)}_{\equiv \Omega_{gUS}} \right), \tag{C.2}$$

for any $i \neq US$. The previously conducted welfare analysis, either the one with TOT effects (Figure 7), or the ones without TOT effects (see Figure 4), are concerned only with the US and thus correspond to the second parentheses in equation (C.2), denoted by Ω_{gUS}.

The percentage change in the price index associated with product g is

$$d \ln P_g = \sum_i \lambda_{gi}(d \ln Y_{gi} + d \ln p_{gi}^X) = \sum_i \lambda_{gi} \left(\frac{1}{1 - \sigma}(d \ln \lambda_{gi} - d \ln \lambda_{gUS}) + \Omega_{gUS} \right), \tag{C.3}$$

which can be simplified as $\frac{1}{\sigma-1} d \ln \lambda_{gUS} + \Omega_{gUS}$ ($\sum_i \lambda_{gi} = 1$) and gives equation (21). The algebra used here follows the spirit of the baseline (i.e., Armington-CES) case in Arkolakis et al. (2012).

D Robustness Checks (Time Periods)

This appendix consists of Figure D1 and Figure D2. They were mentioned in Section 4.5 of the main text. In the main text, 2018 yearly average CIF import prices are used for $\{p_{gi}^*\}$. To check whether the choice of the price data influenced the welfare analysis, the yearly averages from July 2017 to June 2018 (the 12 months right before Tranche 1 took effect) are used in Figure D1 for $\{p_{gi}^*\}$, and yearly averages of 2019 in Figure D2. Both figures show similar results, including factual and counterfactual ones, to Figure 4 in the main text.

Figure D1: Welfare Analysis (CIF Prices: July 2017 to June 2018)
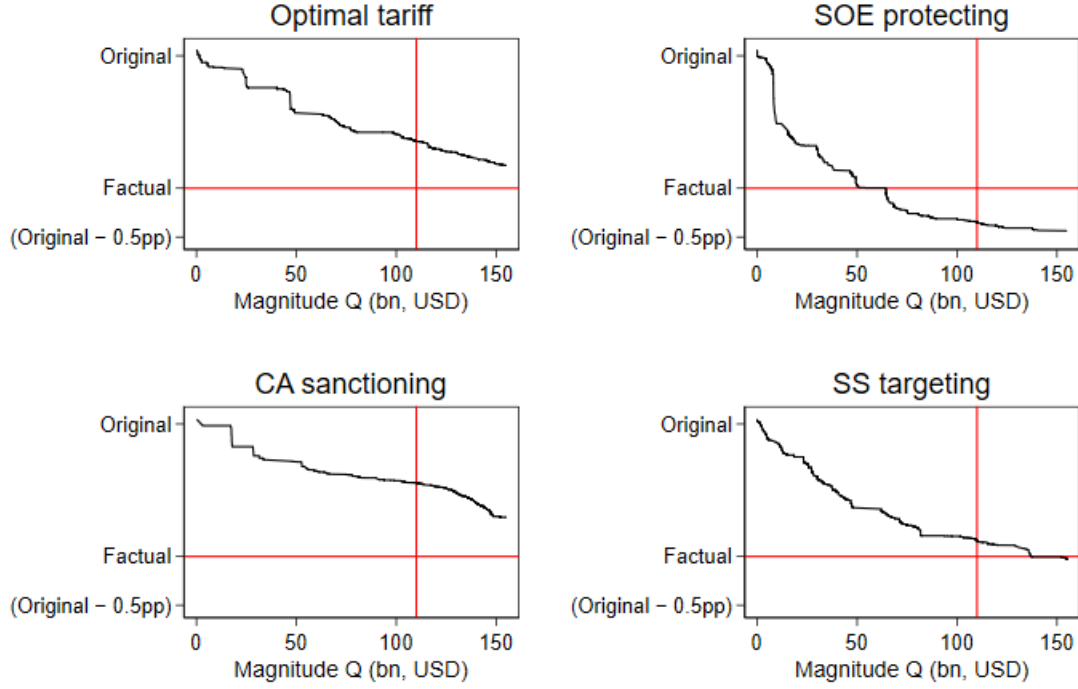
Notes: This figure displays the results from welfare analysis using the yearly average CIF prices from July 2017 to June 2018 for $\{p_i^*\}$. The main text uses the calendar year (2018) to compute yearly averages. The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot.

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Figure D2: Welfare Analysis (CIF Prices: 2019)
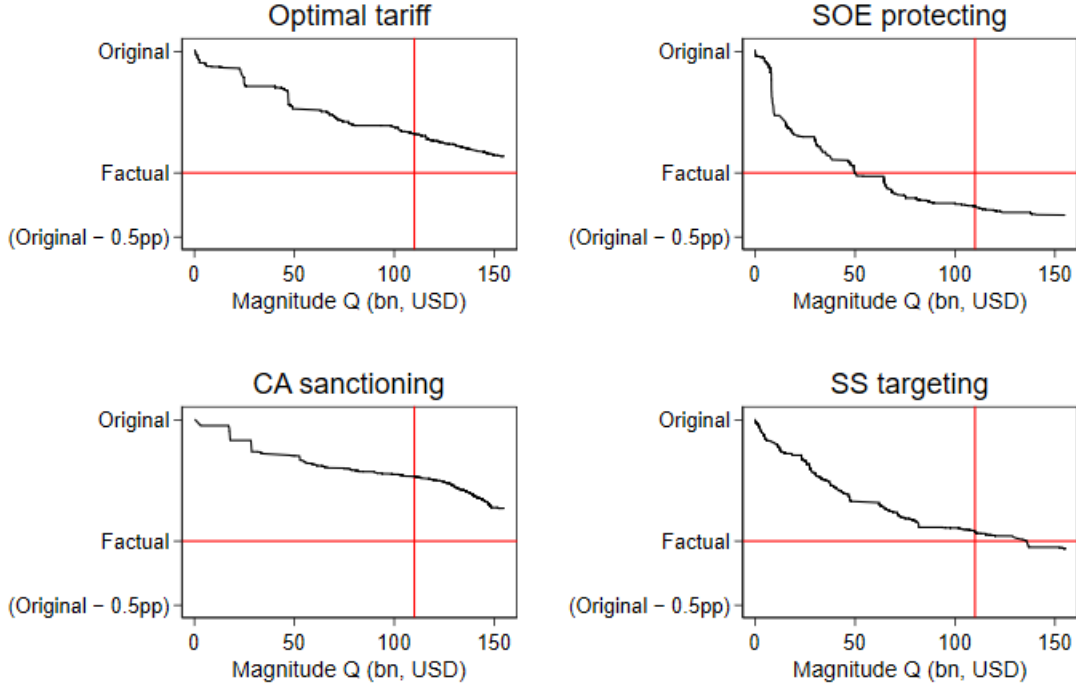
Notes: This figure displays the results from welfare analysis using the yearly average CIF prices from 2019 for $\{p_i^*\}$. The main text uses the calendar year (2018) to compute yearly averages. The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot.
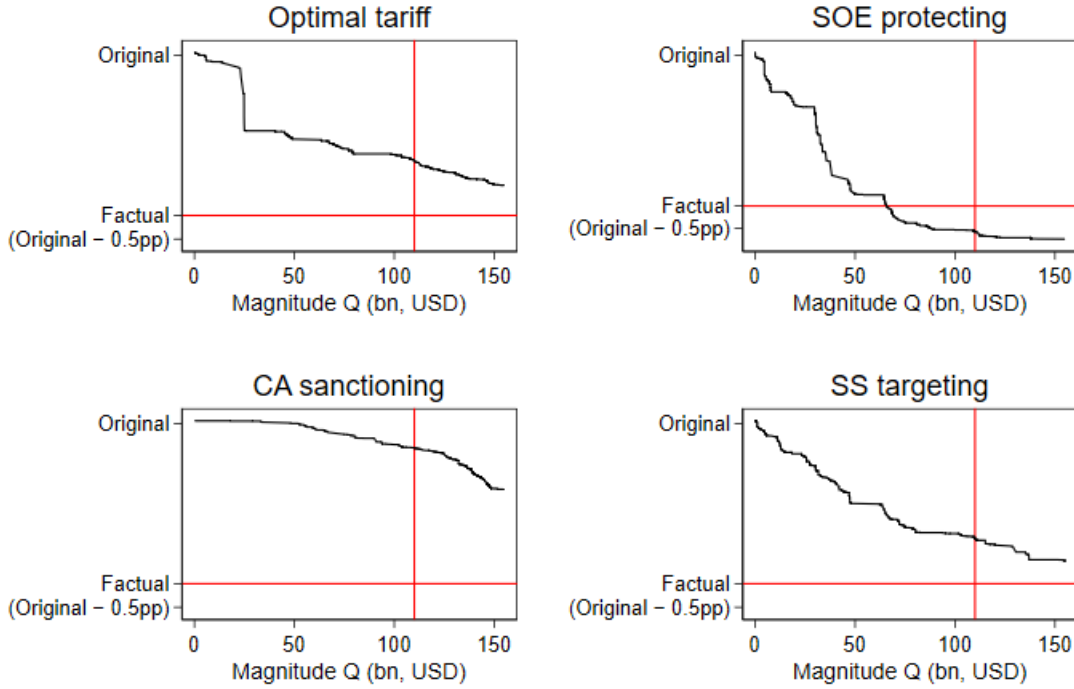
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E Robustness Checks (Trade Regimes)

In addition to standard import trade statistics, Chinese Customs report the products imported by firms for the purpose of further processing and then exporting (known as *processing trade*) separately from other products (known as *ordinary trade*). The welfare analysis reported in the main text does not distinguish the two trade regimes from each other, because the trade regimes chosen by importers for their imported products in customs filings mainly reflect their tax considerations (China's corporate tax collection uses a VAT system). Products imported under processing trade may serve purposes other than processing trade, such as ordinary production and consumption, after necessary VAT adjustments are made. Likewise, products imported under ordinary trade can also be used in processing trade. Thus, we use the trade regime dichotomy only as a robustness check. In addition, we also run a robustness check using only the *intermediate goods* specified by the Classification of Broad Economic Categories (BEC).[6] The welfare analysis in the main text is rerun using only these products as a robustness check.

The results from the processing regime, the ordinary trade regime, and the intermediate goods are reported in Figure E1 to Figure E3. The findings, including factual and counterfactual ones, are highly similar to those from Figure 4 in the main text.
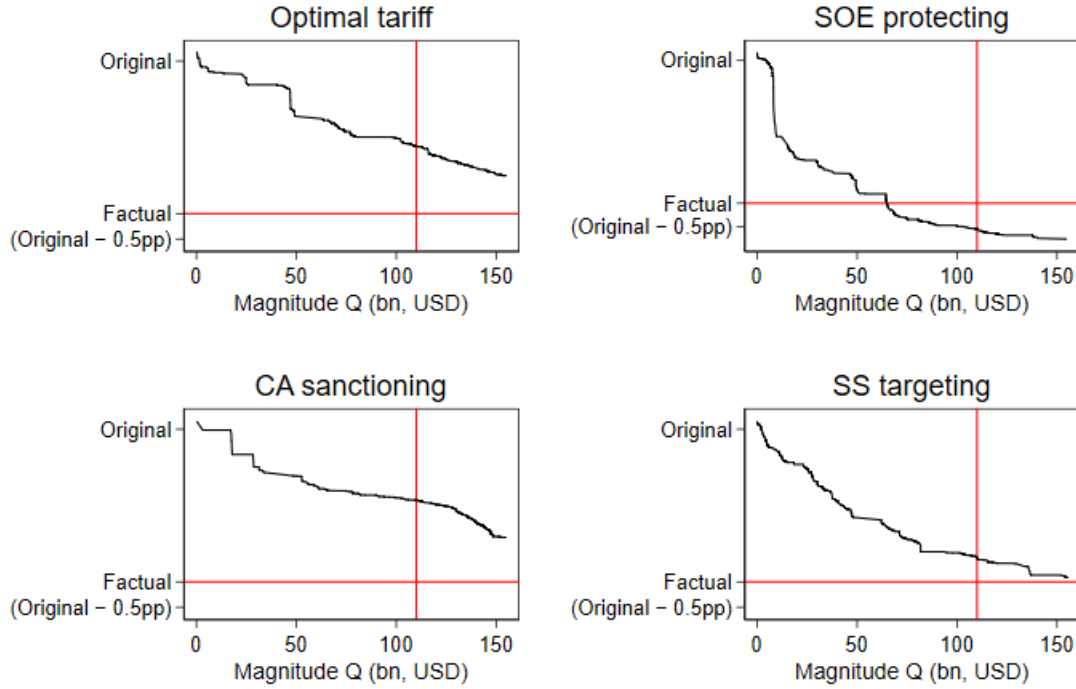
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[6]See the UNSTATS website (web link, including the concordance table).
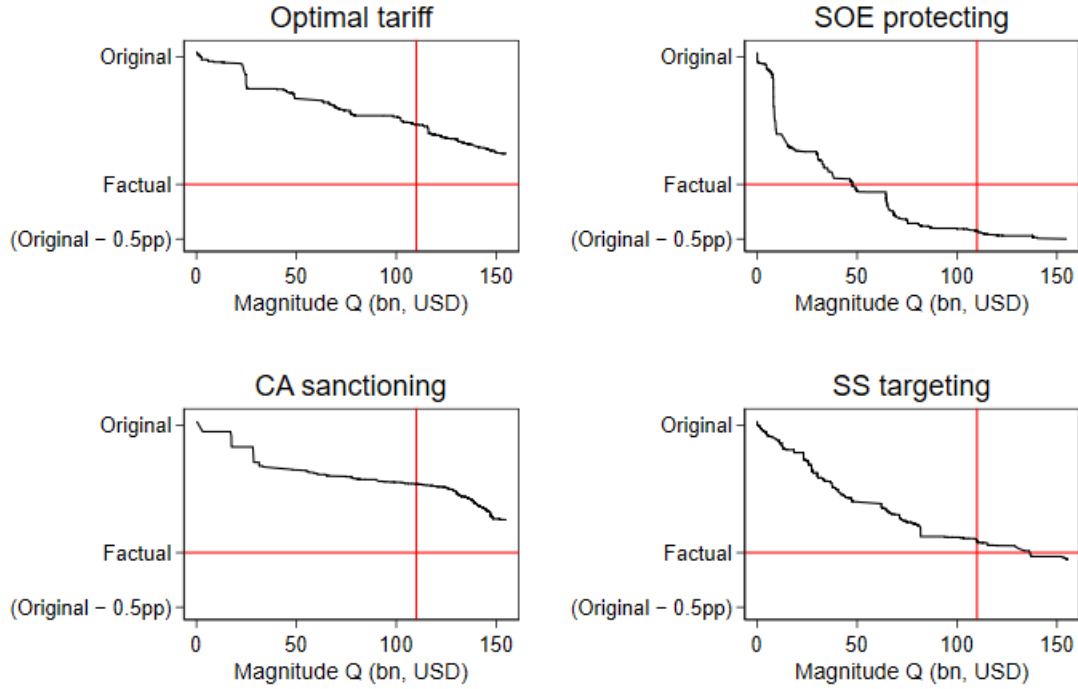
Figure E1: Welfare Analysis (Processing Trade Only)

Notes: The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff, SOE-protecting, CA-sanctioning*, and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot.

Figure E2: Welfare Analysis (Ordinary Trade Only)

Notes: The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot.

Figure E3: Welfare Analysis (Intermediate Goods Only)

Notes: The four plots correspond to the four counterfactual retaliatory schedules (*optimal-tariff*, *SOE-protecting*, *CA-sanctioning*, and *SS-targeting*) respectively. The vertical axis represents welfare level. On the vertical axis of each plot, three welfare levels are marked: (i) the original (without retaliation) welfare level W^O, (ii) the welfare level resulting from the factual retaliation W^F (0.37 percentage points lower than W^O), and (iii) the welfare level 0.50 percentage points lower than W^O (serving as a reference level). W^F is also indicated by a red horizontal line. The welfare loci $W^{CF}(Q)$ of the four counterfactual schedules are displayed in the four plots, with total taxable value (magnitude Q) as the horizontal axis. The total taxable value of the factual retaliation (108bn USD) is indicated by a red vertical line. $W^{CF}(Q)$ beyond the 108bn USD is graphed with hypothetical rate 5% in each plot.

F   Solution to Problem (22)

We first set up the following Lagrangian:

$$L = -\ln P + \mu[V - (1 + t^0_{gUS} + T_{gUS})p^0_{gUS}m^0_{gUS}], \tag{F.1}$$

where the import price index is defined as before: $P = \prod_s (P_s)^{\gamma_s}$, with P_s and then P_g nested (see equation (2) in the main text). μ is the Lagrange multiplier. Derive the first-order conditions for US product variety g in sector s and US product variety h in sector k and divide the former condition with the latter, we obtain

$$\gamma_s \frac{\left(\frac{P_g}{P_s}\right)^{1-\eta}}{\left[1 - \left(\frac{(1+t^0_{gUS}+T_{gUS})p^0_{gUS}}{P_g}\right)^{1-\sigma}\right] X_g} = \gamma_k \frac{\left(\frac{P_h}{P_k}\right)^{1-\eta}}{\left[1 - \left(\frac{(1+t^0_{hUS}+T_{hUS})p^0_{hUS}}{P_h}\right)^{1-\sigma}\right] X_h}. \tag{F.2}$$

The two expenditures in equation (F.2) are

$$X_g = \frac{P_g^{1-\sigma} X_s}{P_s^{1-\sigma}},$$
$$X_h = \frac{P_h^{1-\sigma} X_k}{P_k^{1-\sigma}}, \tag{F.3}$$

where $X_s = \gamma_s X / P_s$, $X_k = \gamma_k X / P_k$, and X is China's total expenditure on imported products.

The system of equations formed by equation (F.2) and the linear constraint in problem (22) has $G + 1$ equations and G unknowns, with G denoting the total number of imported products across sectors. As in the main text, define

$$T^{\triangle}_{gi} = \begin{cases} 1 + \frac{T^+_{gUS}}{1+t^0_{gUS}}, & \text{if } i = US, \\ 1, & \text{if } i \neq US, \end{cases}$$

Then the solutions to the system of equations can be written as

$$p^0_{gUS} T^{\triangle}_{gUS} = \frac{V}{X}\left[\sum_i \left((1+t^0_{gi})T^{\triangle}_{gi}p^0_{gi}\right)^{1-\sigma}\right], \tag{F.4}$$

for US product variety g. This is equation (25) in the main text.