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ABSTRACT

We use Chinese customs data to show that unofficial non-tariff barriers were responsible for 50\%of the overall reduction in Chinese imports from the U.S. during the height of the U.S.-China trade war in 2018 and 2019. We infer non-tariff barriers from the change in imports of U.S. products relative to imports from other countries of the same HS-6 product, after controlling for the change in the relative price of U.S. imports to the same product sold by other countries. These barriers were imposed on a small number of agricultural products, did not apply to state-owned importers, and were larger for products where the share of state importers in total imports of the U.S. product was large. Non-tariff barriers were responsible for more than 90\% of the welfare cost to Chinese consumers of the U.S.-China trade war. The welfare loss to China of a given reduction in imports from the U.S. from non-tariff barriers is about six times larger than an equivalent import decline due to higher tariffs. Non-tariff barriers are more costly compared to tariffs because they applied to some importers and not others, which results in misallocation, and because non-tariff barriers do not generate revenues.

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1 Introduction

In January 2020, in an effort to end their deepening trade war, China agreed to purchase more U.S. products in 2020 and 2021.[1] Over these two years, U.S. exports to China increased by $192 billion. The agreement was specific in the amounts and products that China had to buy, but it did not stipulate any tariff reduction on the Chinese side. But in the absence of any reduction in tariffs, how exactly did Chinese imports from the U.S. increase by 156 percent over U.S. exports to China in 2019?[2] The answer is that higher Chinese imports of U.S. goods could not come from lower tariffs but rather from the use of opaque regulatory measures that, this time, favored U.S. exporters. For example, Chinese authorities might have made it clear to some importers that they would benefit from purchasing American goods, or could have ordered customs and health inspectors to favor U.S. products over those made by other countries.

Although much of the focus has been on the multiple rounds of tariff hikes in the two countries in 2018 and 2019, there is abundant anecdotal evidence that China also used non-tariff regulatory mechanisms to stifle U.S. exports to China in these two years. For example, on May 1, 2018, Chinese authorities announced that new permits were required to sell U.S. pet food in online stores. On May 3, 2018, health officials announced that imports of U.S. apples and lumber were to be inspected for "dangerous pests." And on October 26, 2018, officials of the Agriculture Ministry announced that the formula for pig feed was to change from 20% soybeans to only 12%.

Non-tariff barriers can have large effects on trade and welfare, but because of their opaqueness are difficult to measure. In this paper, we use simple demand theory and Chinese customs level data to infer the use of non-tariff barriers in the U.S.-China trade dispute between 2018 and 2020. This includes China's use of regulatory measures in 2018 and 2019 in the height of the trade war to punish American exporters, as well as in 2020 to *benefit* American exporters in China's effort to meet its purchase agreements under the Phase 1 agreement.[3]

We proceed in three steps. First, we estimate the elasticity of demand for an American import in China at the 6 digit harmonized system level. Specifically, we estimate import demand and export supply curves for agriculture and manufacturing goods, defined as a country and 6 digit harmonized system product pair, using the increase in tariffs on U.S. imports in 2018 and 2019 relative to imports from other countries as instruments for the demand and supply curves. The identifying assumption, which we attempt to validate in the data, is that changes in tariffs on U.S. imports across import varieties are orthogonal to supply shifts and the use of non-tariff barriers. We estimate the elasticity of substitution across HS-6 product-country pairs on the demand side of 3.6 for agricultural products and 2.2 for manufactured products. On the supply side, our estimates suggest that foreign export supply curves are essentially horizontal. This last result suggests that, as found by Fajgelbaum et al. (2019) in the case of American tariffs on Chinese products, the cost of Chinese trade barriers, be it in the form of tariffs or regulatory procedures, were entirely borne by Chinese consumers.

[1] See Bown (2020) for details of the so-called Phase 1 purchase agreement.
[2] U.S. exports to China in 2019 totaled $123 billion.
[3] As we describe later, the customs level data we use ends in 2020.

Our second step is to use the estimates of the demand elasticities to infer non-tariff trade barriers from the import data. Specifically, we infer non-tariff barriers on U.S. imports of a given HS-6 product as the change in U.S. imports relative to imports from other countries for that product, after controlling for the effect of tariffs. Our estimates suggest that non-tariff barriers on U.S. imports increased significantly in 2018 and 2019, by an average of 56 percentage points (in tariff equivalent units) for agricultural products and by 17 percentage points for manufactured products. These hikes are significantly larger than the increase in tariffs on U.S. imports over the same period, which averaged 17 and 9 percentage points for agricultural and manufactured products, respectively. The use of non-tariff barriers were also much more targeted towards specific products compared to the tariffs. For example, our estimates suggest that the tariff equivalent of non-tariff barriers increased by almost 300 percentage points in 2018 and 2019 for the 2-digit HS-6 categories "oil-seeds," "cereals," and "ores, slag and ash." More generally, we find that non-tariff barriers increased by more for agriculture products in which the U.S. has a larger share in Chinese imports of the product.

In addition, because of their opaqueness and unofficial nature, non-tariff barriers can be selectively used to target specific importers, while tariffs cannot. We find that non-tariff barriers increased primarily for non-state importers of U.S. agricultural products, whereas non-tariff barriers faced by state-owned importers were roughly unchanged in 2018 and 2019. Moreover, the products with a larger share of state importers before the trade war are more likely to be selected for non-tariff barriers, indicating that the government care more about state importers. The increase in non-tariff barriers in 2018 and 2019 for agricultural products were partially reversed in 2020, after China agreed to increase purchases of U.S. goods in early 2020, while the tariff hikes in 2018 and 2019 were kept in place in 2020. For manufactured products, we see no evidence that the increase in non-tariff barriers in 2018 and 2019 were reversed in 2020.

Third, we estimate the effect of non-tariff barriers and tariffs on Chinese welfare in a model that accounts for the reallocation of expenditures across source countries for a given HS-6 product and across HS-6 products, but not between imported and Chinese products. In this framework, higher tariffs on U.S. products lower Chinese welfare via their effect on the dispersion of consumer prices across source countries and products. In contrast, higher non-tariff barriers affect Chinese welfare via their effect on the mean and the dispersion of consumer prices for imported products across source countries and products. This is the well known distinction between tariffs and trade barriers that take the form of non-tariff barriers. The other distinction between tariffs and non-tariff barriers in our context is that non-tariff barriers, perhaps because of their opaque and unofficial nature, do not have to apply uniformly to all importers.

Using this framework, we find that about half of the overall decline in U.S. exports to China between 2017 and 2019 was due to higher tariffs and the other half due to higher non-tariff trade barriers. However, the vast majority of the welfare loss incurred by China from the trade war was due to non-tariff trade barriers rather than tariffs. Specifically, we find that China's welfare in 2019 is 40 billion US$ lower compared to 2017 due to the hike in trade barriers in 2018 and 2019, and 92% of the welfare loss was due to higher non-tariff trade barriers imposed in 2018 and 2019.

We also use the model to simulate the effect of the actual change in tariffs and non-tariff barrier between 2017-2019 for each HS-6 product on imports from the U.S. and Chinese welfare. This calculation suggests that the welfare loss from higher non-tariff barriers is about six times larger than from a higher tariff that delivers the same import decline. Put differently, if the objective of the Chinese authorities was to "punish" the U.S. by lowering sales of American firms in China, non-tariff barriers were a particularly costly way to accomplish this objective.

Our paper builds on several recent papers on the effect of the U.S.-China trade war on American consumers, including Amiti, Redding and Weinstein (2019), Fajgelbaum et al. (2019), Flaaen, Hortaçsu and Tintelnot (2020), and Cavallo et al. (2021). In particular, we borrow Fajgelbaum et al. (2019)'s procedure to estimate demand and supply elasticities of American exports to China. We also find, as they do, that export supply curves are essentially elastic so the cost of the trade barriers are entirely borne by consumers. We differ from these papers in that we examine the effect of trade barriers on American exports on Chinese consumers, and we focus on the use of non-tariff trade barriers in addition to tariffs.

Our paper also builds on Khandelwal, Schott and Wei (2013)'s important paper that examines the effect of *export* quotas allocated to Chinese state owned firms. Our paper examines the effect of non-trade barriers facing non-state vs. state-owned *importers*. And as in Khandelwal, Schott and Wei (2013), our point is that efficiency costs of non-tariff trade barriers can be large if such barriers apply to some firms and not to others. Benguria and Saffie (2021) also find, as we do, that variation across products in U.S. exports to China is correlated with the presence of state owners in the particular product. Our paper differs in that we impute non-tariff barriers from the basis of structural model, and we use the model to measure the welfare loss from such barriers. We also use detailed Chinese customs data to separately measure the incidence of non-tariff barriers on state vs. non-state importers.

Finally, Ma, Ning and Xu (2021) and Liu (2020) also use the Chinese customs data to show that Chinese import quantity dropped significantly in products where China increased tariffs on these products. Using high-frequency night lights data and measures of the trade exposure of fine grid locations, Chor and Li (2021) find that a one-percentage-point increase in exposure to the US tariffs led to a 0.6% reduction in night-time luminosity. Our paper differs in that our focus is on the non-tariff trade barriers, which we document was the main instrument used by China in the trade war.

The paper proceeds as follows. First, we discuss the data and present preliminary facts that are suggestive of the presence of non-tariff trade barriers. We then propose a theoretical framework to measure the effect of non-tariff trade barriers (as well as tariffs). The next section then uses the theoretical framework to impute the change in non-tariff trade barriers between 2017 and 2020. We then use the estimates of non-tariff barriers and quantify their effect (as well as the effect of tariffs) on welfare. The following section provides several robustness checks. The last section concludes.

2 Data and Facts

We use the administrative data from China's customs agency from 2015 to July 2020. For 2015, we have transaction level data with information on the importer in China, source country, quantity, *cif* price, and the HS-6 code of the product. From 2017 to 2020, our data is aggregated by state-owned vs. non-state importer and by month. To make the observations in 2020 comparable to the earlier ones, we only use the monthly data from January to July in each year and aggregate the monthly data over these seven months in each year.

The tariff data is constructed in two steps. First, we get the MFN tariff data from the World Trade Organization. Then we add the tariff raised in the trade war against the US, starting on 04/02/2018, ending on 12/26/2020.[4] We calculate the annual average tariff as the weighted average over the year of the tariff at each date of the year.[5] We then merge the tariff data with the customs data using HS 2012 system.[6] Our final dataset has annual total quantities and average tariff rate of each HS-6 product (946 in total) by state-owned and non-stated-owned importers and by source country for 2015 to 2020, and the average tariff rate of each HS-6 product-source country in each year.

Table 1 shows the weighted average level of Chinese tariffs on U.S. goods and the U.S. share of Chinese imports from 2015 to 2020.[7] During the period of the trade war from 2017 to 2019, tariffs on U.S. products increased and the share of U.S. imports fell, as one might expect, with a larger effect on agricultural products compared to manufactured products. In 2020, during the first year of phase 1 of the trade agreement signed in January 2020, the average U.S. share of Chinese agricultural imports increased from an 13.7% to 17.2%, without any reduction in Chinese tariffs on imports of these products from the U.S. Table 1 also shows that there was no increase in the U.S. share of Chinese imports in manufacturing in 2020, and no change in tariffs on U.S. manufacturing goods.

The fact that the U.S. share of agricultural imports in China increased in 2020, despite no decrease in tariffs, suggests that non-tariff mechanisms were used to increase purchases of U.S. agricultural products in 2020. We now probe for evidence that non-tariff mechanisms were also used during the trade war in 2017-2019. We regress the change in log import quantities from all countries on the change in the tariff rate with fixed effects for each HS-6 product interacted with year. Figure 1 plots the residuals of the U.S. from a regression of the change in log import quantities for each source country and HS-6 product pair on the change in tariffs. The top left panel shows the distribution of residual import growth between 2015-2017 and 2017-2019 for agricultural

[4]We compile the list of Chinese tariffs on U.S. products from the official documents released by the Customs Tariff Commission of the State Council between 2018 and 2020. The specific documents with official announcement of tariffs are 2018 Document No. 5 to 8, 10, and 13; 2019 Document No. 1 to 8; 2020 Document No. 1, 3, 4, 8 and 10.

[5]For example, the tariff on U.S. beans was increased by 25% on 07/06/2018, and stayed at the same level until 2020. We impute the average tariff on U.S. beans as $25\% \times \frac{179}{365}$ in 2018, and 25% in both 2019 and 2020.

[6]We use the concordance between HS 2012, HS 2017, and SITC 4 from https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

[7]Unless otherwise indicated, we use the expenditure share of the HS-6 product in 2017 as the weight.

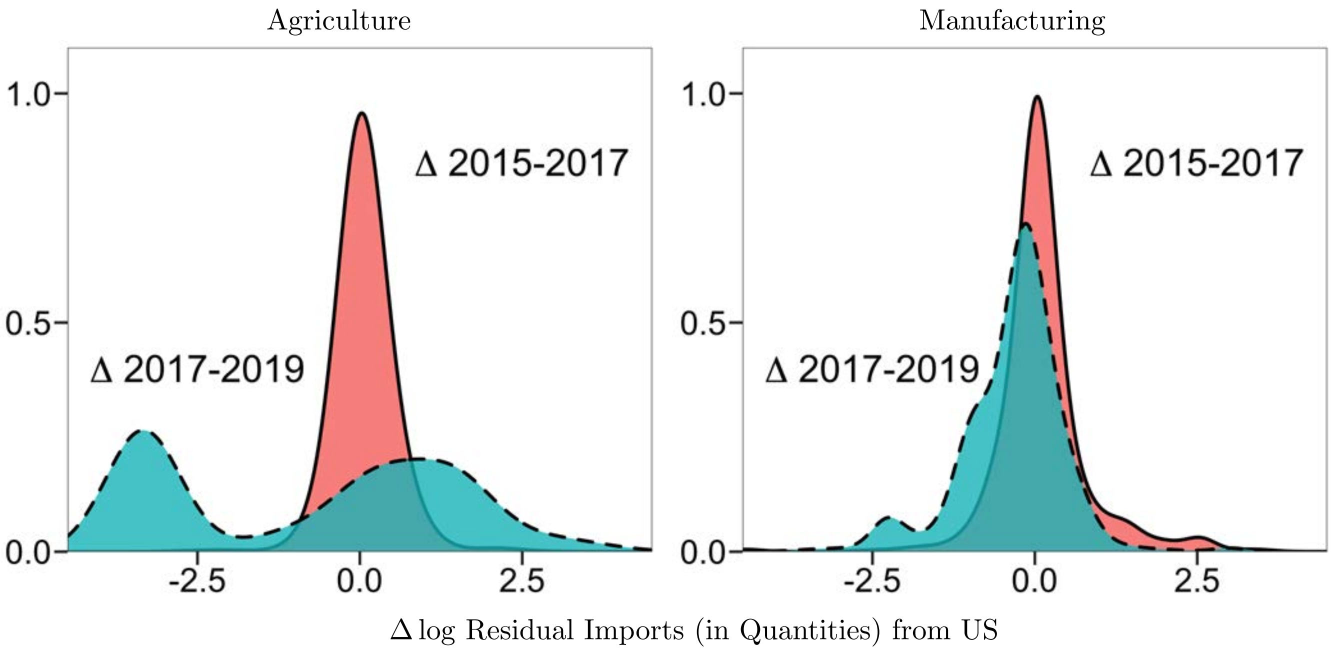
Table 1: US Tariffs and Import Share

	2015	2017	2018	2019	2020
Agriculture					
Average Tariff rate	7.6%	7.5%	14.0%	24.5%	26.0%
Average U.S. import share	20.7%	21.7%	15.0%	13.7%	17.2%
Manufacturing					
Average Tariff rate	5.2%	5.6%	7.8%	14.6%	14.8%
Average U.S. import share	10.5%	9.5%	8.9%	8.4%	7.4%

Note: Table shows weighted average of the tariff rate of each HS-6 product and imports from the U.S. as a share of total Chinese imports of the product for agricultural (top panel) and manufacturing products (bottom panel). Weights are share of imports on the HS-6 product in total imports in 2017.

products, the bottom left panel decomposes the 2017-2019 residual import growth into state firms and non-state firms; the second column shows the same for manufactured products.

Figure 1: Distribution of import growth residuals for U.S. products



Note: Unit of observation is a HS-6 product. Figure plots growth rate between 2015-2017 and 2017-2019 of import quantities of U.S. agricultural (left panel) and manufactured products (right panel) after controlling for the change in the tariff rate.

The figure shows that the distribution of residual import growth of agricultural imports shifted to the left between 2017 and 2019; the mean growth rate falls by 0.87 log points from 2015-2017 to 2017-2019. The dispersion of the residual import growth of agricultural products from the U.S.

also widens considerably; the variance of the growth rate increased 18 folds from 0.296 between 2015-2017 to 5.31 between 2017-2019. The right column shows that the dispersion across HS-6 products of residual import growth for U.S. manufactured products also increased between 2017-2019 compared to 2015-2017 but by much less compared to agricultural products.

The dispersion in the residual import growth in Figure 1 reflects differences in residual import growth across HS-6 products and across state vs. non-state importers. Table 2 probes for evidence of heterogeneity across state vs. non-state importers in the decline of U.S. imports. The table shows the weighted average of the share of state-owned firms in total imports, separately for U.S. products and for products from the rest of the world. The top panel shows the state share of agricultural imports, and the bottom panel for manufacturing imports. The share of state-owners in agricultural imports from the U.S. roughly doubled in 2019, before falling to the "normal" share of about 20%. As for imports of manufactured products from the US, the state share declines gradually over this period. The table also shows that the share of state-owners in imports from other countries (non-US) did not change over this period.

Table 2: Share of Imports by State-Owned Firms

	2015	2016	2017	2018	2019	2020
Agriculture						
U.S.	24.0%	19.5%	19.3%	19.6%	39.8%	19.8%
Rest of World	21.5%	20.1%	19.8%	20.3%	21.4%	21.3%
Manufacturing						
U.S.	20.4%	20.5%	16.2%	14.6%	11.5%	10.5%
Rest of World	13.1%	13.5%	13.7%	13.6%	15.0%	15.4%

Notes: Table shows weighted average of the share of state-owned firms in total imports in each HS-6 product for agricultural products (top panel) and manufactured products (bottom panel) from the U.S. and the rest of the world.

The stark contrast between the non-state and state-owned importers helps explain the bimodal distribution in the growth rate of agricultural imports from the US in the left panel of Figure 1. To see this, we distinguish the imports of a U.S. HS-6 product by non-state and state-owned firms and calculate the residual of import growth after controlling for the change in tariffs and state vs. non-state ownership. In Figure 1, the variance of the residual import growth across HS-6 products and importers with different ownership increases from 0.296 in 2015-17 to 5.31 in 2017-19. Controlling for state vs. non-state ownership reduces the variance of residual import growth to 0.292 and 2.022 in 2015-17 and 2017-19, respectively, suggesting that the difference between non-state and state-owned importers alone account for 38% of the increase in the dispersion of the residual import growth between 2017 and 2019.

3 Welfare Effect of a Trade War

In this section, we lay out a simple model to illustrate how tariffs and non-tariff trade barriers affect welfare.

Utility of a representative consumer from imports is given by:

$$\text{Utility} = \left(\sum_i C_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where i is a HS-6 product, σ is the elasticity of substitution between HS-6 products, and C_i is aggregate consumption of product i defined as:

$$C_i = \left(\sum_j C_i^{j\,\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{2}$$

where j is a local firm that imports the product, η is the elasticity of substitution between firms, and C_i^j is aggregate consumption of product i sold by firm j defined as:

$$C_i^j = \left(\sum_f \left(b_{if}^j \, C_{if}^j \right)^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}} \tag{3}$$

where f is a source country, ϵ is the elasticity of substitution imports of a given product by a given firm across source countries, C_{if}^j denotes consumption of product i from country f sold by local firm j, and b_{if}^j is a time-invariant preference parameter.

The *shadow* price of product i from country f faced by firm j is:

$$\text{Shadow Price}_{if}^j = \left(1 + \phi_{if}^j\right) \left(1 + \tau_{if}\right) p_{if} \tag{4}$$

where τ_{if} is the ad-valorem tariff, ϕ_{if}^j is the tariff-equivalent of the non-tariff trade barriers, and p_{if} is the *cif* price given by:

$$p_{if} = \tilde{p}_{if} \left(\sum_j C_{if}^j \right)^{\frac{1}{\gamma}} \tag{5}$$

where $\tilde{p}_{if}$ is the vertical intercept of the foreign supply curve and γ is the supply elasticity. We assume that all firms pay the same tariff rate τ_{if}. However, non-tariff trade barriers can be applied differently across importing firms so ϕ is also indexed by firm j.

Finally, we assume that tariff revenues are rebated to the consumer. This assumption, combined with the definitions of utility (equations 1-3) and the shadow price (equation 4), yields the following expression for indirect utility V:

$$V = \left(\sum_i \left[\sum_j \left(\sum_f \left[b_{if}^j \frac{(1+\overline{\tau})}{(1+\phi_{if}^j)(1+\tau_{if})\, p_{if}} \right]^{\varepsilon-1} \right)^{\frac{\eta-1}{\varepsilon-1}} \right]^{\frac{\sigma-1}{\eta-1}} \right)^{\frac{1}{\sigma-1}} \tag{6}$$

where the *cif* price p_{if} is given by equation 5, $\overline{\tau}$ is the weighted average across HS-6 products of the weighted average of τ_{if} across all source countries for each HS-6 product.[8]

Trade policy then affects welfare via three channels. First, tariffs affect welfare through the *dispersion* of τ_{if} across source country f, with an elasticity that depends on ϵ, and via the dispersion of the average tariff rate across HS-6 products, with an elasticity that depends on σ. Changes in tariffs that leave the $\overline{\tau}$ unchanged have no effect on welfare.

Second, non-tariff trade barriers that affect all firms equally affects welfare through changes in the dispersion *and* via the mean of ϕ. The welfare effect of trade barriers that take the form of non-tariff trade barriers differs from tariffs only because the tariff revenues are rebated to the consumer, whereas the lost revenues from the non-tariff trade barriers are not. This is the well-known distinction between tariffs and non-tariff barriers.

Third, a feature of non-tariff trade barriers, at least as practiced by China during the trade war with the US, is that these barriers were not publicly disclosed. This "secrecy" may imply that these barriers were not uniformly implemented. To the extent non-tariff trade barriers applied with more force to some firms compared to other firms, their welfare effect will also depend on the dispersion of ϕ across *firms* and the elasticity η.

The main empirical challenge is that, as opposed to tariffs, the opaqueness of non-tariff trade barriers makes them difficult to measure. We use the structure of the theory along with patterns in the changes in imports to infer the magnitude of these non-tariff trade barriers.

Specifically, suppose that non-tariff trade barriers are applied differently for state vs. non-state importers (but are applied equally for all state and all non-state importers). From the demand function for products sold by a given firm type implied by equation 3, we get:

$$\Delta \log \left(\frac{C_{if}^s}{C_{if}^n} \right) = \left(1 - \frac{\epsilon}{\eta} \right) \Delta \log \left(\frac{C_i^s}{C_i^n} \right) - \epsilon \, \Delta \log \left(\frac{1+\phi_{if}^s}{1+\phi_{if}^n} \right) \tag{7}$$

where ϕ_{if}^s and ϕ_{if}^n denote non-tariff barriers faced by state owned and non-state importers. The first term on the right hand side in equation 7 is the ratio of aggregate import quantity of product i of the state vs. non-state importers. This term is common to all countries that sell product i in China. The second term is the change in the ratio of non-trade barriers facing state importers vs. non-state importers of product i from country f. This second term varies by source country. Equation 7 thus says that, up to a constant term common to all source countries, we can infer the ratio of the change in non-tariff barriers faced by state vs. non-state importers of a particular

[8] $1+\overline{\tau} \equiv \left(\sum_i \frac{F_i}{F} \left(\sum_f b_{if}^j (1+\tau_{if})^{1-\varepsilon} \right)^{\frac{\sigma-1}{\varepsilon-1}} \right)^{\frac{1}{1-\sigma}}$, where F_i is the number of source countries that sell product i in China and F is the sum of F_i across all products i. Equation 6 also normalizes aggregate nominal expenditures to 1.

product from the U.S. from data on the ratio of the change in imports by state vs. non-state firms of the U.S. product.

We now turn to the imputation of the non-tariff trade barriers for non-state importers. The change in imports by non-state importers of product i from the US relative to imports of the same product from another country is given by:

$$\Delta \log \left(\frac{C^n_{i,us}}{C^n_{if}} \right) = -\epsilon\, \Delta \log \left(\frac{p_{i,us}}{p_{if}} \cdot \frac{1+\tau_{i,us}}{1+\tau_{if}} \right) - \epsilon\, \Delta \log \left(\frac{1+\phi^n_{i,us}}{1+\phi^n_{if}} \right) \tag{8}$$

The first term on the right hand side is the change in the product of the *cif* price and the tariff of imports of good i from the U.S. relative to same of country f. The second term is the change in the non-tariff trade barriers facing non-state importers of U.S. goods relative to imports of the same good from country f. Conditional on data on *cif* prices and tariffs and an estimate of the demand elasticity ϵ, equation 8 says that, using data on changes in imports from the U.S. by non-state firms relative to imports of the same product from another country, we can infer the change in the *ratio* of non-tariff trade barriers faced by non-state importers of U.S. imports relative to non-tariff barriers on the same product made by another country.

This only gets us the ratio of non-tariff trade barriers facing U.S. goods to the same good made by another country. To infer the non-tariff barrier faced by U.S. goods only, we make one normalization, which is that the weighted average of the change in non-tariff barriers faced by non-state importers of products sold all countries except the US across all imports is zero.[9] This normalization, along with equation 8, then allows us to infer the change in non-tariff barriers faced by non-state importers of U.S. products. This number, combined with the estimate of the ratio of non-tariff barriers of state vs. non-state importers of a product from the U.S. we get from equation 7, then allows us to back out non-tariff barriers faced by *state* importers of the U.S. product.

In summary, we impute the change in non-tariff trade barriers faced by non-state importers of U.S. goods as the residual of the change in the ratio of imports from the U.S. to imports from other countries selling the same product in the Chinese market, after controlling for the ratio of the change in the *cif* price, inclusive of tariffs. This number then allows us to impute the non-tariff barriers faced by state-owned importers of the same good from the ratio of the change in imports of state-owned vs. non-state importers of the same good from the U.S.

4 Estimates of Model Parameters and Non-tariff Trade Barriers

The model is summarized by three forcing variables (τ_{if}, ϕ^n_{if}, and ϕ^s_{if}) and four parameters (ϵ, η, ϕ, and γ). The three forcing variables vary by country-HS6 product. We assume that the four parameters vary by agriculture and manufacturing but otherwise are the same for all HS-6 products.

[9] Specifically we assume $\sum_i \sum_{f \neq us} \omega_{if} \Delta \log \left(1+\phi^n_{if}\right) = 0$ where ω_{if} is the expenditure share of product i from country f in the total expenditure of non-US imports in China in 2017.

4.1 Model Parameters

We first estimate the model parameters. We start with the supply elasticity γ and the elasticity of demand for imports of the same product between source countries ϵ. Specifically, after substituting equations 4 and 5 into the CES demand implied by the preferences in equation 3, the change in import demand and *cif* price of product i from country f are given by:

$$\Delta \log C_{if} = -\frac{\epsilon\,\gamma}{\epsilon+\gamma}\left[\Delta \log\left(1+\tau_{if}\right) + \Delta \log\left(1+\bar{\phi}_{if}\right) + \Delta \log \widetilde{p}_{if}\right] + \mathbb{I}_{if} \tag{9}$$

$$\Delta \log p_{if} = -\frac{\epsilon}{\epsilon+\gamma}\left[\Delta \log\left(1+\tau_{if}\right) + \Delta \log\left(1+\bar{\phi}_{if}\right)\right] + \frac{\gamma}{\epsilon+\gamma}\Delta \log \widetilde{p}_{if} + \mathbb{I}_{if} \tag{10}$$

where C_{if} are total import quantity, $\bar{\phi}_{if}$ is a weighted average of the non-tariff trade barriers on imports of product i from country f, and $\mathbb{I}_{if}$ is a vector of product fixed effects interacted with source country fixed effects.[10] Under the assumption that the change in tariffs is orthogonal to the change in non-tariff trade barriers and supply shifts, we can use the variation in import quantities and tariffs across source countries of a given product to estimate the demand and supply elasticities.[11] Specifically, a regression of Δ log import quantity on Δ log tariff with product fixed effects yields a coefficient of $-\frac{\epsilon\gamma}{\epsilon+\gamma}$ on the change in tariffs. A similar regression of Δ log *cif* price on Δ log tariff yields a coefficient of $-\frac{\epsilon}{\epsilon+\gamma}$.

The first two rows in the top panel in Table 3 shows the estimates from the regressions at the product-country level of the change in import quantities (equation 9) and the change in the *cif* price (equation 10) on the change in tariffs. In the estimates shown in the first column, we pool annual data from 2015 to 2020 for all agricultural products from all countries, and show the coefficient on the change in tariffs in equation 9 (row 1) and equation 10 (row 2). The second column does the same for the sample of manufactured products from 2015 to 2020. All the regressions include product-country fixed effects and year fixed effects so we only use the over-time variation in tariffs for each HS-6 product across source countries.

The first row in Table 3 shows that, as expected, imports from a given source country falls when the tariff rate on imports from the country increases. The elasticity of import quantities with respect to tariffs is -3.1 for agriculture and about -2.3 for manufacturing. The second row shows that the *cif* import price of agricultural products declines slightly by more for imports from countries where tariffs increase, suggesting that some of the incidence of higher Chinese tariffs on agricultural products are borne by the producers. The elasticity of the *cif* import price for manufactured products is even closer to zero.

The bottom panel in Table 3 shows the elasticity of demand ϵ across countries and supply γ implied by the elasticity of imports and import prices to tariffs. The elasticity of substitution for agricultural products is 3.36 and 2.34 for manufactured products. The supply elasticity is 42 for agricultural products and 71 for manufactured products. These supply elasticities imply that

[10] $1+\overline{\phi}_{if} \equiv M_{if}^{-1}\big(\sum_j b_{if}^j(1+\phi_{if}^j)^{1-\eta}\big)^{\frac{1}{1-\eta}}$, where M_{if} is the number of importers of each country-product pair.

[11] We examine this assumption in Section 6.

Table 3: Elasticity of Import Quantities and Price to Tariffs

	Agriculture	Manufacturing
Elasticity with respect to tariff		
Import Quantity Elasticity	-3.108	-2.335
	(0.266)	(0.112)
cif Import Price Elasticity	-0.074	-0.033
	(0.084)	(0.084)
Aggregate Quantity Elasticity	-1.469	-1.248
	(0.122)	(0.036)
Demand and supply elasticity		
Demand across source country ε	3.36	2.34
Supply γ	42	71
Demand across products σ	1.47	1.25

Note: Top panel shows coefficient from regressions of Δ log import quantities (first row) or Δ log cif price (second row) of each HS6 product-source country on Δ log (1 + tariff rate) on annual observations of agricultural products (column 1) or manufacturing products (column 2) from 2015 to 2010. Third row shows coefficient from regressions of Δ log aggregate imports at the HS-6 product level on change in the log of the aggregate tariff rate of each HS-6 product. All regressions include product-country and year fixed effects. Bottom panel shows the demand elasticity of substitution across source countries ϵ, supply elasticity γ, and demand elasticity of substitution across HS-6 products σ implied by the coefficient estimates in the top panel.

almost all the cost of Chinese trade barriers are passed onto Chinese consumers in the form of higher prices.

As for the elasticity of substitution between state and non-state importers η, we borrow the estimates of Khandelwal, Schott and Wei (2013) who measure the change in the market shares and prices paid by state vs. non-state exporters in response to the elimination of export quotas allocated to state owned firms in the early 1990s. Their numbers suggests that $\eta = 2.8$ so we set $\eta = 3$ for our benchmark case.[12]

We now turn to the elasticity of substitution between products σ. Note that the estimates of

[12]Specifically, we estimate the elasticity of substitution η between state and non-state trading firms as $\eta = 1 - \frac{\Delta \ln(S^s/S^n)}{\Delta \ln(P^s/P^n(1+\phi))}$ where S denotes the market share, P is the price index, and ϕ is the tariff-equivalent of the license fee that non-state exporters have to pay but state exporters do not. In Khandelwal, Schott and Wei (2013)'s data (Table 3), the change in the market share is -0.14 and 0.10 for state and non-state exporters and the initial market shares of state and non-state firms are 0.26 and 0.17 (these last two numbers are reported in the working paper version of Khandelwal, Schott and Wei (2013)). The weighted price change for state and non-state exporters are -0.11 and -0.10, and the initial level of prices are 0.26 and and 0.17 for state and non-state exporters (Tables 4 and 5 in Khandelwal, Schott and Wei (2013)) The price changes are then -0.11/0.26 and -0.10/0.17 for each type of exporter. The tariff equivalent of the license fee estimated by Khandelwal, Schott and Wei (2013) is $\phi = 0.14$. These numbers imply that $\eta = 2.8$. An alternative to the estimates in Khandelwal, Schott and Wei (2013) is Brandt et al. (2017)'s estimates of industry-specific markups using the Chinese firm-level data. Their estimates of the markup vary between 0.2 and 0.4, implying a range of 3.5 and 6 for η.

γ in Table 3 based on the variation in import quantities and prices across source countries are "large." When γ is sufficiently large, the change in the CES aggregate of imports C_i of product i is given by:

$$\Delta \log C_i = -\sigma \left[\Delta \log \left(1 + \bar{\tau}_i\right) + \Delta \log \left(1 + \bar{\phi}_i\right) + \Delta \log \bar{p}_i \right] + \mathbb{I}_i \tag{11}$$

where $\bar{\tau}_i$, $\bar{\phi}_i$, and $\bar{p}_i$ denote the weighted average of the tariff rate, non-tariff trade barriers, and the intercept of the foreign supply curve $\tilde{p}_{if}$ of product i, and $\mathbb{I}_i$ is a vector of product fixed effects.[13] Under the assumption that the change in tariffs is orthogonal to the change in non-tariff trade barriers, we can estimate σ using the variation of change in tariffs across products.

The estimates of equation 11 are shown in the third row in the top panel in Table 3.[14] As can be seen, there is a negative correlation between total imports and the average tariff at the HS6 level, and the elasticity of substitution between HS-6 products implied by these elasticities are $\sigma = 1.47$ for agriculture and $\sigma = 1.25$ for manufacturing.

4.2 Non-Tariff Barriers on US goods

With estimates of ϵ, we can now estimate the change in non-tariff trade barriers on U.S. goods from equations 7 and 8. The first two columns in Table 4 show the data moments that go into this calculation. The first column shows the weighted average of the change in import quantities from the U.S. relative to the sum of import quantities from other countries of the same HS-6 product. The ratio of import quantities of agricultural products from the U.S. to import quantities from other countries fell by 2.4 log points between 2017-2019 and increased by 1.7 log points between 2019-2020. The bottom panel shows that the ratio of U.S. manufactured products to products of other countries selling in the Chinese market also fell between 2017-2019, but much less than for agricultural products.

The second column shows the change between 2017-19 and 2019-2020 in the log import price of U.S. goods (inclusive of the tariff) of a HS-6 product relative to the weighted average of the import price of the same HS-6 product of other countries selling to China. The price of U.S. agricultural products increased by .13 log points during the trade war of 2017-19, and was basically unchanged during the first year of the first phase of the trade agreement.

The last three columns then show the change in the tariff equivalent of non-tariff trade barriers on U.S. imports calculated as the residual of changes in the import share of U.S. products, after controlling for the effect of changes in import prices on the import share. The tariff equivalent of non-tariff trade barriers on agricultural products faced by private importers increased by .73 log points between 2017-2019. On the other hand, non-tariff trade barriers on state importers did not change over this period. Average non-tariff trade barriers on U.S. agricultural products, calculated

[13] $1 + \overline{\phi}_i \equiv {M_i}^{-1} \big(\sum_j \big(\sum_f b^j_{if} (1 + \phi^j_{if})^{1-\varepsilon} \big)^{\frac{\eta-1}{\varepsilon-1}} \big)^{\frac{1}{1-\eta}}$ and $1 + \overline{p}_i \equiv {F_i}^{-1} \big(\sum_f b^j_{if} (1 + p_{if})^{1-\varepsilon} \big)^{\frac{1}{1-\varepsilon}}$, where M_i is the number of importers-source country and F_i is the number of source countries for each product i.

[14] We use data on imports and the estimates of ϵ and η in Table 3 to calculate the CES aggregate of imports of a product C_i on the left hand side of equation 11. We also calibrate the preference parameters b^j_{if} by assuming that non-tariff barriers are zero in 2017.

as a weighted average of barriers facing state and non-state importers, increased by .60 log points (column 5).

The second row shows the change in non-tariff trade barriers calculated over the entire 2017-2020 period (trade war plus the first year of the Phase 1 agreement). This includes the trade war in 2018 and 2019 and the first year of the Phase 1 agreement in 2020. It shows that average non-tariff trade barriers over the entire period increased by .14 log points compared to an increase of .60 log points between 2017 and 2019. The logical implication then is that much of the non-tariff trade barriers put in place in 2018 and 2019 were reversed in 2020. The reversal in non-tariff trade barriers is also entirely due to changes in barriers on purchases of U.S. agricultural products by non-state importers, while there was no change on non-tariff trade barriers facing state importers.

Table 4: Δ Non-Tariff Barriers on U.S. Imports

	Δ Import Quantities	Δ *cif* price + tariff	Δ Non-Tariff Barriers Non-State	State	Average
Agriculture					
Trade War (2017-19)	-2.44	0.127	0.725	0.023	0.604
Trade War and Phase 1 (2017-2020)	-0.731	0.133	0.152	0.052	0.138
Manufacturing					
Trade War (2017-19)	-0.287	0.2	-0.066	0.156	-0.015
Trade War and Phase 1 (2017-2020)	-0.569	0.214	0.131	0.342	0.183

Note: Column 1 shows the average change in log U.S. import quantities relative to import quantities from all other countries; Column 2 shows the average change in the log *cif* price of U.S. imports inclusive of tariffs relative to other importers; Columns 3-4 shows the change in non-tariff trade barriers on non-state importers and state importers estimated from the change in imports after removing the effect of the change in import prices using the estimates of ϵ in Table 3 using equations 7 and 8. Column 5 shows weighted average of Δ non-tariff barriers of non-state and state importers of U.S. products.

The bottom panel in Table 4 show that the decline in U.S. manufacturing imports between 2017 and 2019 was smaller than in agriculture. The main reason is that the increase in average non-tariff trade barriers is much smaller than in manufacturing. The tariff equivalent of non-tariff trade barriers in manufacturing was essentially unchanged, while the increase in agriculture was .60. In addition, the use of non-tariff mechanisms in manufacturing was primarily due to import barriers on state-owned instead of non-state firms.

Table 5 shows the change in non-tariff barriers and tariffs between 2017 and 2019 for each HS 2-digit sector. This table shows that non-tariff barriers were focused on a small number of products. Non-tariff barriers increased the most for "oil seeds" and "cereals," by 1 and 1.5 log points respectively. The increase in the tariff rate for the same products were significantly lower, at 0.15 and 0.25 log points for "oil seeds" and "cereals" respectively. On the other hand, tariff rates increased by 0.28 log points for products classified as "beverages, spirits and vinegar" whereas the

Table 5: Δ Non-Tariff Barriers and Tariffs by HS2 Product, 2017-2019

	US Share of Imports	Δ Tariff	Δ Non-Tariff Barriers
Agriculture			
Oil seeds, oleaginous fruits	9.11 %	0.145	1.006
Pulp of wood, recovered paper	2.47 %	0.176	0.247
Wood and articles of wood	1.73 %	0.149	0.105
Cereals	0.99 %	0.250	1.492
Cotton	0.77 %	0.250	-0.204
Meat and edible meat offal	0.60 %	0.533	-0.127
Fish and crustaceans	0.58 %	0.282	-0.083
Raw hides and skins and leather	0.56 %	0.030	0.004
Rubber and articles thereof	0.39 %	0.119	0.370
Fruit and nuts	0.38 %	0.428	-0.392
Food industries, residues and wastes thereof	0.30 %	0.139	0.688
Dairy produce, birds' eggs	0.25 %	0.201	0.309
Miscellaneous edible preparations	0.23 %	0.063	-0.188
Preparations of vegetables	0.16%	0.115	0.089
Beverages, spirits and vinegar	0.07%	0.283	-0.108
Preparations of cereals	0.06 %	0.156	-0.193
Sugars and sugar confectionery	0.05 %	0.100	-0.102
Animal or vegetable fats, oils	0.04 %	0.166	-0.027
Vegetables and certain roots and tubers	0.03 %	0.199	0.223
Wool, fine or coarse animal hair	0.01 %	0.188	0.136
Manufacturing			
Electrical machinery and parts	1.52 %	0.063	-0.191
Nuclear reactors and machinery	1.43 %	0.070	-0.080
Vehicles and parts and accessories thereof	1.39 %	0.002	0.366
Aircraft, spacecraft and parts thereof	1.05 %	0.001	0.186
Optical instruments	1.02 %	0.073	-0.269
Plastics and articles thereof	0.62 %	0.098	-0.059
Pharmaceutical products	0.32 %	0.007	-0.048
Organic chemicals	0.30 %	0.101	0.091
Chemical products n.e.c.	0.27 %	0.030	-0.172
Copper and articles thereof	0.13 %	0.233	-0.102
Iron or steel articles	0.11 %	0.137	-0.111
Aluminium and articles thereof	0.10 %	0.371	-0.221
Inorganic chemicals	0.08 %	0.099	0.328
Glass and glassware	0.07 %	0.093	-0.250
Essential oils and resinoids	0.07 %	0.182	-0.712
Natural, cultured pearls	0.04 %	0.134	-0.159
Salt, sulphur, earths	0.03 %	0.130	-0.133
Iron and steel	0.03 %	0.130	-0.072
Ores, slag and ash	0.02 %	0.097	1.106
Cotton	0.01 %	0.187	0.894

Note: Table shows weighted average of U.S. imports as a share of total imports of the product in 2017 (column 1), $\Delta \log(1 + \tau_{i,us})$ (column 2), and average of $\Delta \log(1 + \phi_{i,us})$ for state and non-state importers (column 3) for a U.S. HS-6 product between 2017 and 2019 for each HS2 sector. Weights are expenditure share of a HS6 product in the HS2 sector.

change in non-tariff barriers we impute is negative. For manufactured products, non-tariff barriers were particularly large for "ores, slag and ash" where the tariff equivalent of non-tariff barriers increased by 1.11 log points.

Recall that tariffs on U.S. products affect Chinese welfare via their effect on the dispersion of the tariff rate, and higher non-tariff trade barriers on U.S. products affect welfare through their effect on the mean *and* the dispersion of non-tariff trade barriers across all source countries, state vs. non-state importers, and across products. Table 6 shows the mean and standard deviation of $\log(1+\tau_{if})$, $\log(1+\phi_{if})$, and the product of these two terms $\log(1+\tau_{if})(1+\phi_{if})$ across these three dimensions (source country, state vs. non-state importer, and product).

Table 6: Mean and Dispersion of Δ Tariffs + Non-Tariff Barriers Across State and Non-State Importers, Source Country, and HS-6 Product

	Mean		Standard Deviation	
	2017-2019	2017-2020	2017-2019	2017-2020
Agriculture				
Δ Tariffs	0.024	0.024	0.073	0.074
Δ Non-Tariff Barriers	0.108	0.053	0.494	0.425
Δ Tariffs + Non-Tariff Barriers	0.132	0.077	0.526	0.434
Manufacturing				
Δ Tariffs	-0.006	-0.008	0.035	0.038
Δ Non-Tariff Barriers	-0.060	0.023	0.381	0.549
Δ Tariffs + Non-Tariff Barriers	-0.066	0.015	0.38	0.549

Note: Table shows mean and standard deviation of $\Delta\ln(1+\tau_{if})$ (row 1), $\Delta\ln\left(1+\phi^j_{if}\right)$ (row 2), and $\Delta\ln(1+\tau_{if})\left(1+\phi^j_{if}\right)$ (row 3) across state and non-state importers, source countries, and HS-6 product between 2017-2019 (columns 1 and 3) and 2017-2020 (columns 2 and 4).

The top panel in Table 6 shows the results for agricultural HS-6 products. The first row shows the weighted average of the mean and standard deviation of $\Delta\log(1+\tau_{if})$ between the two years of the trade war (2017-2019) and for the entire 2017-2020 period. The overall dispersion of tariff rates increased by 0.07 log points between 2017 and 2019, and basically did not change in 2020.

The second row in Table 6 shows the change in non-tariff trade barriers in tariff equivalent units. Here, both the mean and the dispersion of non-tariff trade barriers matter for welfare. The mean of $\log(1+\phi_{if})$ increases by 0.11 log points and the standard deviation by 0.49 log points in 2018 and 2019, so the increase in the mean and the dispersion in non-tariff trade barriers is much higher than the increase in tariff barriers.

The third row in Table 6 shows the sum of the change in tariffs and the tariff equivalent of non-tariff trade barriers $\Delta\log(1+\tau_{if})\left(1+\phi^j_{if}\right)$. The increase in 2018 and 2019 in the dispersion across countries of trade barriers comes mostly from the increase in cross-country dispersion in non-tariff trade barriers. This result suggests that most of the welfare loss from trade barriers between 2017 and 2020 comes from the use of non-tariff trade barriers instead of tariffs (which we show in the next section).

Table 6 also shows the same data moments over the entire 2017-2020 period (third column) and for manufacturing imports (bottom panel). Here we highlight three facts. First, there was no change in tariffs in 2020 – the change in mean and dispersion of tariff rates across countries is the same between 2017-2020 as between 2017-2019. Second, in contrast, there was a reversal in the non-tariff barriers put in place between 2017 and 2019 in the first year of the phase 1 agreement in 2020. Still, it is clear that the reversal in 2020 was not complete – over the entire 2017-2020 period, the mean of non-tariff trade barriers increased by 0.05 log points, about half of the change in 2017-19. Third, the use of non-trade barriers for manufacturing was generally smaller compared to agriculture.

5 Welfare Cost of US-China Trade War

We now estimate the welfare cost to China of the trade barriers imposed during the course of the US-China trade war from 2017 to 2020. Specifically, welfare in our model is given by equation 6, where the US-China trade conflict affects welfare through the dispersion of tariffs across countries and HS-6 product and the mean and the dispersion of non-tariff barriers across countries, state vs. non-state importer, and across HS-6 product. The elasticity of welfare to these forcing variables are determined by the elasticity of demand and supply shown in Table 3, and the elasticity of substitution across firms.

Table 7 shows the resulting estimates of the welfare loss from higher tariffs and non-tariff barriers. Specifically, we start with the forcing variables in 2017 and change only the trade barriers to those prevailing in 2019 and 2020. The table then shows the changes in imports from the U.S. and Chinese welfare in the counterfactuals. The top panel shows the results of this exercise for agricultural HS-6 products. The first row shows the effects only of higher Chinese tariffs on U.S. agricultural products in 2019 and 2020, both relative to 2017. The first two columns show that higher tariffs lower imports of U.S. agricultural products by US$ 10.5 billion in 2019 and by US$ 11 billion in 2020. The next two columns shows that higher tariffs on U.S. products lowers Chinese welfare by 1.7 billion US$ in 2019 and by 1.9 billion US$ in 2020 (relative to the 2017 baseline).

The subsequent rows in Table 7 add the effect of changes in non-tariff barriers. The second row adds the effect of higher non-tariff barriers assuming that the non-tariff barriers facing state and non-state importers are the same and given by the weighted average of the change in non-tariff barriers for the HS-6 product. Adding *average* non-tariff barriers lowers imports of U.S. agricultural products by 21 billion US$ in 2019, or by an additional 10.5 billion US$ relative to the scenario where non-tariff barriers are held fixed. And adding average non-tariff barriers on U.S. exports lowers Chinese welfare by 10.99 billion US$ in 2019 compared to 2017, or additional 9.3 billion US$. The partial reversal of the non-tariff trade barriers in 2020 increases Chinese welfare, but the reversal in 2020 does not entirely undo the higher non-tariff barriers imposed in 2018 and 2019. Chinese welfare in 2020 from consumption of imported agricultural products is still 6.8 billion US$

Table 7: Effect of US-China Trade War on Imports from U.S. and Chinese Welfare (billion US$)

	Δ U.S. Import Value		Δ Welfare	
	2019	2020	2019	2020
Agriculture				
Tariffs Only	-10.5	-11.0	-1.7	-1.9
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-21.0	-17.5	-11.0	-6.8
+ Dispersion Δ NTBs between state/non-state	-21.5	-17.7	-12.7	-7.3
Manufacturing				
Tariffs Only	-12.6	-11.8	-1.6	-1.8
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-23.0	-21.6	-25.1	-38.8
+ Dispersion Δ NTBs between state/non-state	-23.9	-22.6	-27.2	-40.8

Note: Table shows effect of changes in tariffs only (row 1), changes in tariffs and average non-tariff trade barriers (row 2), and changes in all trade barriers (tariffs and non-tariff trade barriers, including differences between state and non-state importers) (row 3) on imports of U.S. products and Chinese welfare (in billions of US$) in 2019 relative to 2017 (columns 1 and 3) and 2020 relative to 2017 (columns 2 and 4).

lower compared to where it was in 2017.

The third row adds in the effect of differential non-tariff barriers between state and non-state importers of American products. So the third row shows the effect of all the trade barriers, including tariffs and all the non-tariff barriers. Adding the differential application of non-tariff barriers between state and non-state importers has little effect on U.S. exports to China, but has a larger effect on welfare. Chinese welfare in 2019 is 12.7 billion US$ lower compared to 2017 when we also take the differential non-tariff trade barrier between state and non-state firms into account, compared to a decline of 11 billion US$ when we do not. Overall, non-tariff barriers account for 86% of the welfare loss from from higher trade barriers on agricultural imports in 2019.

The bottom panel in Table 7 shows the results of the same exercise for trade barriers on manufacturing exports from the US. Remember that trade barriers, both in form of tariffs and also in the form of non tariff barriers, increased by less for U.S. manufactured products compared to agricultural products.[15] However, the effects of trade barriers on imports and welfare are larger than in agriculture because U.S. manufacturing exports to China are much larger than agricultural exports: in 2017 the U.S. manufacturing exports to China totaled 100 billion US$ and U.S. agricultural exports totaled 31.9 billion US$. The total welfare loss from higher trade barriers in 2019 was 27.2 billion US$, and the bulk of the welfare loss (94.1%) comes from the use of non-tariff barriers as opposed to tariffs. In addition, in contrast to what we see for agricultural products, there is no

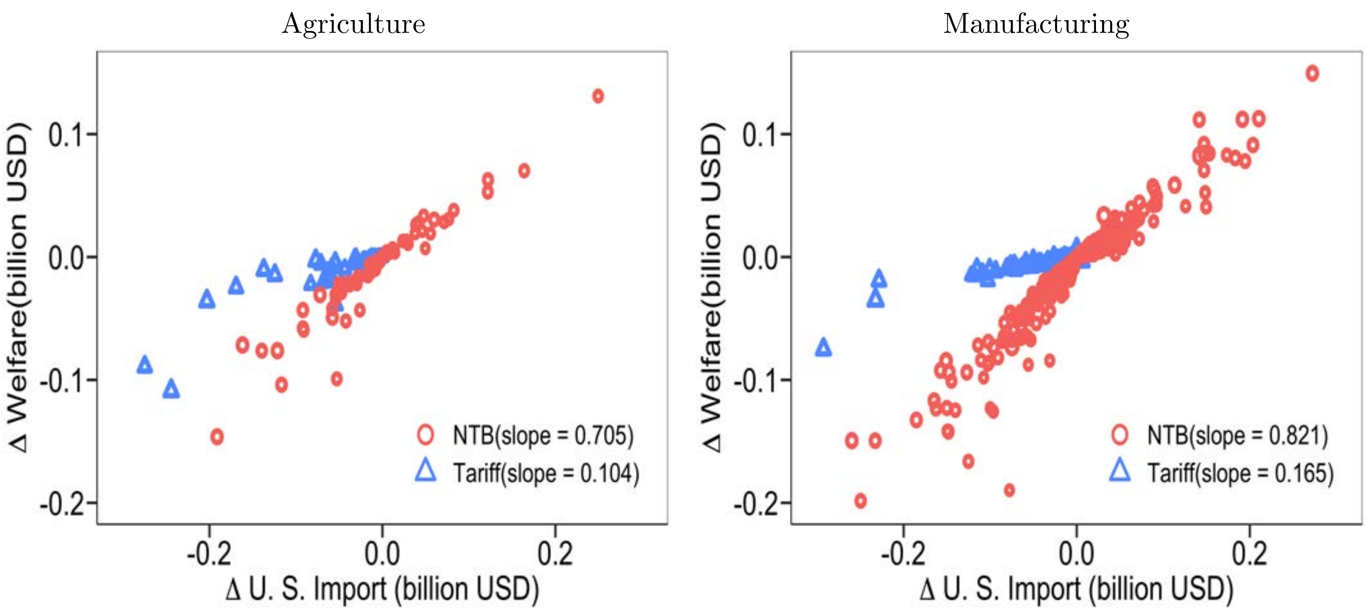
[15]See Table 1 for increase in tariffs and Table 4 for the increase in non-tariff barriers.

evidence of a reversal in the welfare loss in 2020 in the first year of the purchase agreement. The welfare loss in 2020 from higher trade barriers was about the same as in 2019.

Adding up the effects of trade barriers for agricultural and manufacturing goods, our estimates suggest that Chinese welfare fell by 40 billion US$ in 2019 compared to 2017 due to the higher trade barriers imposed by China in 2018 and 2019. The bulk – about 92% – of this welfare cost was due to the use of non-tariff trade barriers instead of higher tariffs. In sum, non-tariff barriers account for about half of the reduction in imports of U.S. products but almost all of the loss in welfare suffered by the Chinese due to the trade war. Some of the higher non-trade barriers facing U.S. agricultural exports were removed in 2020, but not for U.S. manufactured products that account for the most U.S. exports to China. As a consequence, China's welfare loss in 2020 is still 48.11 billion US$ lower compared to 2017.

Figure 2 uses the variation across HS-6 products to highlight non-tariff barriers were much costly compared to tariffs as an instrument to lower imports from the U.S. In this figure, we ask the following question: how much did the increase in tariffs and non-tariff barriers between 2017 and 2019 on each HS-6 product sold by the U.S. lower U.S. imports and Chinese welfare? We calculate the change in imports from the U.S and Chinese welfare for the change in tariffs and imputed non-tariff barriers on each HS-6 product.

Figure 2: Welfare Elasticity of Welfare to US Import Value: Tariffs vs. Non-Tariff Barriers



Note: Each observation is a HS-6 product. Figure plots estimated change in Chinese welfare against estimated change in U.S. imports caused by the actual change in tariffs (dots) and non-tariff barriers (triangles) in 2018-19 for each HS-6 product.

Figure 2 shows the results of this exercise, separately for agricultural products (on the left panel) and manufactured products (on the right panel), where the change in welfare is on the y-axis and the change in imports on the x-axis. The observations in red circle denote the effect of a change in non-tariff barriers on welfare and imports from the U.S., and the observations in blue triangle denote the same for the change in tariffs. The figure shows clearly that for every dollar reduction in imports from the U.S., non-tariff barriers are much more costly to Chinese consumers. The elasticity of welfare change to the change in imports due to non-tariff barriers is about five times larger than the elasticity of welfare with respect to imports due to tariff hikes. Of course, this is to be expected: compared to tariffs, non-tariff barriers are more costly because of there are no tariff revenues and because of the misallocation of imports when non-tariff barriers apply to some firms and not to others. Therefore, to the extent that the goal of the Chinese government was to retaliate against U.S. tariffs on Chinese products by cutting imports from U.S., using non-tariff barriers is a much more costly policy instrument than using tariffs.

6 Robustness

In this section we conduct three sets of robustness checks. First, we infer non-tariff barriers on imports from the U.S. in the Chinese market as the residual of changes in the import share of U.S. product, after controlling for the change in the tariffs. It is possible that this residual reflects other things, such as changes in the quality of the particular U.S. product rather than Chinese non-tariff barriers on the product. To determine whether this is likely, we calculate U.S. exports to the rest of the world (excluding China) as a share of exports of the rest of the world to the rest of the world.[16] If what we infer as non-tariff barriers on U.S. products in China reflects quality or price changes of the U.S. product, we should also see this in a decline of U.S. exports to non-Chinese markets. Figure A1 in the appendix shows the scatterplot of the share of a U.S. product to the rest of the world (excluding China) (relative to exports of the rest of the world to the rest of the world) vs. the non-tariff barrier in the Chinese market of the same product. As can be seen, there is no evidence that U.S. exports to the rest of the world (excluding China) fall by more for HS-6 products where U.S. exports of the same product fall significantly in the Chinese market. U.S. products where we infer a large increase in Chinese non-tariff barriers only see a decline in the Chinese market, and nowhere else.[17]

Second, an identifying assumption behind our estimates of the demand and supply elasticities is that the change in tariffs across countries are orthogonal to the change in non-tariff trade barriers and supply shifts in the source country. Appendix Figure A2 shows the scatter-plot of the change in non-tariff trade barriers for a given HS-6 product from a given country (on the y-axis) vs. the change in tariffs for the same product-source country (on the x-axis). As can be seen, there is essentially zero correlation between these two variables.[18]

As for the possibility that supply side shifts that are correlated with tariffs, we cannot directly observe supply side shifts, but we can use the growth rate of import quantity of the HS-6 product

[16]We calculate this number at the HS-6 product level from the UN's Comtrade data.
[17]The OLS regression of the scatter-plot in Appendix Figure A1 yields 0.016 with a standard error of 0.007.
[18]The OLS regression coefficient of the relationship in in Appendix Figure A2 is 0.014 (0.815).

from a given country as a proxy for trends in productivity growth in the foreign country. Appendix Figure A3 shows the scatter-plot between the growth rate of import quantities of a HS-6 product from a country between 2015-2017 (on the y-axis) and the change in tariffs between 2017-2017 (on the x-axis). Again, the correlation is zero.[19]

Third, the identifying assumption behind our estimates of non-tariff trade barriers on imports from the U.S. are that the average change in non-tariff trade barriers on imports from other (non-U.S.) countries is zero. We check this assumption by estimating the change in non-tariff trade barriers from the four largest exporters to China (in addition to the U.S.), this time assuming that the weighted average of the change in non-tariff barriers facing non-state importers for the other countries (excluding the U.S. and the top four exporters to China) is zero. For example, we use equations 7 and 8 to estimate the non-tariff trade barriers on imports from Brazil assuming that the change in non-tariff trade barriers on imports of the same good from all the other countries (excluding the U.S. and the four largest exporters to China) is zero on average.

Table 8 reports the results for the top five exporters of agricultural products to China. Table 8 shows the imputed non-tariff trade barriers are essentially constant for Brazil, Thailand, and Canada during the course of the U.S.-China trade war between 2017 and 2019. For Australia, consistent with the accounts of what happened after Australia passed a national security law in 2018, our estimates suggest that non-tariff trade barriers increased on imports from Australia. But still, the increase in non-tariff barriers faced by imports from Australia over 2017-2019 period is much smaller compared to the U.S.

Table 8: Δ Non-Tariff Trade Barriers for Agricultural Products, 2017-2019

	Δ Non-Tariff Barriers (2017-2019)
U.S.	0.604
Brazil	0.069
Canada	0.049
Thailand	0.075
Australia	0.131

Note: Table shows weighted average of change between 2017 and 2019 in non-tariff trade barriers of agricultural products from each country. See notes to Table 4 for more details.

Finally, in the appendix we show the main estimates with alternative estimates of the elasticity of substitution across products σ and state vs. non-state importers η. Specifically, we assume the elasticity of substitution across products is 1 and the elasticity of substitution between state and non-state importers η is 5 (instead of 3). Even with these alternative numbers for the two elasticities, we continue to find that non-tariff barriers increased by more than tariffs, that the

[19]An OLS regression of the relationship in the bottom panel of Figure **??** yields -0.02 (0.024).

increase in non-tariff barriers mostly affected non-state importers, and that the elasticity of welfare with respect to imports is much larger for changes in non-tariff barriers compared to changes in tariffs.

7 Explaining Variation in Tariff and Non-Tariff Barriers

It is clear that a central objective of the Chinese authorities was to lower imports from the US. However, why did the authorities choose to lower imports by more for some products, and why did it choose to hike non-tariff barriers compared to tariffs for some products but not for others. In this section we provide suggestive evidence that the variation across products in the use of tariffs vs. non-tariff barriers can be partially explained as an outcome of a government facing dual objectives, which are to "punish" the U.S. by blocking imports from the U.S. and to protect profits of state owned firms.

Remember that tariffs apply equally to all firms whereas non-tariff barriers can apply to some firms and not to others. Further recall our evidence that non-tariff barriers primarily applied to non-state firms but not to state firms. All else equal, the government wants to lower imports from the US by raising barriers (both tariffs and non-tariff barriers) on US imports. However, since the government also cares about profits of state owned firms, it will raise tariffs by less for products imported from the US in which state owned firms have a larger market share. At the same time, since non-tariff barriers do not apply to state owners but benefit the government by lowering imports from the US, the hike in non-tariff barriers will tend to be *larger* for US products where the state share is larger.

Table 9: Regressions of Δ Tariffs and Non-Tariff Barriers on U.S. Imports on State Share

	Δ Tariff		Δ Non-Tariff Barriers	
State Share of HS-6 Product from U.S.	−0.202 (0.042)	−0.222 (0.042)	4.431 (0.655)	4.217 (0.655)
Share of U.S. in Total Imports of HS-6 Product		0.090 (0.025)		0.974 (0.382)
R^2	0.059	0.092	0.113	0.127

Notes: Table shows coefficients from regression at the HS6 product level of the change in tariffs $\Delta \log(1+\tau_{i,us})$ (columns 1 and 2) or non-tariff barriers faced by non-state importers $\Delta \log(1+\phi^n_{i,us})$ (columns 3 and 4) on a HS6 product imported from the US on the share of state-owners in total imports of the HS-6 product from the U.S. in 2017 (row 1) and the share of the U.S. in total imports of the HS-6 product from all countries in the same year (row 2). Number of observations = 353.

Table 9 provides strong support for this prediction. Each observation is weighted by the value of 2017 US imports. The first column shows the regression of the change in tariffs on a U.S. HS-6 product on the share of state owners in total imports from the U.S. of each HS-6 product prior to the trade war. The regression shows that tariffs on a U.S. product increases by less when state owners have a larger share of the imported product. This supports the logic that the government is less likely to raise tariffs when the tariffs will have a larger adverse effect on profits of state owners. The third column shows the regression of the change in non-tariff trade barriers faced by *non-state* imported of the U.S. HS-6 product on the state share of total imports of the U.S. product. Here the coefficient is positive, suggesting that the government hikes up non-tariff barriers facing non-state firms by more in sectors where it has a larger stake.

Columns 2 and 4 in Table 9 introduce controls for the share of U.S. imports in total imports of the HS6 product. The evidence here suggests that the Chinese government indeed increased trade barriers by more for products where the U.S. has a larger share. However, it is still the case that even accounting for the importance of U.S. goods in the HS6 product, tariffs increase by less and non-tariff barriers facing non-state owners increase by more in HS-6 products where state owners have a larger share of imports from the U.S.

8 Conclusion

We estimate the use of non-tariff trade barriers by China in its trade battle with the U.S. in 2018 and 2019 and in the first year of the purchase agreement in 2020. We do this by first estimating the elasticities of demand for U.S. products in China relative to products made by other countries, as well as the elasticity of supply. These estimates indicate that the supply curve is almost horizontal, which suggests that the entire incidence of higher Chinese trade barriers are entirely borne by Chinese consumers.

We then use the estimates of the demand elasticities to back out the changes in non-tariff barriers as the residual of changes in imports of U.S. products relative to imports from other countries of the same HS-6 product, after controlling for the effect of tariffs. These estimates suggest that non-tariff barriers for U.S. agricultural exports increased significantly in 2018 and 2019, by a tariff-equivalent of 60 percent. The increase in non-tariff barriers for U.S. manufacturing exports is smaller. And in 2020, some of the increase in non-tariff barriers on U.S. agricultural exports was reversed.

We use a simple model to estimate the effect of trade barriers, including tariffs and non-tariff barriers, on Chinese welfare. We find that trade barriers imposed in 2018 and 2019 lowered Chinese welfare in 2019 by 40 billion US$, with 93% of the welfare loss coming from the use of non-tariff trade barriers.

Finally, the use of regulatory tools as a trade barrier is not unique to the U.S.-China trade dispute. For example, after Canadian authorities arrested Meng Wangzhou, the CFO of Huawei, Chinese authorities retaliated on Canadian exports not with higher tariffs, but with similar opaque regulatory procedures. For example, Chinese authorities claimed that Canadian canola oil was infected with pests. Imports of Canadian pork and soybeans were subject to long paperwork delays. A similar dynamic took place for Australian exports to China. After Australia passed a national security law and blocked Chinese companies from its 5G mobile networks, Australian exports of barley were hit with anti-dumping duties, import licenses on Australian beef, lobster, and copper were revoked, and directives were issued to stop buying Australian cotton and coal. It would be useful to extend the analysis we undertake in this paper to these, and other, cases.

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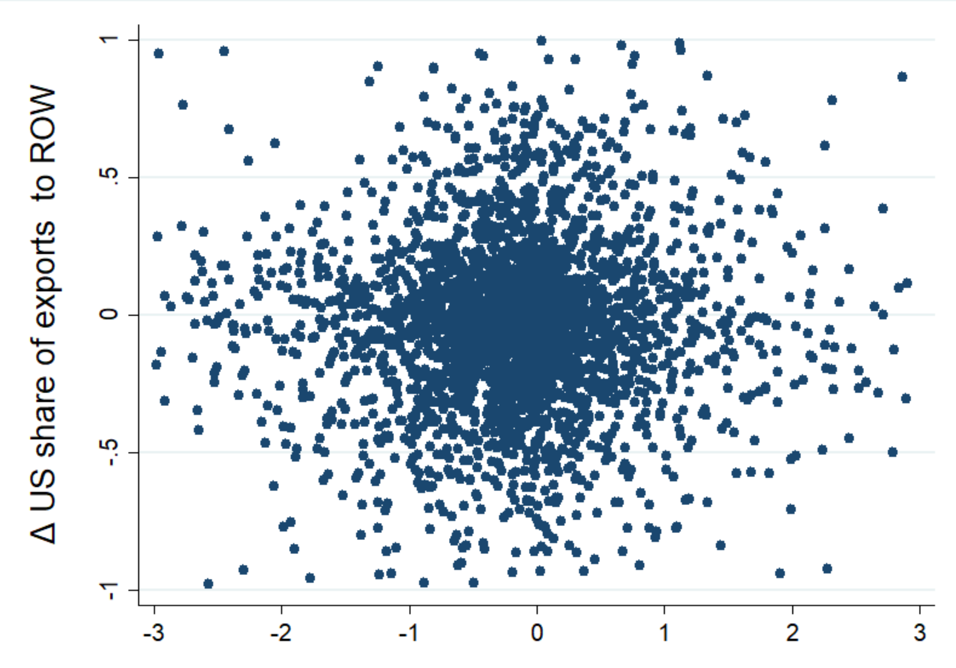
Online Appendix

(Not for publication)

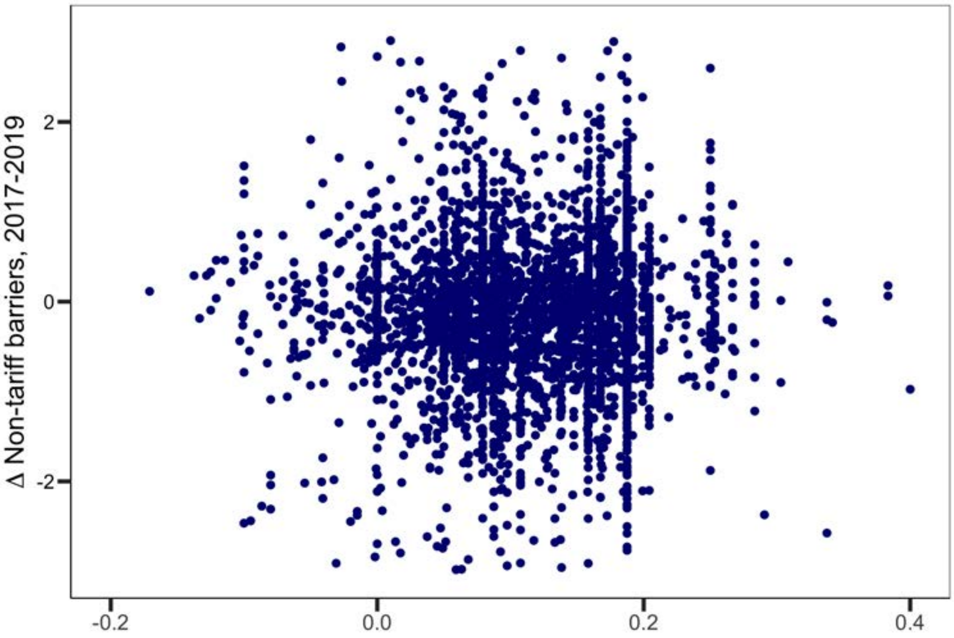
Figure A1: Δ log U.S. exports to rest of world/exports from rest of world to rest of world vs. Δ non-tariff barriers on U.S. exports to China, 2017-2019



Δ Non-tariff barriers on U.S. exports to China, 2017-2019

Note: Each observation is a HS-6 product. Figure presents scatter-plot of the change in log U.S. exports to the rest of the world as a share of exports of the rest of the world to the rest of the world (y-axis) against the change in non-tariff barriers on U.S. exports to China, both calculated between 2017 and 2019. The change of U.S. exports to the rest of the world is calculated from the U.N.'s Comtrade database. See text for details on the calculation of non-tariff barriers on U.S. exports to China.

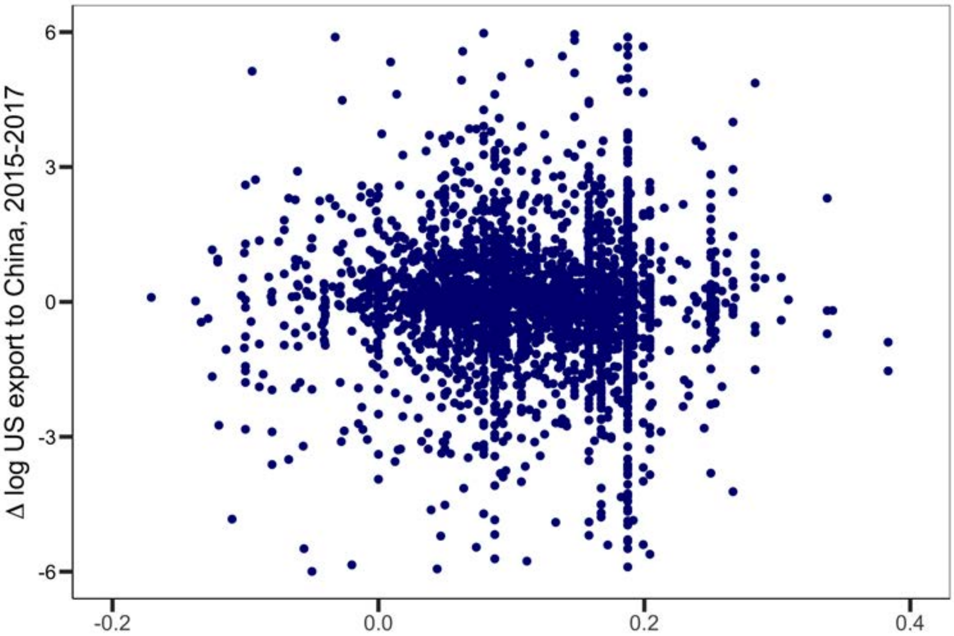
Figure A2: Δ non-tariff on U.S. exports to China vs. Δ tariff on U.S. exports to China, 2017-2019



Δ tariff on U.S. exports to China, 2017-2019

Note: Each observation is a HS-6 product. Figure presents scatter-plot of the change in non-tariff barriers of U.S. exports to China (y-axis) against the change in tariff on U.S. exports to China, both calculated between 2017 and 2019. See text for details on the calculation of non-tariff barriers on U.S. exports to China, and how we compile the tariff data.

Figure A3: Δ log U.S. exports to China, 2015-2017 vs. Δ tariff on U.S. exports to China, 2017-2019



Δ tariff on U.S. exports to China, 2017-2019

Note: Each observation is a HS-6 product. Figure presents scatter-plot of the change in log U.S. exports to China (relative to exports of other countries to China) between 2015 and 2017 (y-axis) against the change in tariff on U.S. exports to China between 2017 and 2019. See text for details on how we compile the tariff data and trade data.

Table A1: Δ Non-Tariff Barriers on U.S. Imports ($\sigma = 1$ and $\eta = 5$)

	Δ Import Quantities	Δ *cif* price + tariff	Δ Non-Tariff Barriers Non-State	State	Average
		Panel A: $\sigma = 1$			
Agriculture					
Trade War (2017-19)	-2.69	0.124	0.676	-0.084	0.544
Trade War and Phase 1 (2017-2020)	-0.861	0.131	0.125	0.003	0.107
Manufacturing					
Trade War (2017-19)	-0.364	0.038	0.118	0.35	0.169
Trade War and Phase 1 (2017-2020)	-0.389	0.096	0.071	0.322	0.124
		Panel B: $\eta = 5$			
Agriculture					
Trade War (2017-19)	-2.44	0.127	0.706	0.056	0.594
Trade War and Phase 1 (2017-2020)	-0.731	0.133	0.146	0.06	0.135
Manufacturing					
Trade War (2017-19)	-0.287	0.2	-0.062	0.106	-0.025
Trade War and Phase 1 (2017-2020)	-0.569	0.214	0.135	0.285	0.173

Note: Column 1 shows the average change in log U.S. imports (in quantities) relative to imports from all other countries; Column 2 shows the average change in the log *cif* price of U.S. imports inclusive of tariffs relative to other importers; Column 3 shows the change in non-tariff trade barriers on non-state importers on U.S. products; Column 4-5 shows the change in non-tariff trade barriers on non-state importers and state importers estimated from the change in imports after removing the effect of the change in import prices using the estimates of ϵ in Table 3 using equations 7 and 8. Column 6 shows the weighted average of Δ non-tariff barriers of non-state and state importers of U.S. products.

Table A2: Effect of US-China Trade War on Imports from U.S. and Chinese Welfare (billion US$) ($\sigma = 1$ and $\eta = 5$)

	Δ U.S. Import Value		Δ Welfare	
	2019	2020	2019	2020
	Panel A: $\sigma = 1$			
Agriculture				
Tariffs Only	-8.87	-10.00	-1.92	-2.18
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-14.41	-14.07	-7.74	-5.99
+ Dispersion Δ NTBs between state/non-state	-15.13	-14.32	-9.63	-6.47
Manufacturing				
Tariffs Only	-12.63	-11.52	-1.93	-2.06
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-25.36	-14.97	-29.30	-27.63
+ Dispersion Δ NTBs between state/non-state	-26.30	-16.02	-31.41	-29.72
	Panel B: $\eta = 5$			
Agriculture				
Tariffs Only	-10.52	-11.01	-1.70	-1.89
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-21.00	-17.46	-10.89	-6.76
+ Dispersion Δ NTBs between state/non-state	-21.68	-17.71	-12.69	-7.13
Manufacturing				
Tariffs Only	-12.81	-11.95	-1.63	-1.82
Tariffs + Non-Tariff Barriers				
+ Δ Average Non-Tariff Barriers	-23.48	-22.49	-25.36	-37.26
+ Dispersion Δ NTBs between state/non-state	-24.33	-23.23	-26.77	-38.51

Note: Table shows the effect of changes in tariffs only (row 1), changes in tariffs and average quantitative restrictions (row 2), and changes in all trade barriers (tariffs and quantitative restrictions, including differences between state and non-state importers) (row 3) on imports of U.S. products and Chinese welfare (in billions of US$) in 2019 and 2020 relative to 2017. The results are scaled by the ratio of annual imports in 2017 to total imports between January to July in 2017, which is 1.75 and 1.85 for agriculture and manufacturing goods, respectively.

Table A3: Welfare Elasticity to US Import Value ($\sigma = 1$ and $\eta = 5$)

	Dependent variable: Δ Welfare	
	by Tariff	by Non-Tariff Barriers
	Panel A: $\sigma = 1$	
Agriculture		
Δ U.S. Import Value	0.095	0.810
	(0.002)	(0.002)
Manufacturing		
Δ U.S. Import Value	0.169	0.744
	(0.001)	(0.004)
	Panel B: $\eta = 5$	
Agriculture		
Δ U.S. Import Value	0.104	0.716
	(0.001)	(0.001)
Manufacturing		
Δ U.S. Import Value	0.165	0.810
	(0.001)	(0.003)

Note: Table reports the estimated elasticity of Chinese welfare with respect to import value change caused by tariffs or non-tariff barriers. The regressions use simulated data from counterfactual exercises (see the text for details).