Elasticities of Related-party Trade

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Abstract

I explore how the import demand of multinationals (MNEs) responds to a short-term tariff shock, given the heterogeneity in shares of related-party imports. In particular, I focus on estimating the trade elasticities of MNEs during the 2017-18 Trump tariff period. Building on Amiti et al. (2019) and Fajgelbaum et al. (2020), I estimated the elasticities of related-party imports to be between -1.578 and -1.955 and more elastic than their arms-length counterparts. The preliminary finding of MNE importers/industry being more responsive to tariff changes than non-MNE counterparts under complete tariff pass-through may reflect their profit-shifting process in a very short run.

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1 Introduction

1.1 Motivation and Literature

A related-party trade, by definition, refers to home multinational firms (MNE) exporting or importing from their foreign affiliates. It decomposes a channel of how MNEs enter the global value chains (GVCs) and contributes to a significant share of overall international trade by the U.S. The dynamic sourcing decision of a firm, on the other hand, is largely shaped by tariff shocks and the existence of industry-specific sunk cost, where its intensive margin is governed by trade elasticity.[1] While both are extensively surveyed and studied in trade literature, little is known about how Multinationals respond differently to short-run tariff shocks. To explore this puzzle, the main focus of this paper is to estimate the import demand elasticities with variations in related-party trade during the 2017-18 Trump administration tariff period.

As import elasticity governs the response to tariff change in quantity, we learn immediately the industry-level sensitivity and expect the impulse/long-term impacts. By looking at related-party imports, we can recover the trade preferences and patterns of multinational firms, the powerhouses of the economy. Multinational firms are an important partition of importers to investigate, and I provide two reasons. First, when people think about multinationals, the majority of studies examine their productivity draws and export patterns but rarely look into their import decisions and intensive margins. Second, upon arrival of trade shock, we expect two *opposite* forces for multinationals' import demand: downward effects due to higher trade costs (elasticity) or sourcing diversion, and then compensating (positive) effects due to adjustment costs or intrafirm trade rigidity (e.g., contracts) (Antràs & Yeaple, 2014). In principle, this related-party import presents a story of Multinationals' sourcing decisions, trade patterns, and their import demand rigidity under trade (cost) shocks. Under contexts of International Trade, this puzzle is traceable by exploring the elasticity of related-party imports.

This paper contributes to trade literature on decomposing and refining the short-run

[1] The intuition follows by importing firms optimally source intermediate/final goods, depending on both tariffs τ and switching costs κ, in CES preferences. Importer problem also see Eaton and Kortum (2002).

shock responses (i.e., elasticity) by related-party channel (σ_{MNE}) and arms-length channels (σ_{NMNE}). Specifically, I look at the Trump administration tariffs period. The seminal paper Amiti et al. (2019) was the first to estimate the elasticity during the Trump 2017-18 tariff and approximated the deadweight loss. Among literature investigating Trump tariffs, Fajgelbaum et al. (2020) incorporates both a theoretical framework and empirical identifications for elasticities and welfare. To understand multinationals' dynamics, Antràs and Yeaple (2014) is a holistic handbook on the structural framework of MNEs with CES preferences. Ramondo et al. (2016) presented empirical findings of intrafirm (i.e., related-party) trade but focused more on export patterns from the foreign affiliates. Ruhl (2015) discussed the usage and robustness of related-party trade data. Bernard et al. (2006) elaborated on MNEs' price settings and mark-ups yet again focusing on the export side of the related-party trade. Costinot and Rodríguez-Clare (2014) documented gravity structures in trade and augmented (Armington) elasticity models and firm-level heterogeneity with CES preferences. Engel and Wang (2011) provided elasticity insights under international finance contexts via nondurable versus durable CES composites. Lastly, a recent study by Cox (2023) looked into the Bush 2002-03 steel tariffs and found that a temporal, targeted tariff shock can lead to a persistent response for that specific industry and its downstream.

This paper is inspired by Amiti et al. (2019) and Cox (2023), and I ask how MNEs respond differently to a short-run tariff shock. I aim to bridge the gap between the two key literature, and the contributions of this paper are threefold. First, I investigate the short-run shock responses in imports by decomposing into related-party channels and arms-length channels. For intrafirm measurement, I propose an alternative definition of a Multinational firm when firm-level data is unavailable or infeasible. Second, for point estimates, I estimate the import elasticity of multinationals (related-party; σ_{MNE}) to be around -1.578 and -1.955, which is *more elastic* than NMNEs. In addition, the trade elasticity is monotonically increasing in the share of related-party imports. The magnitude is cohesive to literature in International Trade and International Real Business Cycle (IRBC). Lastly, for implication, the observation that MNE importers are *more responsive* to tariff changes than NMNEs may reflect the "profit-shifting" process.

2 Empirical Framework

The main empirical estimation for related-party import elasticity follows Amiti et al. (2019) and Fajgelbaum et al. (2020).

2.1 Data and Variables

I use the data accessible from Amiti et al. (2019) and the publicly available Related Party Time Series Data to estimate the elasticity of import demand on related-party trade during the Trump tariff period. The Amiti et al. (2019) data includes monthly bilateral imports data at HS10 × Country × Month level. The sample period is from January 2015 to December 2018, and the authors focused on January 2017 to December 2018 for the Trump tariff exercise. Specifically, a crosswalk between HS10 and NAICS6 has been matched in their dataset using the Pierce and Schott (2012) concordance. I obtain **log-change of import quantities** ($\Delta \mathbf{q} \equiv \Delta \ln q_{ijt}$), **log-change of tariff changes** ($\Delta \boldsymbol{\tau} \equiv \Delta \ln 1 + \tau_{ijt}$), and **log-change of before-duty unit prices** ($\Delta \mathbf{p} \equiv \Delta \ln p_{ijt}$) from the Amiti data.

For the inferences in the heterogeneous intensity of related-party trade, I supplement the Amiti data by merging Related Party Time Series Data from the U.S Census Bureau. It is the merchandise trade data collected by the U.S. Bureau of Customs and Border Protection. This bilateral annual data keeps track of main trade metrics such as total domestic import and related-party import from the U.S. trading partners and is coded at NAICS6 × Country × Year level.

I further use this related-party trade data to construct a set of supplemental variables, including related-party imports status (binary), the share of related-party imports, related-party trade balance status (binary), and share of related-party trade balance. This set of variables allows me to fully explore the industry-level variations in related-party trade status/intensity in response to the short-run Trump tariff shock. In particular, I filtered out import records with *only* "Not reported trade" from the related-party trade data. It indeed eliminates some potential variations in related-party import share, but my justification is that it provides convenient empirical purposes in yielding a binary decomposition of total values of imports into related-party and arms-length channels, namely:

$$v_{jt} = \sum_{i \in \mathcal{I}} v_{ijt} = \sum_{i \in \mathcal{I}} v^r_{ijt} + v^a_{ijt}, \tag{2.1}$$

where i is sourcing origin, j is commodity, t is time period (month), superscript r denotes related-party, and superscript a denotes arms-length. With this binary channels of import, the **share of related-party imports** ($\%RelatedParty$; α_r) is defined and calculated by:[2]

$$\%RelatedParty \equiv \alpha_r \equiv \frac{v^r_{ijt}}{v_{ijt}} = \frac{v^r_{ijt}}{v^r_{ijt} + v^a_{ijt}}. \tag{2.2}$$

Table 1 presents the summary statistics of Related-party Trade Data from January 2017 to December 2018.

Table 1: Summary Statistics, Related-party Trade (Partial)

	mean	sd	min	p25	p75	max
Total Imports	81.70	906.41	0.00	0.03	7.60	78398.92
Related-party Imports	40.47	601.18	0.00	0.00	1.28	48329.58
Non related-party Imports	41.23	485.62	0.00	0.02	4.31	59038.40
$\mathbb{1}\{\text{Related-party Imports}\}_t$	0.61	0.49	0.00	0.00	1.00	1.00
% RelatedParty	0.25	0.33	0.00	0.00	0.45	1.00
			$Obs = 58988$			
Lagged status						
$\mathbb{1}\{\text{Related-party Imports}\}_{t-1}$	0.65	0.48	0.00	0.00	1.00	1.00
$\mathbb{1}\{\text{Related-party Trade Balance}\}_{t-1}$	0.44	0.50	0.00	0.00	1.00	1.00
			$Obs = 52956$			

Note: The data is obtained from the Related Party Time Series Data, with a sample period 2017-2018. Units in million. Also see Appendix A.1 Table A1 for a full descriptive table for the related-party trade data.

In the following subsection, I show why it is meaningful to calculate α_r. In principle, the share of related-party imports will be a powerful tool to define MNEs and help estimate their trade elasticities (i.e., shock responses).

[2] I use "%" for a shorthand of "share." In Table 1 summary statistics I did not multiply it by 100. Also see Antràs and Yeaple (2014) Section 7 Table 2.5 for the construction of this variable.

2.2 From MNE concentration to Share of Related-party Imports

I seek to draw insights into multinationals' import demand and thus need a parameter of multinational concentration. The ideal and more direct way to identify multinationals' imports is to look at firm-level data and classify which import shipments were done between related parties. In that case, I can easily calculate industry–level multinational concentration. However, it is empirically infeasible to gather every multinational's firm-level shipment data to compute the trade elasticity. In this paper, I propose an alternative definition of multinationals by leveraging Related–Party Time Series data. The logic is that I can first use the share of related-party imports "α_r" (calculated in Section 2.1) as an ordering of MNE concentration for each import data and define MNEs by their corresponding share of related-party imports. Then, I get to compute their trade elasticity by regression estimation.

Assumption 2.1 (Data)**.** By reordering the data, the MNE concentration $m \in \mathbb{R}_+$ has $\sup m = M,\ \mathbb{E}\,|\mathcal{M}| < \infty$ (finite), $\mathcal{M} \neq \emptyset$.

Proposition 2.1. *The MNE concentration $m \in \mathcal{M} = [0, M]$ is order isomorphic to the share of related-party trade $\alpha_r \in \mathcal{A} = [0, 1]$. In other words, $\forall m_1, m_2 \in \mathcal{M}$, $m_1 \leq_{\mathcal{M}} m_2$ if and only if $\alpha_{r,1} \leq_{\mathcal{A}} \alpha_{r,2}$.*

Proof. See Appendix A.1.[3] □

The Assumption on data and Proposition jointly suggest that, by exploiting the variations of related-party imports share, the derived import elasticities can trace out the intensive margins of Multinationals. We are on the track to reach the desirable goal of this paper–exploring multinationals' import responses/rigidities under tariff shocks. So, I now define the Multinationals by:

Definition 2.1 (MNE)**.** Firms source $\alpha_r \in [0, 1]$ share of goods from their foreign affiliates/related parties. A firm is a Multinational if and only if $\alpha_r \in (0, 1]$.[4]

To see how I use this α_r, we can consider the following three scenarios of a firm:

[3] This came from insights when I looked at the related-party trade data, noticing that values of the related-party imports are driven by very condensed groups of sectors. Ramondo et al. (2016) also documented this type of observation in their empirical findings.

[4] This definition of MNE is second-best since I don't have firm-level data.

- ($\alpha_r = 1$) *All* imports by this firm are under related-party trade. It means that this firm is indeed a Multinationals. (✓)
- ($\alpha_r \in (0, 1)$) *Some* of the imports by this firm are under related-party trade. It means that this firm is still a Multinationals. (✓)
- ($\alpha_r = 0$) *None* of imported goods by this firm are related-party. Therefore, it suggests that this firm collapses to a Non-multinationals.

To summarize, we have:

Definition 2.2 (Median MNE)**.** A median MNE has a share of related-party imports:

$$\tilde{\alpha}_r^+ \equiv \text{median}(\alpha_r; \alpha_r > 0), \tag{2.3}$$

where $\tilde{\alpha}_r^+ > 0$ by construction.

To summarize this subsection, I propose a secondary definition of Multinationals by share of related-party imports since 1) I do not have firm-level data, and 2) it is infeasible to collect all firm-level data to compute trade elasticities. If agreeing with this definition of MNE, we observe that Multinational firms must have a α_r that is strictly greater than zero. As a result, I define the median share of related-party import, $\tilde{\alpha}_r^+$ by the median of *non-zero* α_r's. I will fix α_r by this $\tilde{\alpha}_r^+$ for the elasticity estimation and interpret the estimates as import elasticity of a "representative MNE" in Section 2.3.

2.3 Baseline Estimation of Trade Elasticity σ

Consider the reduced form of log-change of import quantities on log-change of tariff change:

$$\Delta \ln q_{ijt} = \sigma \Delta \ln (1 + \tau_{ijt}) + \mu_j + \zeta_{it} + \xi_{ijt}, \tag{2.4}$$

where $\Delta \ln q_{ijt} \equiv \ln(q_{ij,t}) - \ln(q_{ij,t-12})$ is the 12-month log change of the U.S. imports of commodity j from origin i in time period t. Similarly, $\Delta \ln (1 + \tau_{ijt})$ is the 12-month log change of tariff rate on commodity j. The error components contain commodity-fixed effect μ_j, country $\times$ time fixed effect ζ_{it}, and idiosyncratic errors ξ_{ijt}. Following justifications in

Amiti et al. (2019), standard errors are clustered in HS8 level since tariff changes happen at more aggregate level for some commodities.

Ideally, running two separate OLSs by splitting observations into related-party versus arms-length, the coefficient of interest σ gives us useful insights and interpretations of (related-party) import elasticities. The *problem* is that related-party trade data is at *industry-level* aggregation, not as detailed *commodity-level* as in Amiti et al. (2019) data. I proposed two alternative strategies to get away with this empirical concern:

(A1) Adjust the commodity-level imports quantity and tariff changes by weighted average *within* HS8/NAICS4 industries.

(A2) Interact tariff changes with "Share of Related-party Imports" ($\alpha_r; \%RelatedParty$):

$$\Delta \ln q_{ijt} = \underbrace{\phi_B \Delta \ln(1+\tau_{ijt})}_{\text{standalone elasticity}} + \underbrace{\phi_{MNE} \Delta \ln(1+\tau_{ijt}) \times \%RelatedParty}_{\text{diff. effect of related-party (MNE)}} + \mu_j + \zeta_{it} + \xi_{ijt} \tag{2.5}$$

In essence, these two Alternatives present the trade-off between effects arguments and levels of aggregation. Strategy (A1) maintains natural interpretations of industry-level aggregate effects of trade elasticities but loses detailed commodity-level insights. Strategy (A2) maintains commodity-level insights but only provides differential/relative effects between related-party import share industries and arms-length (i.e., loss of interpretations of the aggregate related-party import elasticity). Yet, another problem arises for Strategy (A1) as there is no official definition or concordance between HS8–NAICS, like Pierce and Schott (2012) did for HS10–NAICS6. The reweighing procedures for the tariffs and quantities became sort of meaningless as standard errors would no longer be clustered correctly. Therefore, this paper will proceed with **Strategy (A2)**.

2.4 Identification Assumptions and Threats

For notation ease, I first rewrite Equation (2.5) by:

$$\Delta \mathbf{q} = \phi_B \Delta \boldsymbol{\tau} + \phi_{MNE} \Delta \boldsymbol{\tau} \cdot \boldsymbol{\alpha}_r + \mu_j + \zeta_{it} + \xi_{ijt}. \tag{2.6}$$

This paper proceeds with Strategy **(A2)** along with the following identification assumptions:

① Idiosyncratic shocks: Trump administration tariffs ($\Delta \boldsymbol{\tau}$) were *exogeneous* to all industries and *uncorrelated* to unobserved foreign supply/demand shocks ($\boldsymbol{\xi}$), in the sense that the U.S. multinationals (importers) and the associated MNE-concentrated industries were *unanticipated* of such trade policy shock.[5]

② Share of Related-party imports: $\boldsymbol{\alpha}_r$ is assumed to be exogeneously determined.[6]

③ Complete tariff pass-through: no impact of tariffs on before-duty prices. In other words, this makes sure that the quantity changes we observe in imports are induced by the domestic import demand, not the foreign supply side.

There are indeed some threats to identification, mostly documented by Fajgelbaum et al. (2020). The first threat is the simultaneity issue when estimating quantity on "prices" (tariffs). To get away with this bias, one needs to instrument *duty-inclusive* prices by $\Delta \boldsymbol{\tau}$ and estimate domestic import demand and foreign export supply altogether as a system. Here, I don't have foreign export data. I acknowledge this potential bias and am conservative about my estimates. The second one is that complete tariff pass-through may not always be the case. Suppose we do not have a complete tariff pass-through, then there may appear a slight decrease in border import prices over time and therefore a drop in foreign supply. This is unwanted since I cannot isolate the quantity drop solely by domestic import demand. Though not directly tested, Table 3 Panel 1 provides supportive evidence on complete tariff pass-through. Lastly, ② is a strong assumption. Realistically, firms should be able to endogeneously determine how much portion of goods they import from foreign affiliates. Here, I claim this exogeneity of related-party import share for estimation and interpretation

[5] This is a widely-accepted assumption in literature, and therefore I follow the convention of claiming this exogeneity. Also see discussion in Amiti et al. (2019), Fajgelbaum et al. (2020), Cox (2023)

[6] For justification, I think of this α_r as some exogeneous draw of multinational firm status.

purposes (e.g., the elasticity of a representative MNE) and seek to relax this assumption.

2.5 Elasticities for Multinationals

Recall, in Section 2.2, we have walked through why looking at related-party imports is sufficient to draw inferences on multinationals' import responses under tariff shocks. We now have the baseline model in Section 2.3, Equation (2.5), and the final task is to construct a formal expression for σ_{MNE} and σ_{NMNE}, the elasticities of non/multinational-concentrated industries. First, we denote $\mathbf{\Delta q} \equiv \Delta \ln q_{ijt}$, $\boldsymbol{\Delta\tau} \equiv \Delta \ln (1+\tau_{ijt})$, $\alpha_r \equiv \%RelatedParty$. Then, under the identification assumptions on $\boldsymbol{\Delta\tau}, \alpha_r$ and $\boldsymbol{\xi}$ (discussed in Section 2.4), I obtain the stacked Conditional Expectation function (CEF):[7]

$$
\begin{aligned}
\mathbb{E}[\mathbf{\Delta q}|\boldsymbol{\Delta\tau}, \alpha_r] &= \mathbb{E}\left[\phi_B \boldsymbol{\Delta\tau} + \phi_{MNE} \boldsymbol{\Delta\tau} \cdot \boldsymbol{\alpha}_r + \mu_j + \zeta_{it} + \xi_{ijt} | \boldsymbol{\Delta\tau}, \alpha_r\right] && (2.7)\\
&= (\phi_B + \phi_{MNE} \cdot \boldsymbol{\alpha}_r)\boldsymbol{\Delta\tau} && (2.8)\\
&= \underbrace{\begin{pmatrix} 1 & 0 \\ 1 & \alpha_r \end{pmatrix}}_{\equiv \boldsymbol{\alpha}} \underbrace{\begin{pmatrix} \phi_B \\ \phi_{MNE} \end{pmatrix}}_{\equiv \boldsymbol{\phi}} \boldsymbol{\Delta\tau} \longleftarrow \text{stacked 2 eqns} && (2.9)\\
&\equiv \boldsymbol{\sigma}(\boldsymbol{\phi}; \boldsymbol{\alpha})\boldsymbol{\Delta\tau}, && (2.10)
\end{aligned}
$$

Therefore, by fixing $\alpha_r = \tilde{\alpha}_r^+ \in (0, 1]$, I can recover the trade elasticities by:

$$
\boldsymbol{\sigma}(\boldsymbol{\phi}, \alpha) = \begin{cases} \sigma_{NMNE} \equiv \phi_B + \phi_{MNE} \cdot 0 = \phi_B \\ \sigma_{MNE} \equiv \phi_B + \phi_{MNE} \cdot \tilde{\alpha}_r^+ \end{cases} \tag{2.11}
$$

where $\tilde{\alpha}_r^+$ is the median of *non-zero* share of related-party imports and $\boldsymbol{\phi}$ is identified via OLS.

Table 2 recaps the Empirical strategy. My research question asks how multinationals respond differently upon a short-run tariff shock, and empirically this puzzle coincides with estimating the trade elasticity of multinationals. To do the elasticity exercise, I look at the Trump tariff period and obtain the basic metrics of $\mathbf{\Delta q}, \boldsymbol{\Delta\tau}, \mathbf{\Delta p}$ from Amiti et al. (2019)

[7] See Appendix A.2 for full derivation.

data. Due to the lack of firm-level data (and the feasibility issue), I generally don't know the multinational concentration m and what shipment is done by which multinational firm. As a secondary option, I use Related Party Time Series data to calculate α_r and define multinationals by related-party imports. To obtain a median MNE's elasticity, I assume α_r to be a matched moment and fix it by its median value $\tilde{\alpha}_r^+$. Given $\boldsymbol{\alpha}$, I thus can estimate $\boldsymbol{\phi}$ and work out $\boldsymbol{\sigma}$, the import elasticities/short-run shock responses.

Table 2: Notations in Estimation Strategy

Notations	Concept	Known?
$\mathbf{\Delta q} \equiv \Delta \ln q_{ijt}$	12-month log changes of import quantities	✓
$\boldsymbol{\Delta\tau} \equiv \Delta \ln (1+\tau_{ijt})$	12-month log changes of tariffs	✓
$\mathbf{\Delta p} \equiv \Delta \ln p_{ijt}$	12-month log changes of before-duty import prices	✓
m	MNE concentration $m \in [0, \mathcal{M}]$	No, but $\cong \alpha_r$
α_r	Share of Related-party Imports $\alpha_r \in [0,1]$	✓
$\tilde{\alpha}_r^+$	Median of non-zero Share of Related-party Imports	0.299
ϕ_B	Standalone effect of tariff changes on import quantities	Est. by OLS
ϕ_{MNE}	Differential effect of tariff changes $\times\alpha_r$ on import quantities	Est. by OLS
Parameters of Interest		
σ_{NMNE}	Trade elasticities of Non-multinationals (calculated by $\boldsymbol{\sigma}(\boldsymbol{\phi};0)$)	ϕ_B
σ_{MNE}	Trade elasticities of Multinationals (calculated by $\boldsymbol{\sigma}(\boldsymbol{\phi};\tilde{\alpha}_r^+)$)	$\phi_B + \phi_{MNE} \cdot \tilde{\alpha}_r^+$

Note: This table summarizes the empirical strategy. I obtain $\mathbf{\Delta q}, \boldsymbol{\Delta\tau}, \mathbf{\Delta p}$ from Amiti et al. (2019). We generally don't know the multinational concentration m, and I use Related Party Time Series data to calculate α_r, which help estimate the trade elasticitity of multinationals. To obtain a median MNE's elasticity, I assume now α_r is exogeneously predetermined and fix a median value $\tilde{\alpha}_r^+$. See Appendix B.2 Table B2 for a case study of steel-specific ($\tilde{\alpha}_r^{+,steel} = 0.520$).

3 Estimation Results

3.1 Estimation Results

Table 3 presents the baseline estimation results of Equation (2.5). Column 1 and 2 examine the tariff pass-through by regressing the log-change of before-duty prices on log-change tariff changes. This is a replication of Amiti et al. (2019), and I find no significant impact of tariff changes on foreign exporter prices. This serves as supportive evidence of a complete pass-through of tariffs. The implication we can learn from this panel is that 1) almost all tariff burdens fall on U.S. domestic consumers/importers, and 2) we can be relatively confident claiming that, upon tariff shock, the changes in import quantities are induced by domestic importers.

The second panel is the main exercise for the elasticities of multinationals and non-multinationals. Column 3–4 follow Amiti et al. (2019) and estimate the reduced-form trade elasticity for multinationals. Column 5 is a reduced form extension by regressing log-changes in import quantities on an interaction term of the binary indicator for the higher share of related-party imports and log-changes in tariffs. As specified in the previous section, the standard errors are all clustered at the HS8 level, concerning that tariff variation for some commodities only happened at the HS8 aggregation.

For our main interest, we need to calculate the point estimates of σ_{MNE} and σ_{NMNE}. The elasticities from these four columns are recovered by using a median $\%RelatedParty \equiv \tilde{\alpha}_r^+ = 0.299$ for *non-zero* related-party imports share. The justification follows Definition 2.1 and 2.2 in Section 2.2: by looking at the median of non-zero related-party shares, I can proxy the trade elasticities of median/representative Multinationals and their short-run response to tariff shocks. The point estimates of the trade elasticities are computed by Equation (2.11) expressions and reported at the bottom of Table 3.[8] The preliminary results are cohesive to the realistic ranges (Ruhl, 2008) and show that the import demand of Multinationals is more elastic than non-multinationals.

[8] I use 'nlcom' command in Stata to compute the estimates of import elasticity of MNE and associated standard errors.

Table 3: Impact of the Trump tariffs, Related-party Trade (Partial)

	log–diff *Foreign Exporter Prices* $\Delta \ln p_{ijt}$		*log–diff* *Import Quantities* $\Delta \ln q_{ijt}$		
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln(1+\tau_{ijt})$	-0.012	-0.057	-1.802***	-0.854*	-1.551***
	(0.023)	(0.038)	(0.327)	(0.499)	(0.413)
$\Delta \ln(1+\tau_{ijt}) \times \%RelatedParty$		0.113		-2.422**	
		(0.069)		(0.965)	
$\Delta \ln(1+\tau_{ijt}) \times \mathbb{1}HighRelatedParty$					-0.404
					(0.428)
σ for Non-MNE			-1.802***	-0.854*	-1.551***
			(0.327)	(0.499)	(0.413)
σ for MNE			-1.802***	-1.578***	-1.955***
			(0.327)	(0.341)	(0.370)
Commodity FE	Yes	Yes	Yes	Yes	Yes
Country × Time FE	Yes	Yes	Yes	Yes	Yes
N	1,647,617	1,641,326	2,473,895	2,464,296	2,473,895
R^2	0.021	0.021	0.197	0.197	0.197

Source: Amiti et al. (2019) and Related Party Time Series Data, U.S Census Bureau.
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Column 1 and 2 examine the tariff pass-through, finding no impact on foreign exporter prices. Column 3–4 estimate the reduced-form trade elasticity for multinationals. Column 5 is an extension of using a binary indicator of high share of related-party imports. The elasticities of MNE in Column 3–5 are recovered by the median = 0.299 for all non-zero share of related-party imports, and their point estimates are reported. I employed the inverse of the hyperbolic sine transformation for Column 3–5, namely $\log[x + (x^2+1)^{0.5}]$, to estimate 0-valued changes as suggested in Amiti et al. (2019). Standard errors in parentheses are clustered at the HTS8 level, considering that tariff variations for some commodities only happened at the HTS8 aggregation.

3.2 Potential Mechanism

A higher trade elasticity tells us that multinationals are more responsive to price/tariff changes than non-multinationals. When a trade shock occurs and leads trade costs to increase, MNEs are observed to drop more quantity of imports than their counterparts. Though not directly tested with firm-level data, the more elastic import demand of MNEs may indicate the early stage of the profit-shifting process.

A multinational firm is naturally expected to have a better ability to shift its sourcing origins from its largest affiliate site to a secondary country. If a multinational firm believes the industry–country-specific tariff or even the entire Trade War will be on for a longer period, it may be more inclined to shift its imports to another affiliate in a low–tax country or simply consume the intermediate goods from domestic production (i.e., reshoring). A multinational firm may possess a better ability to shift its sourcing origins from the first-best affiliate site to a secondary option. The transition of Multinational firms' production and imports leads to a more significant drop in import demands than non–multinationals.

4 Future Directions

Future directions include but are not limited to pushing forward on the **policy implications**. We would want to know, among multinational firms, who or what clusters of them are reducing imports under a trade shock. Expecting that MNEs are more responsive to tariff changes, what do policymakers improve in terms of the efficiency/goal of tariff policy? We should be thinking more carefully about how MNEs can perform profit-shifting instead of reshoring their production. Also, it is worth adding more years of import data to see the shock responses of MNEs over a longer period.[9] This direction connects to Cox (2023) and allows more inferences in the persistence of a trade shock.

Investigating the MNE textbfsourcing dynamics is also a big unknown. So far, I restrict MNEs to have a strictly positive share of related-party imports and fix a $\tilde{\alpha}_r^+$ to compute the trade elasticity of a median MNE. I do not allow MNEs to endogeneously choose or evolve their α_r. It may be a whole new topic for trade uncertainty paper. One needs to think of it as a profit-maximizing firm and model their import decisions. We would love to look into how the uncertainty in trade policy affects MNEs' import diversions, intermediate goods imports, and production reshoring. On the other hand, I need to refine the intrafirm measurements and formalize the relationship between MNE concentration and the share of related-party imports. Jointly speaking, these connect to Ruhl (2015) and Ruhl (2008).

[9] I thank Kim Ruhl for providing a supplemental set of data that extends the Amiti data to the year 2023.

5 Summary and Concluding Remarks

This paper is a preliminary attempt of proxying and estimating the trade elasticity of multinationals. The motivation is to learn insights into how MNEs respond differently to short-run tariff shock, and I build on literature to estimate elasticity during the Trump tariff period. The main contribution is that I refine the short-run shock responses, namely elasticity, by related-party channel (σ_{MNE}) and arms-length channels (σ_{NMNE}). I propose a secondary definition of multinationals and use publicly available related-party trade data to help estimate their short-run shock responses.

Under the empirical assumptions on tariff changes and complete tariff pass-through, I estimated the elasticity of multinationals to be generally higher than that of non-multinationals, with a value of around -1.6 to -2. Since I look at 12–month changes in tariffs and quantities of imports, the derived elasticities imply that multinationals are more responsive to tariff changes (i.e., price/cost changes) than their counterparts in a very short-run period. I discuss the profit-shifting process of MNEs as one potential mechanism, which may explain why we observe a higher elasticity and a more significant drop in import quantities in the short run. Future works on policy implications, trade uncertainty, and intrafirm measurements will complete the discussions in this preliminary working report.

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Appendix A: Empirical Framework

A.1 Proof of Concept

To define MNE in the second-best setting, I have not yet shown but taken advantage of relating **share of related-party imports** to **MNE concentration** already. The idea here is that I want multinational concentration in data to be bounded by a constant $M \in \mathbb{R}^+$. So now the MNE concentration has a range in $\mathcal{M} = [0, M]$ and is an isomorphism to any close interval in $\mathbb{R}$. We can take the share of related-party imports (α_r), which has a support on the unit interval. Here is a walk–through of my Proof of Concept attempt in Section 2.2.

Assumption (Data)**.** By reordering the data, the MNE concentration $m \in \mathbb{R}_+$ has $\sup m = M$, $\mathbb{E}\,|\mathcal{M}| < \infty$ (finite), $\mathcal{M} \neq \emptyset$.

Proposition. The MNE concentration $m \in \mathcal{M} = [0, M]$ is order isomorphic to the share of related-party trade $\alpha_r \in \mathcal{A} = [0, 1]$. In other words, $\forall m_1, m_2 \in \mathcal{M}$, $m_1 \leq_{\mathcal{M}} m_2$ if and only if $\alpha_{r,1} \leq_{\mathcal{A}} \alpha_{r,2}$.

Proof. We need to show there exists an affine transformation from m onto α_r and check if the ordering is preserved. By **Assumption.(Data)** and Heine-Borel Theorem, $\mathcal{M} \subseteq \mathbb{R}$ is compact. So, any continuous function defined on $\mathcal{M}$ attains its min/max values. Let's consider the simplest affine transformation $\alpha_r = \varphi(m) = \frac{1}{M} m,\ m \in \mathcal{M} = [0, M]$. We note:

① The supp of α: $\frac{1}{M} m \in [0, 1]$ for all $m \in \mathcal{M} = [0, \mathcal{M}]$ and will attain its min/max (✓)

② Bijection: automatically true since $\varphi(\cdot)$ is linear (✓)

③ Ordering: Given $m_1 \leq_{\mathcal{M}} m_2, m_1, m_2 \in \mathcal{M}$. Since $\mathcal{M} \neq 0$ and $\frac{1}{\mathcal{M}} > 0$, we have $\alpha_{r,1} = \varphi(m_1) = \frac{1}{\mathcal{M}} m_1 \leq_{\mathcal{A}} \frac{1}{\mathcal{M}} m_2 = \varphi(m_2) = \alpha_{r,2}$ (✓)

We conclude that $\alpha_r = \varphi(m)$ is one affine transformation that preserves order-isomorphic property from m to α_r. □

Remark. It seems promising to use the share of related-party imports (α_r) to proxy MNE concentration and to help estimate the trade elasticity of Multinationals (σ_{MNE}).

A.2 Derivation for Elasticities of Non/Multinationals

Recall, I denote $\boldsymbol{\Delta}\mathbf{q} \equiv \Delta \ln q_{ijt}$, $\boldsymbol{\Delta\tau} \equiv \Delta \ln (1+\tau_{ijt})$, $\alpha_r \equiv \%RelatedParty$ and rewrite Equation (2.5) as:

$$\boldsymbol{\Delta}\mathbf{q} = \phi_B \boldsymbol{\Delta\tau} + \phi_{MNE} \boldsymbol{\Delta\tau} \cdot \boldsymbol{\alpha}_r + \mu_j + \zeta_{it} + \xi_{ijt} \tag{5.1}$$

Under our identification assumptions on $\boldsymbol{\Delta\tau}$, α_r and $\boldsymbol{\xi}$, we obtain the Conditional Expectation function (CEF):

$$\begin{aligned}
\mathbb{E}[\boldsymbol{\Delta}\mathbf{q}|\boldsymbol{\Delta\tau}, \alpha_r] &= \mathbb{E}\left[\phi_B \boldsymbol{\Delta\tau} + \phi_{MNE} \boldsymbol{\Delta\tau} \cdot \boldsymbol{\alpha}_r + \mu_j + \zeta_{it} + \xi_{ijt} | \boldsymbol{\Delta\tau}, \alpha_r\right] && (5.2)\\
&= \mathbb{E}\left[\phi_B \boldsymbol{\Delta\tau} + \phi_{MNE} \boldsymbol{\Delta\tau} \cdot \boldsymbol{\alpha}_r | \boldsymbol{\Delta\tau}, \alpha_r\right] + \underbrace{\mathbb{E}[\xi_{ijt}|\boldsymbol{\Delta\tau}, \alpha_r]}_{=0 \text{ by assump.}} && (5.3)\\
&= \mathbb{E}\left[(\phi_B + \phi_{MNE} \cdot \boldsymbol{\alpha}_r)\boldsymbol{\Delta\tau} | \boldsymbol{\Delta\tau}, \alpha_r\right] + 0 && (5.4)\\
&= \mathbb{E}\left[(\phi_B + \phi_{MNE} \cdot \boldsymbol{\alpha}_r)\boldsymbol{\Delta\tau} | \boldsymbol{\Delta\tau}, \alpha_r\right] && (5.5)\\
&= (\phi_B + \phi_{MNE} \cdot \boldsymbol{\alpha}_r)\boldsymbol{\Delta\tau} && (5.6)\\
&= \underbrace{\begin{pmatrix} 1 & 0 \\ 1 & \alpha_r \end{pmatrix}}_{\equiv \boldsymbol{\alpha}} \underbrace{\begin{pmatrix} \phi_B \\ \phi_{MNE} \end{pmatrix}}_{\equiv \boldsymbol{\phi}} \boldsymbol{\Delta\tau} \longleftarrow \text{stack 2 eqns with boundary conditions} && (5.7)\\
&\equiv \boldsymbol{\sigma}(\boldsymbol{\phi}; \boldsymbol{\alpha})\boldsymbol{\Delta\tau}, && (5.8)
\end{aligned}$$

where $\boldsymbol{\sigma}(\boldsymbol{\phi}; \boldsymbol{\alpha})$ is the derived trade elasticity function given $\boldsymbol{\phi}$ and $\boldsymbol{\alpha}$. Let's focus on $\alpha_r \in (0,1]$ (in particular, $\tilde{\alpha}_r^+$) and the CEF:

$$\mathbb{E}[\boldsymbol{\Delta}\mathbf{q}|\boldsymbol{\Delta\tau}, \boldsymbol{\alpha}] = \boldsymbol{\sigma}(\boldsymbol{\phi}; \boldsymbol{\alpha})\boldsymbol{\Delta\tau} \tag{5.9}$$

I can fix $\alpha_r = \tilde{\alpha}_r^+$ since α_r is assumed to be exogeneously given. In this case, I have 2 equations with 2 unknowns (ϕ's) with a positive definite matrix $\boldsymbol{\alpha}$ (invertible). This suggests that I can identify $\boldsymbol{\phi}$ simply via OLS. With $\boldsymbol{\alpha}$ and $\boldsymbol{\phi}$ both known, I can derive "σ_{MNE}", the elasticity of multinationals (related-party), and "σ_{NMNE}", the elasticity of non-multinationals (arms-length).

A.3 Full Table 1

Table A1: Summary Statistics, Related-party Trade (Full)

	mean	sd	min	p25	p75	max
Total Imports	81.70	906.41	0.00	0.03	7.60	78398.92
Related-party Imports	40.47	601.18	0.00	0.00	1.28	48329.58
Non related-party Imports	41.23	485.62	0.00	0.02	4.31	59038.40
$\mathbb{1}\{\text{Related-party Imports}\}_t$	0.61	0.49	0.00	0.00	1.00	1.00
% RelatedParty	0.25	0.33	0.00	0.00	0.45	1.00
Total Trade Balance	-44.68	875.44	-77986.20	-1.62	1.84	27524.11
Related-party Trade Balance	-27.50	552.13	-48329.58	-0.27	0.05	9460.98
Non related-party Trade Balance	-17.83	499.37	-58686.64	-0.59	1.98	22232.32
$\mathbb{1}\{\text{Related-party Trade Balance}\}_t$	0.42	0.49	0.00	0.00	1.00	1.00
			$Obs = 58988$			
Lagged status						
$\mathbb{1}\{\text{Related-party Imports}\}_{t-1}$	0.65	0.48	0.00	0.00	1.00	1.00
$\mathbb{1}\{\text{Related-party Trade Balance}\}_{t-1}$	0.44	0.50	0.00	0.00	1.00	1.00
			$Obs = 52956$			

Note: The data is obtained from the Related Party Time Series Data, with a sample period 2017-2018. Units in million.

I took out the Trade Balance panel in Section 2.1 since this paper assumes balanced trade. I aim to explore more on imbalanced trade and draw insights from international finance, including how Multinationals make their sourcing decisions, their trade uncertainty, and bond/capital portfolio in sourcing origins.

Appendix B: Estimation

B.1 Full Table 3

Table B1 includes the log–change of total import values (Column 6 and 7 and replicates the table style of Amiti et al. (2019) Table 1. Additionally, I incorporate Column 5 to showcase a binary grouping of "high related–party import share" versus "low related–party import share". The deterministic threshold of being high and low is given by the median of non–zero related-party import share ($\tilde{\alpha}_r^+$).

Table B1: Impact of the Trump tariffs, Related-party Trade (Full)

	log–diff *Foreign Exporter Prices*		*log–diff* *Import Quantities*			*log–diff* *Import Values*	
	$\Delta \ln p_{ijt}$		$\Delta \ln q_{ijt}$			$\Delta \ln (p_{ijt} \times q_{ijt})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta \ln(1 + \tau_{ijt})$	-0.012	-0.057	-1.802***	-0.854*	-1.551***	-1.597***	0.164
	(0.023)	(0.038)	(0.327)	(0.499)	(0.413)	(0.340)	(0.549)
$\Delta \ln(1 + \tau_{ijt}) \times \%RelatedParty$		0.113		-2.422**			-4.430***
		(0.069)		(0.965)			(1.146)
$\Delta \ln(1 + \tau_{ijt}) \times \mathbb{1}HighRelatedParty$					-0.404		
					(0.428)		
σ for Non-MNE			-1.802***	-0.854*	-1.551***		
			(0.327)	(0.499)	(0.413)		
σ for MNE			-1.802***	-1.578***	-1.955***		
			(0.327)	(0.341)	(0.370)		
Commodity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,647,617	1,641,326	2,473,895	2,464,296	2,473,895	2,473,895	2,464,296
R^2	0.021	0.021	0.197	0.197	0.197	0.206	0.206

Source: Amiti et al. (2019) and Related Party Time Series Data, U.S Census Bureau.

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Column 1 and 2 examine the tariff pass-through, finding no impact on foreign exporter prices. Column 3–4 estimate the reduced-form trade elasticity for multinationals. Column 5 is an extension of using a binary indicator of high share of related-party imports. Column 6–7 estimate the changes of import value and serve as reassurance of Column 3–4. The elasticities of MNE in Column 3–5 are recovered by the median = 0.299 for all non-zero share of related-party imports, and their point estimates are reported. I employed the inverse of the hyperbolic sine transformation for Column 3–6, namely $\log[x + (x^2 + 1)^{0.5}]$, to estimate 0-valued changes as suggested in Amiti et al. (2019). Standard errors in parentheses are clustered at the HTS8 level, respecting that tariff variations for some commodities only happened at the HTS8 aggregation.

B.2 Full Elasticity Estimation, with Steel Industry

Table B2 presents full sets of elasticity estimation, using reduced form specification in Amiti et al. (2019) and structural specification in Fajgelbaum et al. (2020). Additionally, I examine a particular industry of interest– steel manufacturing.

TABLE B2: RELATED-PARTY TRADE ELASTICITY, STEEL INDUSTRY

	log–diff Import Quantities							
	General: $\Delta \ln q_{ijt}$				*Steel Industry:* $\Delta \ln q_{ijt}^{steel}$			
	Reduced form		Structural		Reduced form		Structural	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \ln(1+\tau_{ijt})$	-1.802***	-0.854*			-2.509**	0.192		
	(0.327)	(0.499)			(1.100)	(1.694)		
$\Delta \ln(1+\tau_{ijt}) \times \%RelatedParty$		-2.422**				-6.368*		
		(0.965)				(3.518)		
$\Delta \ln(\tilde{p}_{ijt})$			-11.234***	-9.787***			-65.735**	-66.186**
			(2.038)	(2.884)			(28.809)	(29.077)
			[54.92]	[31.93]			[1.54]	[0.92]
$\Delta \ln(\tilde{p}_{ijt}) \times \%RelatedParty$				-2.501				-13.139
				(3.543)				(9.363)
				[38.44]				[40.57]
σ for Non-MNE	-1.802***	-0.854*	-11.234***	-9.787***	-2.509**	0.192	-65.735**	-66.186**
	(0.327)	(0.499)	(2.038)	(2.884)	(1.100)	(1.694)	(28.809)	(29.077)
σ for MNE	-1.802***	-1.578***	-11.234***	-10.535***	-2.509**	-3.119***	-65.735**	-73.018**
	(0.327)	(0.341)	(2.038)	(2.200)	(1.100)	(1.199)	(28.809)	(29.348)
Commodity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,473,895	2,464,296	2,473,895	2,464,296	73,295	73,295	73,295	73,295
R^2	0.197	0.197	0.197	0.197	0.231	0.231	0.231	0.231

Source: Amiti et al. (2019) and Related Party Time Series Data, U.S Census Bureau.
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. I define steel industry by a NAICS6 code of either {331110, 331210, 331221, 331121, 331513, 332111}. Column 1–2 and 5–6 follow Amiti et al. (2019) to estimate the reduced-form trade elasticity for multinationals. Column 3–4 and 7–8 follow Fajgelbaum et al. (2020) to estimate the structural trade elasticity for multinationals by regressing log–change of quantities on log-change of prices instrumented by tariff changes. The corresponding F statistics are reported in square brackets. The elasticities of MNE in Column 1–4 are recovered by the median = 0.299 for all non-zero share of *general* related-party imports. The elasticities of MNE in Column 5–8 are recovered by the median = 0.520 for all non-zero share of *steel* related-party imports. All the point estimates are reported. I again employed the inverse of the hyperbolic sine transformation for Column 1–8 to estimate 0-valued changes. Standard errors in parentheses are also clustered at the HTS8 level, respecting that tariff variations for some commodities only happened at the HTS8 aggregation.

I found that, in general, the import demand of the steel industry is more elastic than the aggregate import demand. Within the steel industry, the multinational's imports have been the main drivers of the entire industry-level elasticity and are estimated to be more elastic than their non–MNE counterparts. A recent study by Cox (2023) found that the short-run Bush tariff on the steel industry brings long-term effects to this industry. Here, my contribution is to extend the discussion by examining the same industry but during the more recent Trump tariff period. A similar mechanism discussed in Section 3.2 also applies to the steel industry: the multinationals' import demand for steel is significantly more responsive to tariff changes and may present a profit–shifting process. In addition, this may echo the sourcing model in Cox (2023) Section 6, leading to a long-run drop in steel imports.

Steel tariffs are the third wave of the Trump tariff.[10] I estimated the trade elasticities of both general imports and steel imports. In a reduced-form specification, my estimate of steel trade elasticities in Table B2 Column 5 is cohesive to the Cox (2023) results.[11] In addition, I calculated the trade elasticity of a median multinational steel importer to be -3.119, which is more elastic than the trade elasticity of the overall steel industry (-2.509).

The first two columns in Table B2 Panel 1 (*General*) are essentially the reduced form estimations in Table 3 and are presented for comparison purposes. Column 3–4 follow Fajgelbaum et al. (2020) to estimate the structural trade elasticity for multinationals using IV specification. One thing to note in Column 3–4 is that I instrument changes of foreign exporter prices by changes of tariffs for the first stage least square. Then, I regress the changes in import quantities on the instrumented price changes (i.e., projections of tariff changes) for the second stage. The corresponding first-stage F statistics are reported. By symmetry, Table B2 Panel 2 (*Steel Industry*) is estimated the same way as above, following a reduced form in Amiti et al. (2019) and a structural form in Fajgelbaum et al. (2020). As I discussed in Section 4, completing the case study of the steel industry is one of the future directions and will bridge to discussions in Cox (2023).

[10] Also see Appendix D: Waves of Tariffs and Fajgelbaum et al. (2020) Appendix A.2.2.

[11] Also see Cox (2023) Section 2.2 and Table 1.

Appendix C: A Short Note for Theoretical Framework

I did not include the Theoretical Framework in the paper draft since 1) it is still incomplete, and 2) the empirical estimation sections have pretty much delivered the insights of multinationals being more elastic/responsive to tariff changes. I still found it important to understand the structural contexts of trade elasticities to formally interpret the estimates. Amiti et al. (2019) showcased empirical estimations and delivered the elasticities and welfare stories, but they did not address much on theoretical parts. My working version of the theoretical framework for this related-party import elasticities mainly follows Fajgelbaum et al. (2020) and Costinot and Rodríguez-Clare (2014). Inspired by Engel and Wang (2011) using Cobb-Douglas and CES the "nondurable versus durable" in international finance contexts, I constructed a CES composite by "related-party versus arms-length" to reflect MNEs' intermediate imports. I also take into consideration multiple-sector production and intermediate goods setups in Costinot and Rodríguez-Clare (2014).

These choices follow intuition and the prevalence of CES in trade literature, and the fact that I *should be able* to get a clean expression for import price mark-ups based on elasticities.[12] Note that assuming this class of utility implicitly implies I assume a gravity structure in bilateral trades. Relaxing the gravity structure is beyond the scope of this paper but can be one of the future directions. This paper also implicitly assumes a *balanced* trade status. One future direction is to relax in this setting and think about how multinationals choose their import demand in intermediate goods markets and bond/capital markets. This links to International Finance/Macro literature and may be more suitable for discussions in a whole new paper.

[12] Specifically, also see Fajgelbaum et al. (2020) Online Appendix C and Costinot and Rodríguez-Clare (2014) Section 3.3.

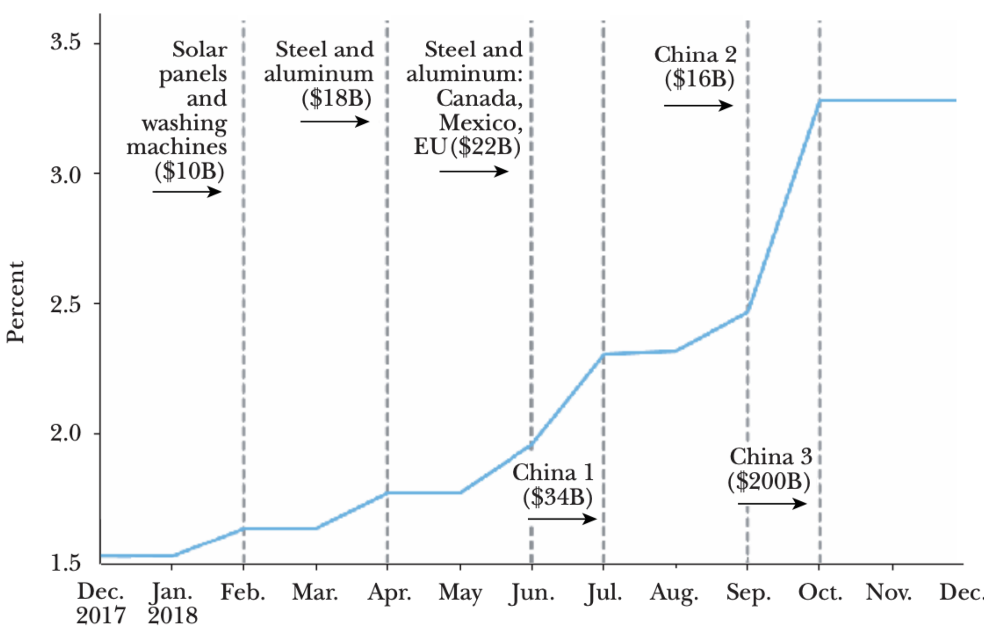
Appendix D: Waves of the Trump Tariffs

D.1 Waves

According to documentations in Amiti et al. (2019) and Fajgelbaum et al. (2020), we can roughly classify the Trump Administration Tariffs by 6 waves:[13] ① Solar Panels & Washer import tariffs ② Steel & Aluminum import tariffs (without Canada, Mexico, and the EU) ③ Steel & Aluminum import tariffs (general) ④ the China import tariffs, wave 1 ⑤ the China import tariffs, wave 2 ⑥ the China import tariffs, wave 3. Below I provide the original Amiti et al. (2019) Figure 3: **Average Tariff Rates** for reference and my replications in D.2:

Figure 1: Original Amiti et al. (2019) Figure 3

Figure 3
Average Tariff Rates



Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Tariffs on the ten-digit Harmonized Tariff Schedule (HTS10) product code by country, weighted by 2017 annual import value. Dashed vertical lines indicate the implementation of each of the six major waves of new tariffs during 2018; tariffs implemented after the fifteenth of the month counted for the subsequent month. Three tranches of tariffs were imposed on China, designated by 1, 2, and 3.

[13] Also see Amiti et al. (2019) Figure 3 (above) and my Figure 3: Replication of 6-wave Figure.

D.2 Replication of Figures

Figure 2 replicates Amiti et al. (2019) Figure 3: **Average Tariff Rates**, and Figure 3 replicates Amiti et al. (2019) Figure 4: **Twelve-Month Proportional Change in Import Prices by Tariff Wave**. We should read the y–axis of Figure 2 as "Average rate of the U.S. tariff," and I apologize for any confusion due to this careless coding mistake.

Figure 2: Replication of Figure 3 in Amiti et al. (2019)

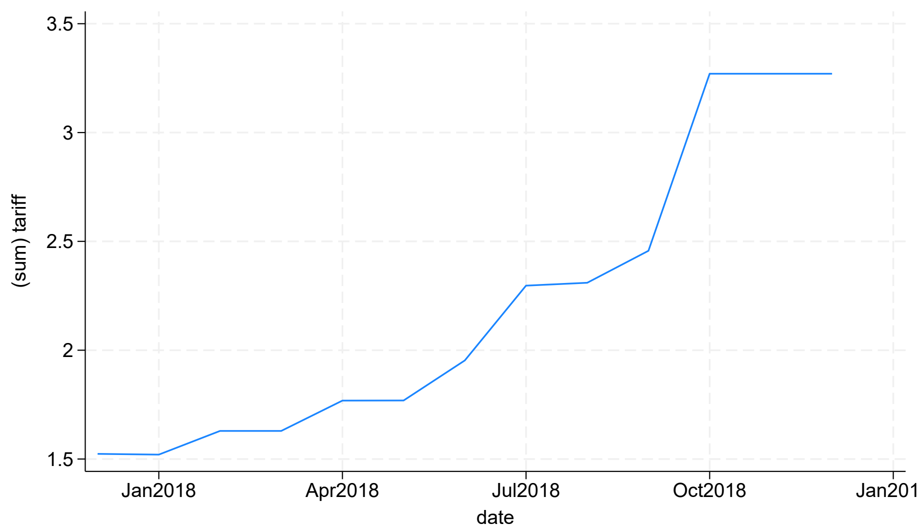


Figure 3: Replication of Figure 4 in Amiti et al. (2019)