The US-China Trade War and Global Value Chains

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Motivation

The US-China Trade War: The most significant trade war since the 1930s (Smoot-Hawley)

- Chinese goods: $\$550$ billion announced
- US goods: $\$185$ billion announced

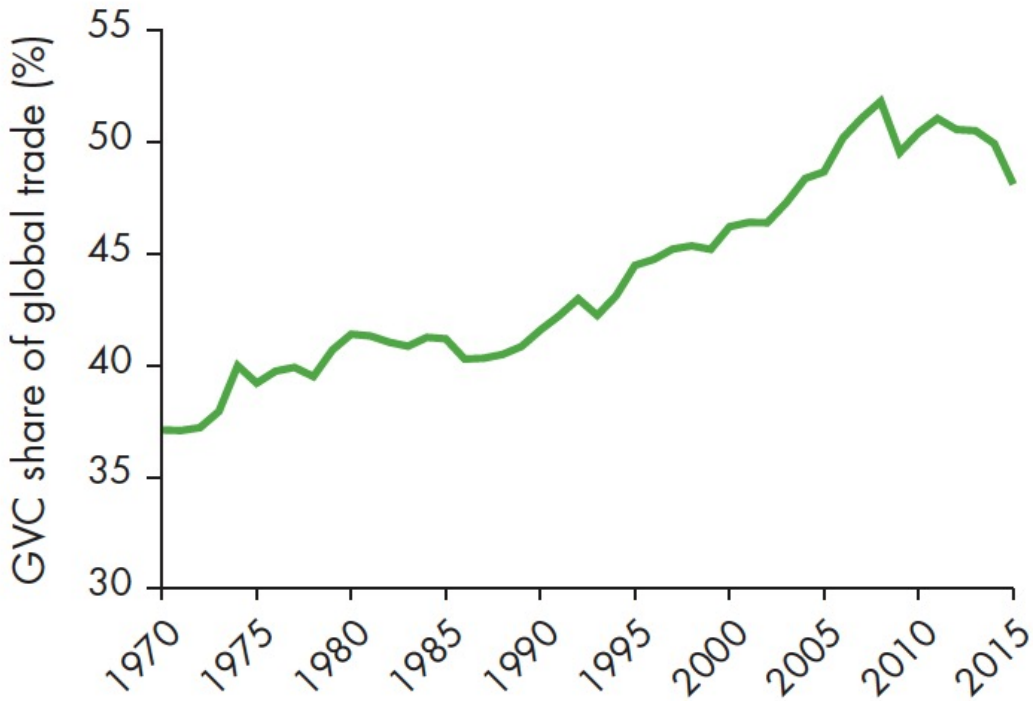
Jan 2018 - Jan 2020 (phase one deal):

- US tariffs on Chinese goods $3.1\% \rightarrow 19.3\%$
- China's tariffs on US goods $8.0\% \rightarrow 20.3\%$
- **Round 1 Jul-Aug 2018**:
  US implements 25% tariffs on $\$50$ billion Chinese exports
  China implements 25% tariffs on $\$50$ billion US exports
  most intermediate goods
- **Round 2 Jun 2019**:
  US implements $10\% - 25\%$ tariffs on $\$200$ billion Chinese exports
  China implements 5%-25% tariffs on $\$60$ billion US exports
  intermediate + consumption goods

Tariff Change

Motivation

The US-China Trade War occurs in the context of growing Global Value Chains



Source: World Development Report 2020

Other evidences:Hummels et al. (2001),Yi(2003),Borin and Mancini (2019),Johnson and Noguera (2012),Flaaen et al. (2020)

Questions and Findings

Research Question: What is the impact of the trade war on different industries and countries in the presence of global value chains?

Findings:

- US CPI increases by 0.03% in Round 1, increases by 0.06% in Round 2
- Both Rounds of Trade War:
  - reduce US downstream employment,while increase US upstream employment
  - especially hit the US industries that heavily rely on targeted Chinses intermediate goods.

Welfare Effects:

- 2017 as base year, in terms of real income, the trade war
  - Round 1 costs China $\$12.2$ billion, costs US $\$7.5$ billion
  - Round 2 costs China $\$35.2$ billion, costs US $\$15.6$ billion

Contribution

This paper

- Builds a two-stage, multi-industry, multi-country general equilibrium model to study the impacts of the trade war taking into account the reshaping of GVCs

Contributions

- build a multi-country general equilibrium model with the reshaping of GVCs, and rebated tariff revenues
- add a dimension of comparative advantage at stage level by estimating the share of each industry that is in the upstream and downstream stages

Related Literature

- **the US-China trade war**

  Handley and Kamal (2020), Bown et al.(2020), Amiti et al. (2019),Fajgelbaum et al. (2020)

- **Global Value Chains**

  Antràs and De Gortari (2020), Caliendo and Parro (2015), Yi (2003),Johnson and Noguera (2012),Borin and Mancini (2019)

Model

Preference: country $i \in \mathcal{J}$, industry $s \in \mathcal{S}$, variety $z \in [0,1]$

$$\max_{C_{is}} U_i = \prod_{s=1}^{S} {C_{is}}^{b_s}$$

$$C_{is} = \left[\int_0^1 c_{is}(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}}$$

s.t

$$\sum_{s=1}^{S} \int_0^1 p_{is}(z) c_{is}(z) dz = w_i \bar{L}_i + TR_i$$

where TR_i is tariff revenue collected by government in i

Model

Technology: Each final product z in industry s is produced through 2 stages

stage1 occurs in country i:

$$y_{is}^1(z) = \frac{1}{a_{is}^1(z)} L_{is}^1(z)^{\gamma_{is}} I_{is}^1(z)^{1-\gamma_{is}}$$

stage2 occurs in country i:

$$y_{is}^2(z) = \left[\frac{1}{a_{is}^2(z)} L_{is}^2(z)^{\gamma_{is}} I_{is}^2(z)^{1-\gamma_{is}} \right]^{\alpha_s} [x_{is}(z)]^{1-\alpha_s}$$

where

$$I_{is}^n(z) = \prod_{s'=1}^{S} M_{is's}^n(z)^{b_{s's}} \qquad \forall n \in \{1,2\}$$

$$M_{is's}^n(z) = \left[\int_0^1 m_{is's}^n(z'z)^{\frac{\sigma-1}{\sigma}} dz' \right]^{\frac{\sigma}{\sigma-1}}$$

Model

Two Types of Intermediate Goods

- $x_{is}(z)$:
  - $x_{is}(z)$ is stage-1 product used in stage-2
  - market clearing condition for stage-1 product:

$$\sum_{j\in\mathcal{J}} y^1_{js}(z) = \sum_{i\in\mathcal{J}} x_{is}(z)$$

  - $x_{is}(z)$ connects two production stages within the same industry

- $m^n_{is's}(z'z)$:
  - $m^n_{is's}(z'z)$ is stage-2 product used in both stages
  - market clearing condition for stage-2 product:

$$\sum_{j\in\mathcal{J}} y^2_{js}(z) = \sum_{i\in\mathcal{J}} \left[c_i(z) + \sum_{n\in\{1,2\}} \sum_{s'\in\mathcal{S}} \int_0^1 m^n_{iss'}(zz')dz' \right]$$

  - $m^n_{is's}(z'z)$ is embedded in composite intermediate good $I^n_{is}(z)$
  - $m^n_{is's}(z'z)$ connects across different industries

Model

Products from both stages are tradable with trade cost

$$\tau_{jis}^{n} = d_{jis}^{n}\left(1 + t_{jis}^{n}\right)$$

where iceberg transportation cost $d_{jis}^{n} \geq 1$ and ad valorem tariff $t_{jis}^{n} \in [0, 1]$

Tariff Revenue of Government in Country i

$$TR_i = TR_i^c + \sum_{s \in \mathcal{S}} TR_{is}^m + \sum_{s \in \mathcal{S}} TR_{is}^x$$

- TR_i^c: generated when country i imports $c_{is}(z)$.
- TR_{is}^m: generated when industry s in country i imports $m_{is's}^{n}(z'z)$.
- TR_{is}^x: generated when industry s in country i imports $x_{is}(z)$.

Productivity and Sourcing Strategy

- **The 2-stage production structure generates production paths**

  J countries, J^2 production paths

- **Assume the productivity of a production path follows a Frechet distribution**

  omit z for notation simplicity

$$\Pr\left[\left(a_{is}^{1}\right)^{1-\alpha_s}\left(a_{js}^{2}\right)^{\alpha_s} \geq a\right] = \exp\{-a^{\theta}\left(T_{is}^{1}\right)^{1-\alpha_s}\left(T_{js}^{2}\right)^{\alpha_s}\}$$

- **Sourcing Strategy**

  Products from each stage are imported from the place offering the lowest price

- **Pricing**

  Price of a final good serving each country is determined by its production path

Analytical Solution to the Model

$\forall$ country $i, j, k \in \mathcal{J}$

Let l_{js} be a production path to serve country j for final products in industry s

Under l_{js}, the production locations of stage1 and stage2 are country i and country k

- **Analytical Solution to $\pi_{l_{js}}$**

  $\pi_{l_{js}}$: country j's expenditure share of on final products produced under l_{js}

$$\pi_{l_{js}} = \frac{\left[T_{is}^1 \times \left(v_{is}^1 \tau_{iks}^1\right)^{-\theta}\right]^{1-\alpha_s} \times {T_{ks}^2}^{\alpha_s} \left({v_{ks}^2}^{\alpha_s} \tau_{kjs}^2\right)^{-\theta}}{\Theta_{js}}$$

  where

$$v_{is}^n = \gamma_{is}^{-\gamma_{is}} (1-\gamma_{is})^{\gamma_{is}-1} w_i^{\gamma_{is}} {P_{is}^n}^{1-\gamma_{is}}$$

  P_{is}^n: price index of I_{is}^n

  $\pi_{l_{js}}$ decreases in the tariffs along the path

- **Model Mechanism**

  tariff shock $\rightarrow$ change in $\pi_{l_{js}}$ $\rightarrow$ labor fixed within country but mobile across industries $\rightarrow$ change in industry-level and aggregate endogenous variables

Parameters

Table: Parameters and Exogenous Variables

Parameter	**Definition**	**Specific by**
T_{js}^{n}	productivity	country,industry,stage
γ_{js}	equipped labor share	country,industry
α_{s}	share of stage2 production in final output	industry
b_{s}	industry expenditure share of consumption (U)	industry
$b_{ss'}$	industry expenditure share of intermediate (I)	industry
θ	heterogeneity within industry	none
σ	elasticity of substitution among same-industry varieties	none
Exogenous Variable		
$\bar{L}_{i}$	population	country
d_{ijs}^{n}	iceberg transportation cost	country,industry,stage
t_{ijs}^{n}	ad valorem tariff	country,industry,stage

Calibration

Economy

- countries: CHN, USA, ROW
- industries: 18 industries more

Data Source

tariff data:

- UNCTAD: Trade Analysis Information System (TRAINS)
- the Office of the United States Trade Representative
- Ministry of Finance of the People's Republic of China

other data:

- OECD: Inter-Country Input-Output (ICIO) Table ICIO Tabel
- US Census Bureau: US International Trade in Goods and Services Reports

Calibration T_{js}^{n} (country j, industry s, stage n)

productivity T calibrated to trade flows

- T_{js}^{n} targets US imports share $\frac{Imports_{j,us,s}^{n}}{\sum_{j \in \mathcal{J}} Imports_{j,us,s}^{n}}$

  $Imports_{j,us,s}^{n}$: US imports in stage-n products of industry s from country j

- $Imports_{j,us,s}^{n}$ derived from trade flows of 1046 4-digit HS commodities
- In each industry s, **which commodities belong to stage1, which belong to stage2?**

Calibration T_{js}^{n} (country j, industry s, stage n)

Determine the upstream and downstream products in each of the 18 industries

- Use US Input-Output Matrices (451 products) to measure each product's weighted average distance from final use. (Antràs et al., 2012)

  For example: one-country, one-sector economy, $\$100$ output:

  - If $\$100$ used as final consumption

    upstreamness $= 1 \times \frac{100}{100} = 1$
  - If $\$50$ used as final consumption, $\$50$ used as intermediate inputs

    $\$0.5$ intermediates needed to produce $\$1$ output [unit requirements]

    upstreamness $= 1 \times \frac{50}{100} + 2 \times \frac{\frac{1}{2}50}{100} + 3 \times \frac{\frac{1}{2}^{2}50}{100} \ldots = 2$
- choose a cut-off such that each of the 18 industries has both upstream and downstream products
- cut-off: 1.9

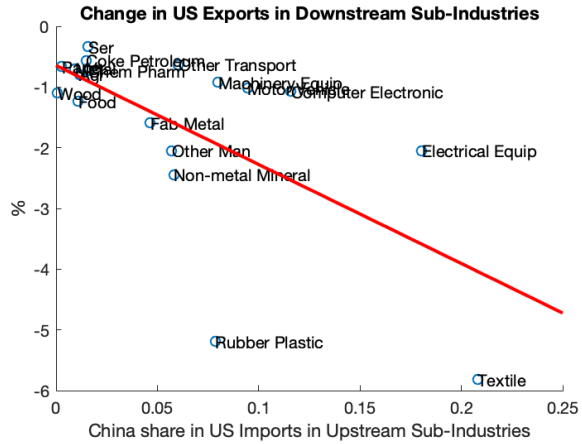
  products with upstreamness $\geq$ 1.9: upstream

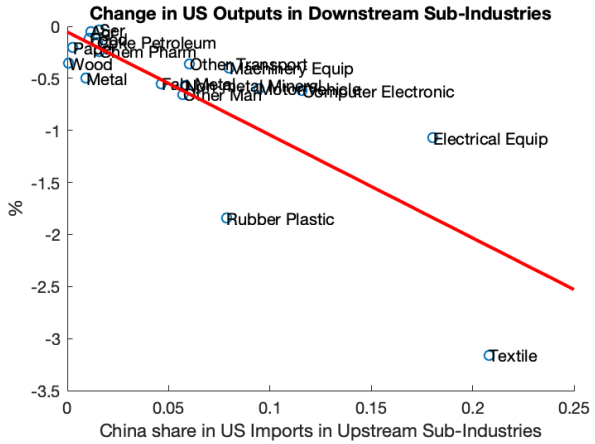
  products with upstreamness $<$ 1.9: downstream

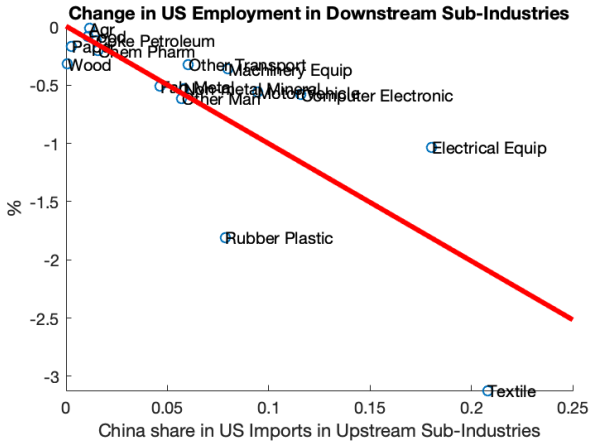
Counterfactual Analysis: Impacts through x_{is}

Increase tariff on upstream products in all 18 industries by six times

Check US domestic downstream sub-industries in all 18 industries

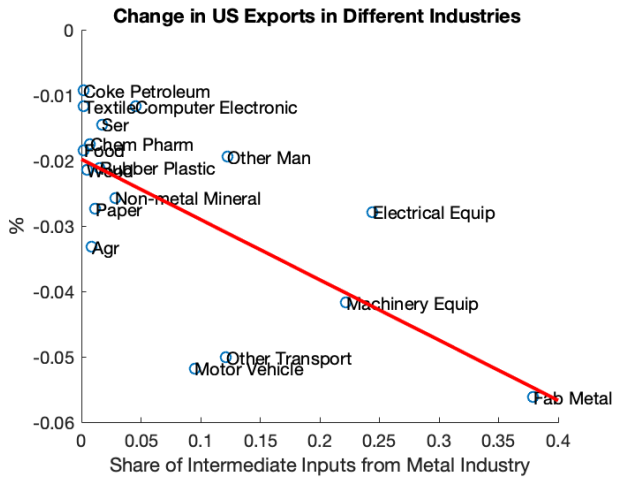


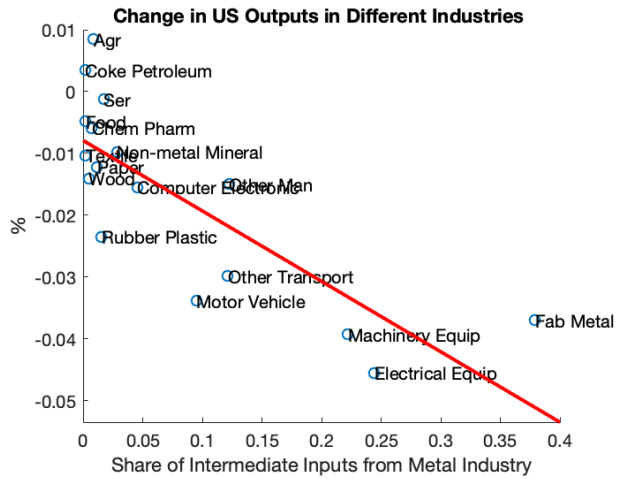


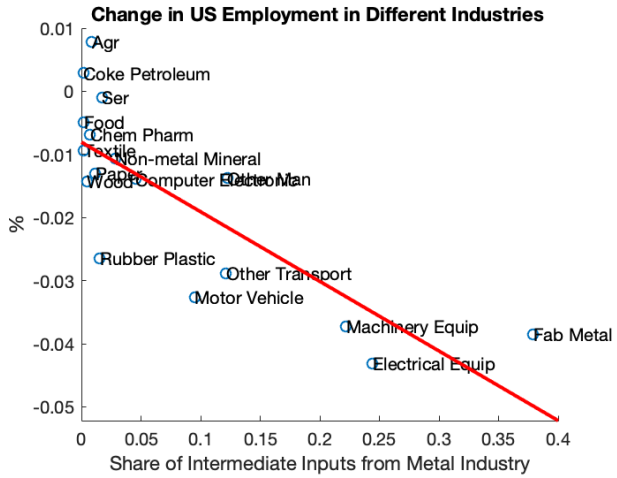


Counterfactual Analysis: Impacts through $m_{is's}^{n}$

Increase tariff on metal by six times, check other industries



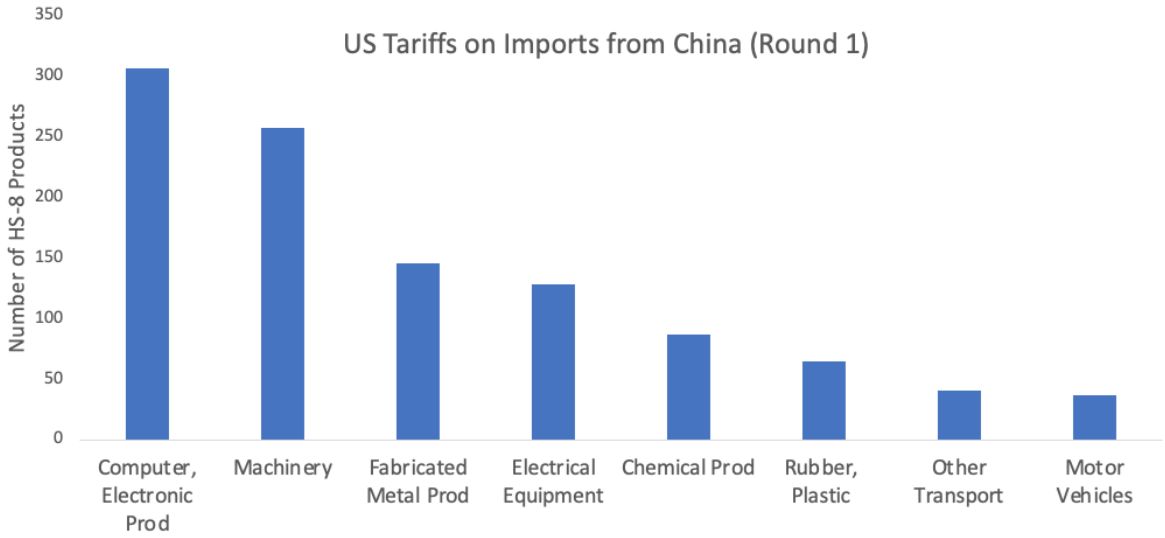


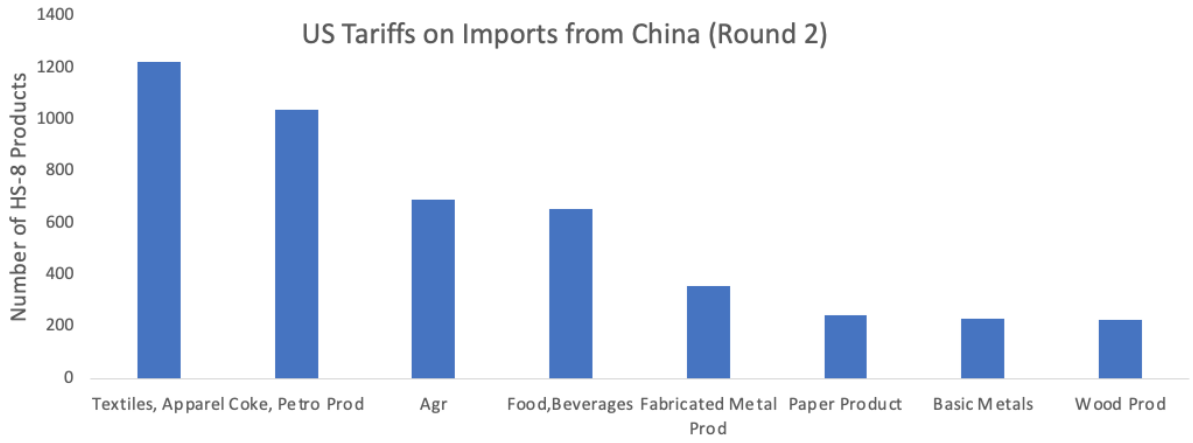


Two Rounds of Trade War

$\%change$	Round 1	Round 2
US price index	0.03%	0.06%
CN price index	1.25%	2.40%
US upstream employment	0.13%	0.27%
CN upstream employment	0.04%	0.03%
US downstream employment	-1.00%	-2.08%
CN downstream employment	-0.87%	-0.65%

Two Rounds of Trade War





source: the Office of the United States Trade Representative

Two Rounds of Trade War

Table: Round 1 % Change in Output

Top Hit		Top Benefit	
Automotive	-2.81%	Electrical Machinery	4.32%
Agriculture	-0.65%	Machinery	0.58%

Table: Round 2 % Change in Output

Top Hit		Top Benefit	
Chemical	-1.31%	Textile	0.98%
Agriculture	-0.32%	Rubber and Plastic	0.05%

Results: Welfare Effect

Real income in country i

$$\frac{w_i L_i + Tr_i}{P_i}$$

Choose 2017 as the base year, in terms of real income

- 1^{st} round trade war
  - costs China $\$12.2$ billion
  - costs US $\$7.5$ billion
- 2^{nd} round trade war
  - costs China $\$35.2$ billion
  - costs US $\$15.6$ billion

Sensitivity Test (tariff+iceberg v.s. pure iceberg)

Table: % Change in Real Income

	2-stage model(tariff+iceberg)	2-stage model(iceberg only)
CHN	-0.23	-3.2
USA	-0.09	-1.3
ROW	0.01	0.01

Sensitivity Test (2-stage model v.s. 1-stage model)

Table: % Change in Real Income

	2-stage	1-stage ($\alpha = 1$ recalibrate γ)
CHN	-0.23	-0.09
USA	-0.09	-0.02
ROW	0.01	0.002

Tariff Change in the Trade War

source: Chad Bown, PIIE

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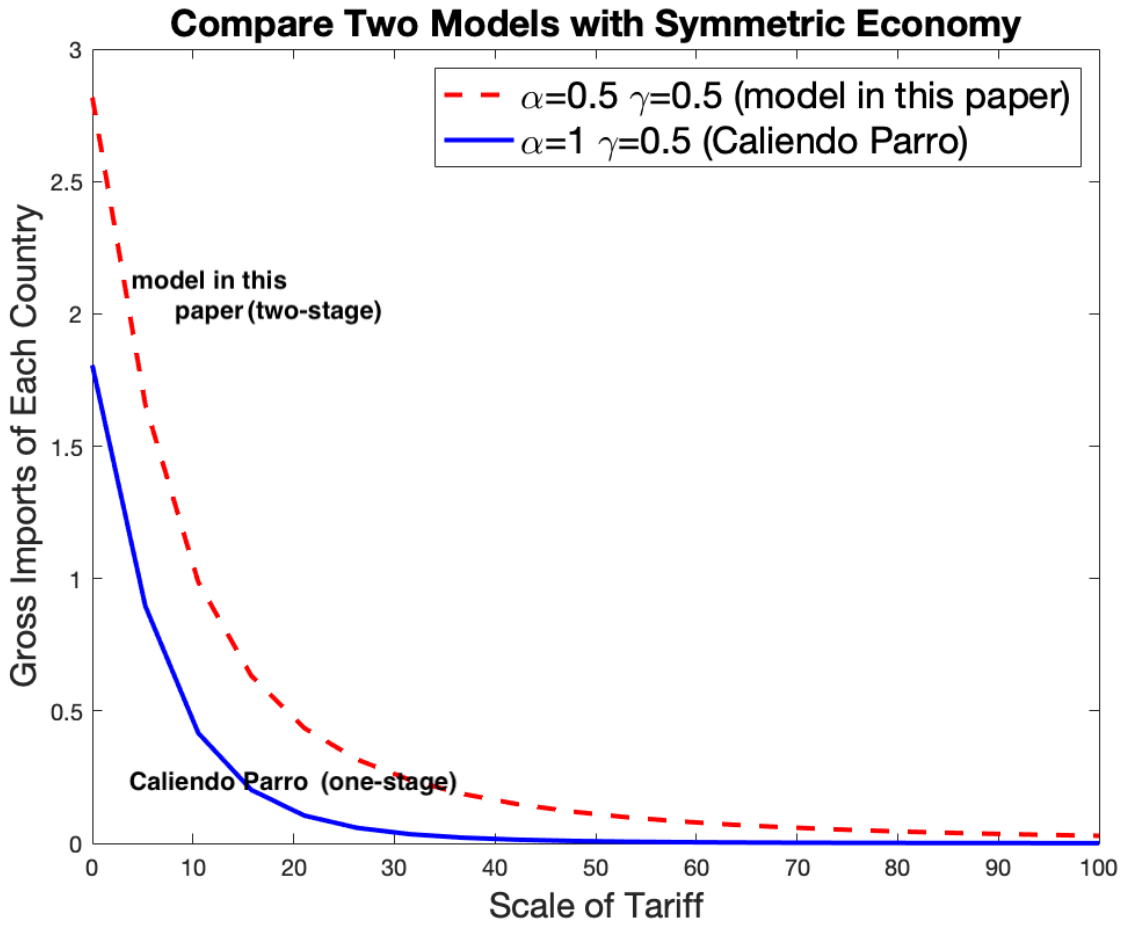
Model Comparison



Assumption:

$$Pr[(a_i^1)^{(1-\alpha)}(a_j^2)^{\alpha} \geq a] = exp\{-a^{\theta}(T_i)^{(1-\alpha)}(T_j)^{\alpha}\} \tag{1}$$

Analytical solution: Let $l_j^{*1} = i,\ l_j^{*2} = k$

$$\pi_{l_j^*} = \frac{(T_i(v_i\tau_{ik})^{-\theta})^{1-\alpha} \times T_k^{\alpha}({v_k}^{\alpha}\tau_{kj})^{-\theta}}{\Theta_j} \tag{2}$$

where

$$v_i = \gamma_i^{-\gamma_i}(1-\gamma_i)^{\gamma_i - 1} w_i^{\gamma_i} P_i^{1-\gamma_i} \tag{3}$$

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ICIO Table for Calibration

	Country_i,Sector_s	Country_i,Sector_s'	Country_j,Sector_s	Country_j,Sector_s'	Country_i	Country_j	Gross_Output
Country_i,Sector_s	X_iiss	X_iiss'	X_ijss	X_ijss'	F_iis	F_ijs	Y_is
Country_i,Sector_s'	X_iis's	X_iis's'	X_ijs's	X_ijs's'	F_iis'	F_ijs'	Y_is'
Country_j,Sector_s	X_jiss	X_jiss'	X_jjss	X_jjss'	F_jis	F_jjs	Y_js
Country_j,Sector_s'	X_jis's	X_jis's'	X_jjs's	X_jjs's'	F_jis'	F_jjs'	Y_js'
Tax_Revenue	TR_is	TR_is'	TR_js	TR_js'	TR^f_i	TR^f_j	
Value_Added	VA_is	VA_is'	VA_js	VA_js'			
Gross_Output	Y_is	Y_is'	Y_js	Y_js'			

Source: OECD

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The Eighteen Industries

Code	Industry
D01T09	Agriculture, forestry, fishing, mining
D10T12	Food products, beverages and tobacco
D13T15	Textiles, wearing apparel, leather and related products
D16	Wood and products of wood and cork
D17T18	Paper products and printing
D19	Coke and refined petroleum products
D20T21	Chemicals and pharmaceutical products
D22	Rubber and plastic products
D23	Other non-metallic mineral products
D24	Basic metals
D25	Fabricated metal products
D26	Computer, electronic and optical products
D27	Electrical equipment
D28	Machinery and equipment
D29	Motor vehicles, trailers and semi-trailers
D30	Other transport equipment
D31T33	Other manufacturing; repair and installation of machinery and equipment
D35T98	Service

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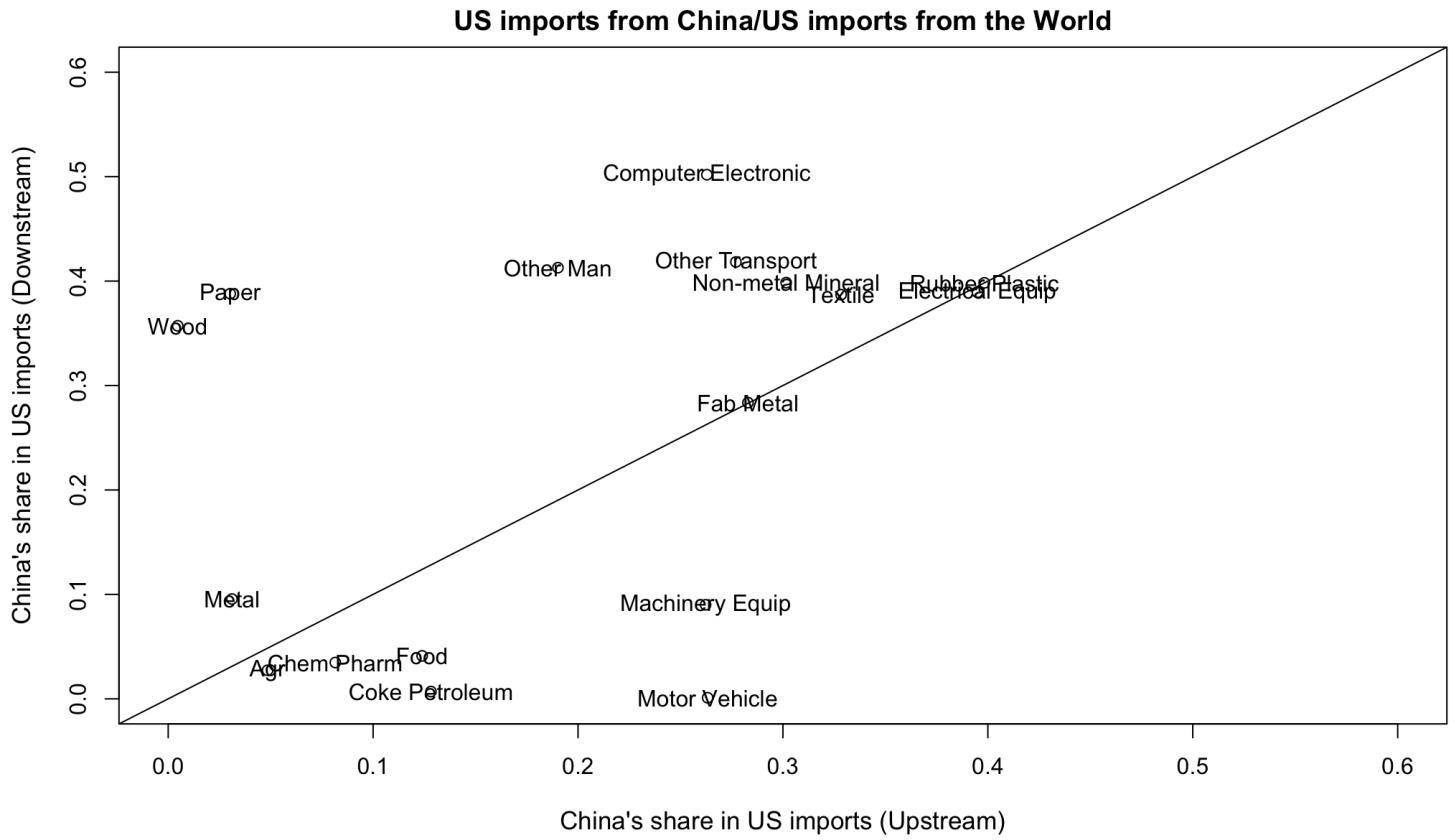
My Paper

- calibrate T using US Census Bureau trade data
- set T as stage-specific
- parameterization is supported by evidence from data



Data Source: US Census Bureau back

		CHN	USA	ROW	
	α	γ	γ	γ	b
Agriculture	0.24	0.96	0.99	0.99	0.037
D10T12	0.44	0.46	0.32	0.42	0.054
D13T15	0.72	0.31	0.39	0.46	0.015
D16	0.01	0.98	0.91	0.61	0.001
D17T18	0.01	0.68	0.80	0.55	0.003
D19	0.01	0.39	0.46	0.29	0.012
D20T21	0.13	0.46	0.87	0.58	0.020
D22	0.01	0.55	0.77	0.56	0.003
D23	0.28	0.53	0.78	0.61	0.002
D24	0.01	0.53	0.45	0.42	0.001
D25	0.47	0.34	0.61	0.62	0.006
D26	0.79	0.23	0.83	0.42	0.019
D27	0.83	0.23	0.48	0.38	0.011
D28	0.84	0.26	0.40	0.40	0.026
D29	0.95	0.18	0.24	0.26	0.031
D30	0.96	0.27	0.39	0.33	0.011
D31T33	0.77	0.38	0.56	0.49	0.014
Service	0.99	0.49	0.61	0.56	0.734

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	CHN		USA		ROW	
	$stage\ 1$	$stage\ 2$	$stage\ 1$	$stage\ 2$	$stage\ 1$	$stage\ 2$
	T	T	T	T	T	T
Agriculture	0.60	1.11	50	50	0.02	0.12
D10T12	1.50	12.00	50	50	0.65	9.88
D13T15	6.00	25.00	50	50	7.89	10.21
D16	0.83	6.00	50	50	0.20	0.48
D17T18	0.85	3.50	50	50	0.22	0.08
D19	8.00	0.01	50	50	0.33	0.42
D20T21	1.80	4.60	50	50	0.22	0.25
D22	9.00	9.00	50	50	0.40	0.40
D23	2.81	5.12	50	50	0.20	1.10
D24	5.00	5.00	50	50	1.50	1.50
D25	0.82	10.00	50	50	0.03	0.61
D26	0.007	4.50	50	50	0.05	1.00
D27	0.10	28.00	50	50	0.02	3.00
D28	0.002	5.00	50	50	0.02	3.00
D29	6.00	0.15	50	50	5.00	3.00
D30	$1E-5$	3.5	50	50	$1E-5$	0.33
D31T33	0.008	8.20	50	50	0.015	2.00
Service	1.40	1.40	50	50	0.006	0.006

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References

Amiti, M., S. J. Redding, and D. E. Weinstein (2019). The impact of the 2018 tariffs on prices and welfare. *Journal of Economic Perspectives 33*(4), 187–210.

Antràs, P., D. Chor, T. Fally, and R. Hillberry (2012). Measuring the upstreamness of production and trade flows. *American Economic Review 102*(3), 412–16.

Antràs, P. and A. De Gortari (2020). On the geography of global value chains. *Econometrica 88*(4), 1553–1598.

Borin, A. and M. Mancini (2019). Measuring what matters in global value chains and value-added trade. *World Bank policy research working paper* (8804).

Caliendo, L. and F. Parro (2015). Estimates of the trade and welfare effects of nafta. *The Review of Economic Studies 82*(1), 1–44.

Fajgelbaum, P. D., P. K. Goldberg, P. J. Kennedy, and A. K. Khandelwal (2020). The return to protectionism. *The Quarterly Journal of Economics 135*(1), 1–55.

Flaaen, A., A. Hortaçsu, and F. Tintelnot (2020). The production relocation and price effects of us trade policy: the case of washing machines. *American Economic Review 110*(7), 2103–27.

Hummels, D., J. Ishii, and K.-M. Yi (2001). The nature and growth of vertical specialization in world trade. *Journal of international Economics 54*(1), 75–96.

Johnson, R. C. and G. Noguera (2012). Accounting for intermediates: Production sharing and trade in value added. *Journal of international Economics 86*(2), 224–236.

Yi, K.-M. (2003). Can vertical specialization explain the growth of world trade? *Journal of Political Economy 111*(1), 52–102.