

On the Distributional Effects of International Tariffs

Daniel Carroll (FRB Cleveland)

Sewon Hur (FRB Cleveland)

International Trade Dynamics Workshop

June 12, 2020

The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

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- ▶ Effect on prices: Carroll and Hur (2020)
 - ▶ **poor** most sensitive to tradable consumption prices
- ▶ In this paper, we study the consequences of tariffs across the **skill**, income, and **wealth** distribution

Overview

- ▶ Introduce a Ricardian trade model with
 - ▶ non-homothetic preferences
 - ▶ uninsurable income risk with borrowing constraints
 - ▶ skilled and unskilled labor
 - ▶ distortionary taxes
- ▶ Study the distributional effects of tariffs
 - ▶ with/without retaliation
 - ▶ under various ways of redistributing tariff revenue
 - ▶ with/without mobility across sectors

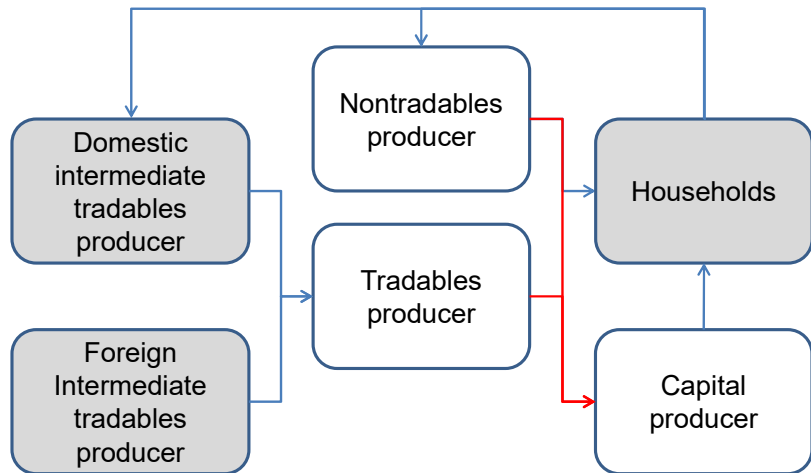
Model

Model

- ▶ Two countries indexed by $i = 1, 2$
- ▶ Households
 - ▶ consume, work, and save
 - ▶ 2 types: unskilled and skilled
 - ▶ face uninsurable labor income risk
- ▶ Production and Trade
 - ▶ tradables/nontradables used for consumption/investment
 - ▶ $\omega \in [0, 1]$ continuum of tradable intermediate goods
- ▶ Government taxes to finance exogenous expenditures
- ▶ Capital-skill complementarity \Rightarrow trade increases skill premium

A brief overview the model

- We begin with the production of nontradables and capital



Non-tradables producer

- ▶ A representative firm produces non-tradable output Y_{iN}
- ▶ It solves the static profit maximization problem

$$\begin{aligned} \max_{H_{iN}, L_{iN}, K_{iN}} \quad & P_{iN} Y_{iN} - w_{iH} H_{iN} - w_{iL} L_{iN} - r_i K_{iN} \\ \text{s.t.} \quad & Y_{iN} = F(H_{iN}, L_{iN}, K_{iN}). \end{aligned}$$

Capital producer

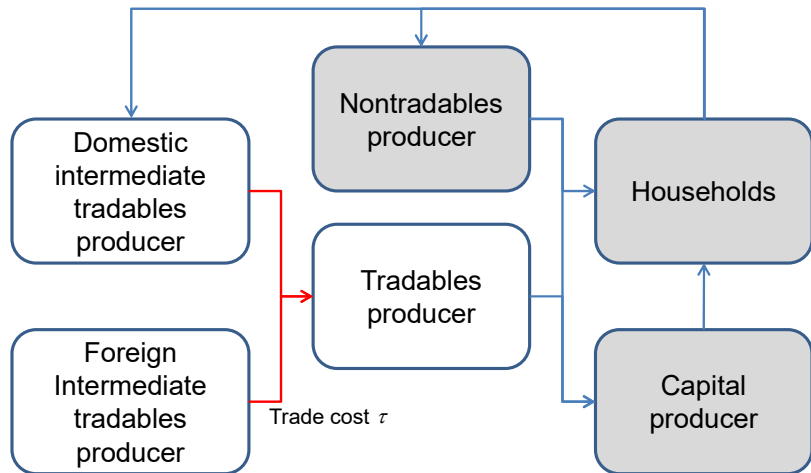
- ▶ A representative firm produces capital X_i , by solving

$$\begin{aligned} \max_{l_{iT}, l_{iN}} \quad & P_{iX} X_i - P_{iT} l_{iT} - l_{iN} \\ \text{s.t.} \quad & X_i = z_{iX} l_{iT}^{\kappa} l_{iN}^{1-\kappa}. \end{aligned}$$

- ▶ The capital price is given by $P_{iX} = \frac{1}{z_{iX}} \left(\frac{P_{iT}}{\kappa} \right)^{\kappa} \left(\frac{P_{iN}}{1-\kappa} \right)^{1-\kappa}$

Outline of model

- Let's discuss the production of tradable goods



Final tradables producer

- ▶ A representative final tradables producer bundles the varieties of tradables $\{q_{oi}(\omega)\}_{\omega,o}$ into a final good, Y_{iT} , and solves

$$\begin{aligned} \max_{\{q_{oi}(\omega)\}_{\omega}} \quad & P_{iT} Y_{iT} - \int_0^1 \sum_{o=1,2} [\tau_{oi} p_o(\omega) q_{oi}(\omega)] d\omega \\ \text{s.t. } Y_{iT} = \quad & \left\{ \int_0^1 \left[\sum_{o=1,2} q_{oi}(\omega) \right]^\rho d\omega \right\}^{\frac{1}{\rho}}. \end{aligned}$$

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- ▶ Solution: $q_{oi}(\omega) \leq \left(\frac{\tau_{oi} p_o(\omega)}{P_{iT}} \right)^{-\theta} Y_{iT}$, $=$ if $q_{oi}(\omega) > 0$.
- ▶ Price: $P_{iT} = \left[\int_0^1 \min_o \{ \tau_{oi} p_o(\omega) \}^{1-\theta} d\omega \right]^{\frac{1}{1-\theta}}$ where $\theta = \frac{1}{1-\rho}$ is the elasticity of substitution across varieties.

Intermediate tradables producer

- ▶ Each intermediate firm produces a single tradable variety, ω
- ▶ Taking as given the price $p_i(\omega)$, it solves

$$\begin{aligned} \max_{h_i(\omega), l_i(\omega), k_i(\omega)} & p_i(\omega) y_i(\omega) - w_{iH} h_i(\omega) - w_{iL} l_i(\omega) - r_i k_i(\omega) \\ \text{s.t. } & y_i(\omega) = z_i(\omega) F(h_i(\omega), l_i(\omega), k_i(\omega)) \end{aligned}$$

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- ▶ Zero-profit price:

$$p_i(\omega) = \frac{P_{iN}}{z_i(\omega)}$$

- ▶ Assumption of perfect mobility and common production function simplifies this expression

Productivity distributions in tradables production

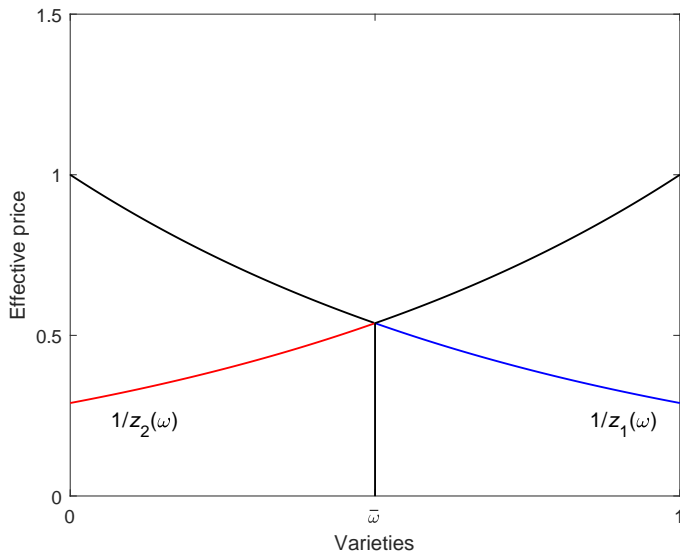
- ▶ Productivities for variety ω are distributed according to

$$z_1(\omega) = e^{\eta\omega}$$

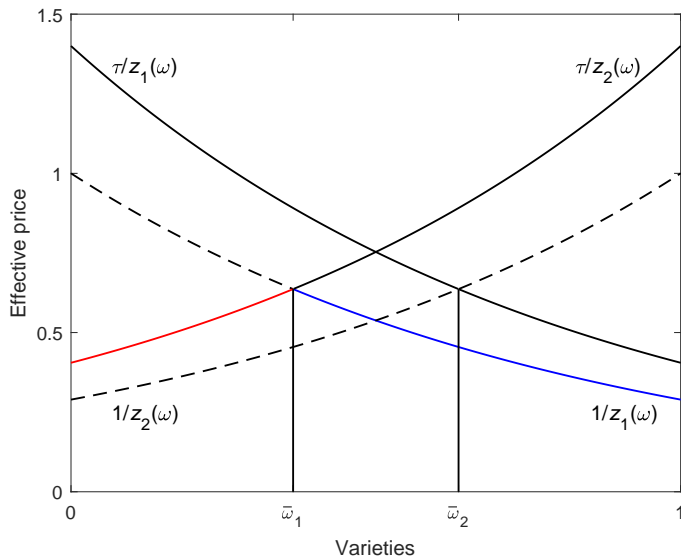
$$z_2(\omega) = e^{\eta(1-\omega)}$$

- ▶ Country $i = 1$ is more productive at producing high ω

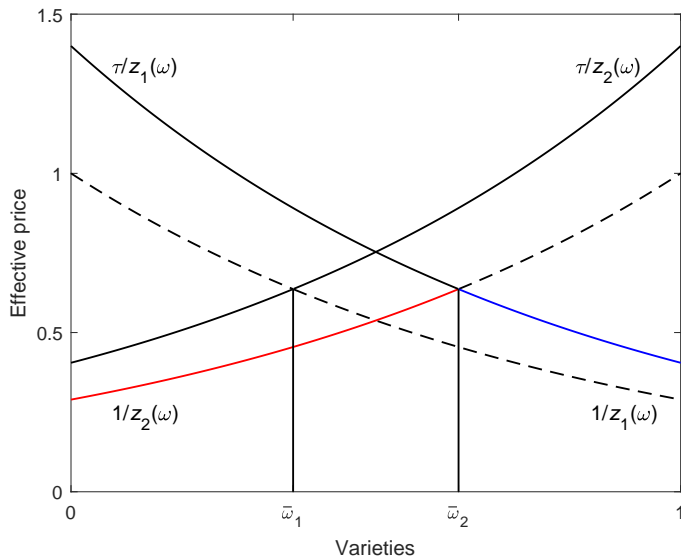
Pattern of production (free trade with symmetry)



Pattern of production (costly trade with symmetry)

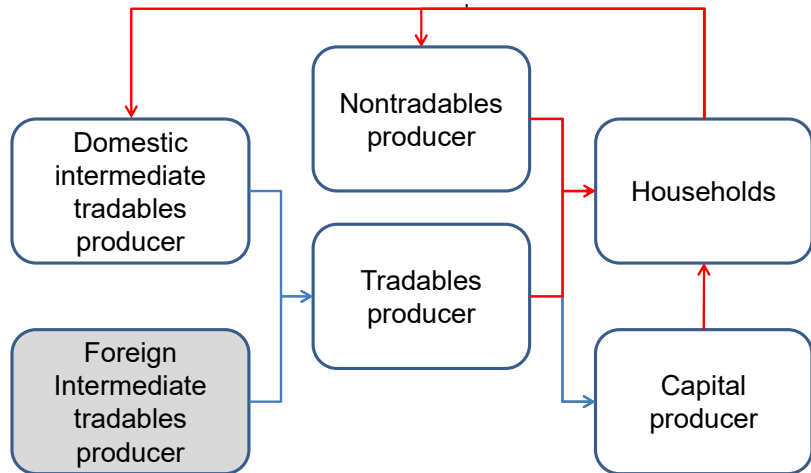


Pattern of production (costly trade with symmetry)



Outline of model

- ▶ Next, we discuss the household problem



Households

- ▶ Household with skill type j , wealth k , productivity ε solves

$$V_{ij}(k, \varepsilon) = \max_{c_T, c_N, \ell, k'} u(c_T, c_N, \ell) + \beta E_{\varepsilon'|\varepsilon} V_{ij}(k', \varepsilon')$$
$$\text{s.t. } P_{iT} c_T + P_{iN} c_N + P_{iX} (k' - k) \leq \tilde{w}_{ij} \ell \varepsilon + \tilde{r}_i P_{iX} k + T_i,$$
$$k' \geq 0$$

$$\text{where } u(c_T, c_N, \ell) = \frac{\left(c_T^\gamma (c_N + \bar{c})^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} - \psi \frac{\ell^{1+\nu}}{1+\nu}$$

- ▶ \tilde{w}_{ijt} and \tilde{r}_{ijt} are after-tax returns:

$$\tilde{w}_{ij} = (1 - \tau_{il}) w_{ij}$$
$$\tilde{r}_i = (1 - \tau_{ik}) \left(\frac{r_i}{P_{iX}} - \delta \right).$$

Government

- ▶ The government finances a constant stream of (wasteful) expenditures, G_i , by collecting
 - ▶ taxes on labor income, τ_{il}
 - ▶ taxes on capital income, τ_{ik}
 - ▶ tariffs, τ_{iP}
 - ▶ lumpsum tax/transfer, T_i

Equilibrium

A *steady-state recursive equilibrium*, given fiscal policies

$\{\tau_{il}, \tau_{ik}, \tau_{iP}, G_i, T_i\}_{i=1,2}$, is for $i = 1, 2$,

- ▶ Functions $\{V_{ij}, g_{ijT}, g_{ijN}, g_{ij\ell}, g_{ijk}\}_{j=H,L}$,
- ▶ Nontradable producer plans $\{Y_{iN}, H_{iN}, L_{iN}, K_{iN}\}$,
- ▶ Final tradable producer plans $\{Y_{iT}, \{q_{oi}(\omega)\}_{\omega \in [0,1], o=1,2}\}$,
- ▶ Intermediate producer plans $\{y_i(\omega), h_i(\omega), l_i(\omega), k_i(\omega)\}_{\omega}$,
- ▶ Capital producer plans $\{X_i, l_{iT}, l_{iN}\}$,
- ▶ Prices $\{w_{iH}, w_{iL}, r_i, P_{iT}, P_{iX}, \{p_i(\omega)\}_{\omega}\}$, and
- ▶ Invariant distributions $\{\mu_{ij}^*\}_j$ such that:

1. Given prices, households optimize.
2. Given prices, firms optimize.
3. Goods markets clear.
4. Factor markets clear.
5. Balanced trade.
6. Gov't budget holds: for $o \neq i$,

$$G_i + T_i = \tau_{il} \sum_j w_{ij} \int \varepsilon g_{ijl}(k, \varepsilon) d\mu_{ij}(k, \varepsilon) \\ + \tau_{ik}(r_i - \delta P_{iX}) \sum_j \int k d\mu_{ij}(k, \varepsilon) + \tau_{iP} \int q_{oi}(\omega) d\omega.$$

7. For any $(\mathcal{K}, \mathcal{E}) \in \mathcal{B}$, the invariant distribution μ_{ij}^* satisfies

$$\mu_{ij}^*(\mathcal{K}, \mathcal{E}) = \int_S \sum_{\varepsilon' \in \mathcal{E}} 1_{\{g_{ijk}(k, \varepsilon) \in \mathcal{K}\}} \Gamma(\varepsilon', \varepsilon) d\mu_{ij}^*(k, \varepsilon).$$

Characterization of equilibrium (under symmetry)

- ▶ The tradable price is given by $P_T = \frac{1}{\tilde{z}(\tau)}$,
where $\tilde{z}(\tau)$ is a measure of aggregate productivity:

$$\tilde{z}(\tau) = \left[\int_0^{1-\bar{\omega}(\tau)} \left(\frac{z_2(\omega)}{\tau} \right)^{\theta-1} d\omega + \int_{1-\bar{\omega}(\tau)}^1 z_1(\omega)^{\theta-1} d\omega \right]^{\frac{1}{\theta-1}}$$

- ▶ Trade costs distort ...

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- ▶ Trade costs distort the **extensive** ...

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- ▶ Trade costs distort the extensive and **intensive** margins

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- ▶ The capital price is given by $P_X = \frac{1}{z_X} \left(\frac{P_T}{\kappa} \right)^\kappa \left(\frac{1}{1-\kappa} \right)^{1-\kappa}$
- ▶ Comparative statics:

$$\frac{d \log(P_T)}{d\tau} = -\frac{d \log(\tilde{z}(\tau))}{d\tau} > 0$$
$$\frac{d \log(P_X)}{d\tau} = -\kappa \frac{d \log(\tilde{z}(\tau))}{d\tau} > 0$$

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- ▶ The capital price is given by $P_X = \frac{1}{z_X} \left(\frac{P_T}{\kappa} \right)^\kappa \left(\frac{1}{1-\kappa} \right)^{1-\kappa}$
- ▶ Comparative statics
- ▶ Asymmetry complicates analysis with real exchange rate movements, so we now turn to quantitative analysis

Quantitative Analysis

Quantitative Analysis

- ▶ Calibrate model to match features of U.S. economy
 - ▶ US vs. ROW (China + OECD – US)
 - ▶ ROW is 2 times larger than US
- ▶ Experiments
 1. raise US tariffs by 5 percent
 - ▶ with and without retaliation
 - ▶ with and without redistribution
 2. repeat same exercise without mobility across sectors

Calibration

► Preferences:

Parameters	Values	Targets / Source
Discount factor β	0.97	Wealth-to-GDP: 4.8 (2014)
Risk aversion σ	2	Standard value
Tradable share γ	0.26	Tradable exp. share: 35% (2004–14)
Non-homotheticity \bar{c} ,	0.11	Tradable exp. share of wealthiest quarter: 31 percent (2004–14) Carroll and Hur (2010)
Disutility from labor ψ	440	Average hours: 33 percent
Frisch elasticity $1/\nu$	0.5	Standard value

Calibration

- ▶ Assume $\tau_P = 0$ (less than 2% of gov't revenue in 2014)
- ▶ Other parameters:

Parameters	Values	Targets / Source
Elas. of subs. between tradable intermediates, θ	6.54	Trade elasticity: 4
Factor elasticity, κ	0.56	Tradable input shares in capital
Productivity distribution, η	1.29	Emp. share of top 17 percent of large mfg. est.: 32 percent
Iceberg cost, $\tau - 1$	0.09	Import share: 17 percent
Income tax, $\tau_\ell = \tau_k$	0.20	Gov't consumption: 15% of GDP
Depreciation, δ	0.05	Standard value

Calibration

- Production function with capital-skill complementarity

$$F(L, H, K) = \left[(1 - \mu) L^{\zeta} + \mu[(1 - \alpha) H^{\chi} + \alpha K^{\chi}]^{\frac{\zeta}{\chi}} \right]^{\frac{1}{\zeta}}$$

Parameters	Values	Targets / Source
Skilled fraction, \bar{H}_1	0.33	Skilled labor force: 33 percent
Capital weight, α	0.85	Capital income share: 36%
Skilled weight, μ	0.51	Skilled wage premium: 81%
Elasticity of substitutions,		
unskilled-capital, $1/(1 - \zeta)$	1.67	Krusell et al. (2000)
skilled-capital, $1/(1 - \chi)$	0.67	Krusell et al. (2000)

Productivity shocks

- ▶ ε follows a finite-state Markov process which approximates the continuous process,

$$\log \varepsilon_t = \rho_\varepsilon \log \varepsilon_{t-1} + \nu_t, \nu_t \sim N(0, \sigma_\nu^2)$$

- ▶ Estimate using PSID
 - ▶ $\rho_\varepsilon = 0.935$ and $\sigma_\nu = 0.195$ (skilled)
 - ▶ $\rho_\varepsilon = 0.938$ and $\sigma_\nu = 0.182$ (unskilled)

Solution algorithm

1. Given prices, solve for optimal household decisions
2. Using household decision rules and shock processes, compute the invariant distribution across productivity and wealth
3. Using market clearing and firm optimality conditions, update prices

Solution algorithm

1. Given prices, solve for optimal household decisions
 2. Using household decision rules and shock processes, compute the invariant distribution across productivity and wealth
 3. Using market clearing and firm optimality conditions, update prices
- Additionally, solving for the transition path involves solving for the entire path of prices and aggregates, including budget-neutral tax rates and/or transfers

Experiment: Trade war

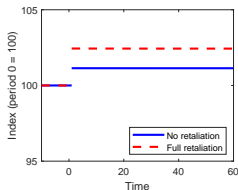
Main results

- ▶ Increase US tariffs by 5 percent
 - ▶ full retaliation by ROW
 - ▶ no retaliation
- ▶ First, we show the case with no redistribution
 - ▶ higher tradable/investment prices
 - ▶ capital shallowing
 - ▶ larger fall in skilled wage

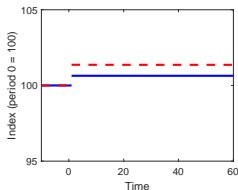
Effect of tariffs on prices (no redistribution)

- ▶ Tradables price and investment price increase

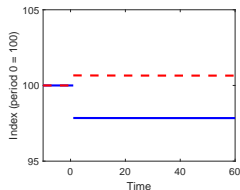
(a) Tradables price



(b) Investment price



(c) Real exch. rate

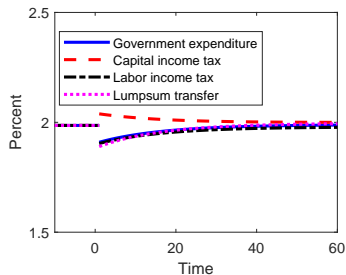


- ▶ Tradables/Investment prices rise less without retaliation, due to improvement in terms of trade
- ▶ We now focus on the full retaliation case

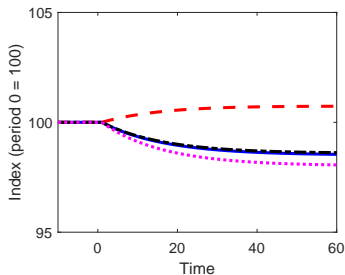
Effect of tariffs on aggregates (full retaliation)

- Capital declines, except with capital income tax case

(a) After-tax net return



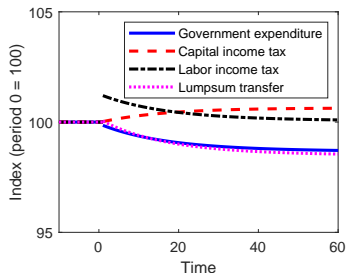
(b) Capital



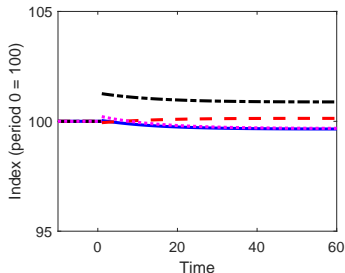
Effect of tariffs on wages (full retaliation)

- Skilled wages fall by more, without tax reductions

(a) Skilled wage



(b) Unskilled wage

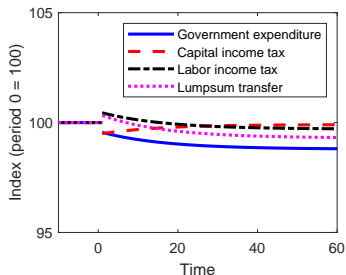


- Skilled wages rise when capital income taxes are reduced
- Unskilled wages rise when labor income taxes are reduced

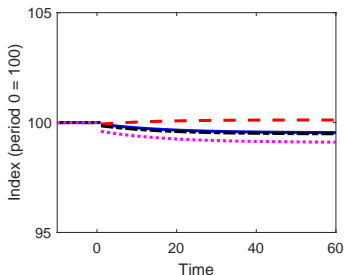
Effect of tariffs on aggregates (full retaliation)

- ▶ Output permanently lower, except with capital income tax reform

(a) Consumption



(b) GDP



- ▶ Aggregate outcomes are not indicative of welfare, which we now turn to

Welfare

- ▶ Welfare depends on how tariff revenue is redistributed
- ▶ Without redistribution
 - ▶ tariffs harm everyone
 - ▶ but skilled more than unskilled and poor more than rich

Welfare

- ▶ Welfare depends on how tariff revenue is redistributed
- ▶ Without redistribution
 - ▶ tariffs harm everyone
 - ▶ but skilled more than unskilled and poor more than rich
- ▶ With redistribution
 - ▶ labor income tax reduction delivers higher average welfare than capital income tax reduction, but also lower GDP
 - ▶ small average welfare increase from lump-sum redistribution, at the expense of the skilled

Welfare Calculation

- ▶ For each household, we compute consumption equivalence, Δ
- ▶ How much would initial steady state consumption have to be permanently increased for a household to be indifferent to the decline in trade costs?
- ▶ Solve for Δ such that $V_{ij\Delta}(k, \varepsilon) = V_{ij,t=1}(k, \varepsilon)$

$$V_{ij\Delta}(k, \varepsilon) = u\left((1 + \Delta) g_{ijT}^{ss}(k, \varepsilon), (1 + \Delta) g_{ijN}^{ss}(k, \varepsilon), g_{ij\ell}^{ss}(k, \varepsilon)\right) \\ + \beta E_{\varepsilon'|\varepsilon} V_{ij\Delta}(g_{ijk}^{ss}(k, \varepsilon), \varepsilon')$$

- ▶ If $\Delta > 0$, then the household supports trade. If $\Delta < 0$, then it does not

Welfare effects of Tariffs

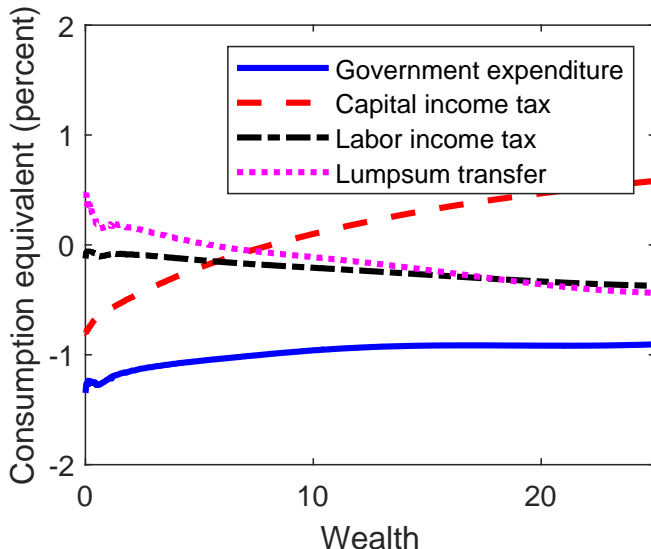
	Avg. welfare	% with welfare gain
<i>Full retaliation</i>		
no redistribution	-1.1	0
lumpsum transfer	0.1	67
labor income tax	-0.1	27
capital income tax	-0.3	21
<i>No retaliation</i>		
no redistribution	-0.5	0
lumpsum transfer	0.9	99
labor income tax	0.6	100
capital income tax	0.4	71

Units: percent

Welfare by wealth (full retaliation)

By skill

No retaliation



Key takeaways

- ▶ Poor and skilled households lose the most from tariffs
- ▶ Welfare of trade war
 - ▶ crucially depends on how tariff revenue is redistributed
 - ▶ reducing income taxes or increasing lumpsum transfers can generate some winners
 - ▶ but tariffs (with full retaliation) reduce average welfare (excluding lumpsum redistribution)

Key takeaways

- ▶ Poor and skilled households lose the most from tariffs
- ▶ Welfare of trade war
 - ▶ crucially depends on how tariff revenue is redistributed
 - ▶ reducing income taxes or increasing lumpsum transfers can generate some winners
 - ▶ but tariffs (with full retaliation) reduce average welfare (excluding lumpsum redistribution)
- ▶ Sectoral mobility matters
 - ▶ no mobility \Rightarrow wages respond more than prices

Next steps

- ▶ Limited mobility across sectors No mobility
- ▶ Tariffs and the COVID-19 pandemic both hurt poor households. How costly are tariffs during the pandemic?

Appendix

Data

- ▶ How do tradable expenditures vary with income/wealth?
- ▶ We use two complementary datasets:
 - ▶ Consumer Expenditure Survey (CEX, 2004–14)
 - + detailed expenditure categories
 - + self-reported owner-equivalent rent
 - can't compute net worth: only liquid wealth
 - ▶ Panel Survey of Income Dynamics (PSID, 2004–14)
 - more aggregated expenditure categories
 - have to impute owner-equivalent rent
 - + detailed measures of wealth

Tradable expenditure shares (CEX)

- ▶ Total expenditures: 500+ expenditure categories
 - ▶ exclude mortgage interest, property taxes, home insurance
 - ▶ include self-reported owner's equivalent rent
- ▶ Tradable expenditures: 307 items
 - ▶ if imports or exports exceed 11 percent of production Examples
- ▶ 23,090 working-age household-year observations

Tradable expenditure shares (PSID)

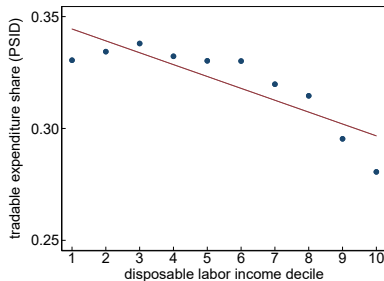
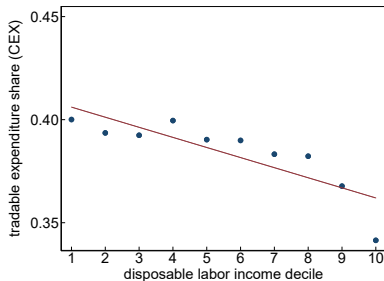
Exp. category	Tradable	Nontradable
Child care & education		✓
Clothing	✓	
Food	food at home	away from home
Health care	prescriptions	all other
Housing w/o repairs	furnishings	utilities, rent*
Transportation	gasoline, purchase and	all other
w/o repairs	lease of cars and trucks	
Vacation/ent.	21 percent	all other
Repairs	21 percent	all other

- ▶ * : excludes mortgage, property taxes, and home insurance, but includes owner-equivalent rent, imputed by dividing state-level price-to-rent ratios from value of primary residence
- ▶ 30,228 working-age household-year observations

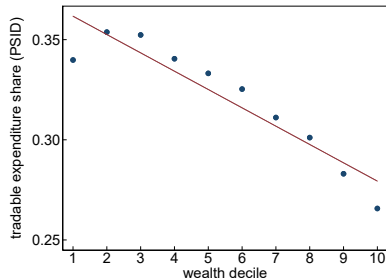
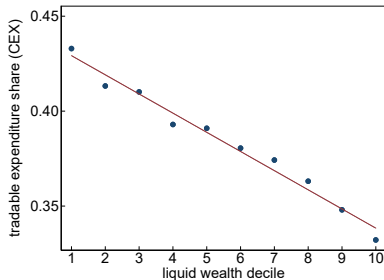
Tradable shares decline with labor income

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- Level is higher in CEX



Tradable shares decline with wealth [back](#)

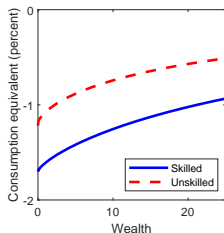


Summary of empirical findings

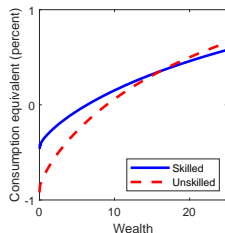
- ▶ Tradable expenditure shares decline with income and wealth
- ▶ Robust to controlling for household characteristics:
 - ▶ household head age and education
 - ▶ household size
 - ▶ home ownership
- ▶ Robust to:
 - ▶ not adjusting for owner-equivalent rent
 - ▶ no partial PSID adjustments (vacation/ent./repairs)
 - ▶ using total labor income
 - ▶ alternative tradability measures (to include indirect imports)
- ▶ Motivates our model of
 - ▶ uninsurable income risk → wealth and income heterogeneity
 - ▶ non-homothetic preferences → different consumption baskets

Welfare of tariffs with retaliation [back](#)

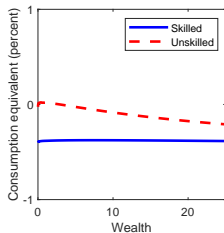
(a) Without redistribution



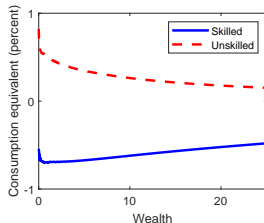
(b) Capital income tax



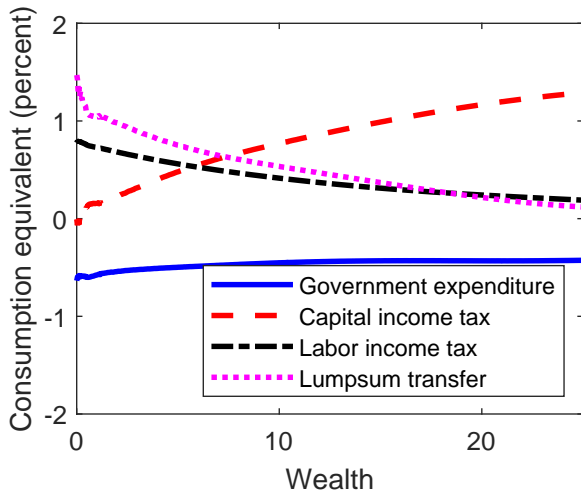
(c) Labor income tax



(d) Lumpsum transfer



Welfare by wealth (no retaliation) [back](#)



Prices (no mobility)

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Figure: Tradable price

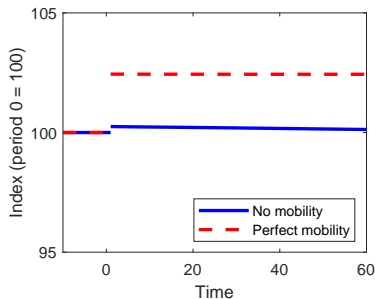
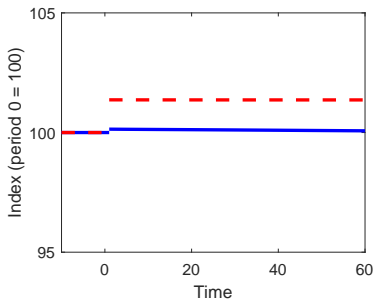


Figure: Investment price



Wages (no mobility)

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Figure: Skilled wage

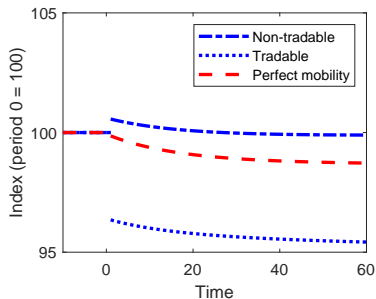
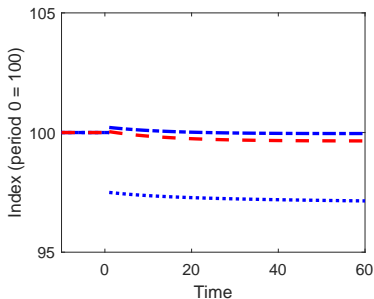


Figure: Unskilled wage



Welfare (no mobility)

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