LOCAL IMPACTS OF GLOBAL MARKETS

Dynamic Adjustment to Trade Shocks

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Dynamic Adjustment to Trade Shocks

- Costs of trade disruptions depend on adjustment of trade flows

- In the data, trade responds dynamically: short-run $\neq$ long-run
  (Dekle et al 07; Ruhl 08; Anderson Yotov 23; Boehm et al 23)

- In benchmark quantitative models, trade elasticity is constant

- *De facto* time-varying trade elasticity demands reconciliation

This Paper

- Theory to guide estimation of time varying trade elasticity
- Microfoundations of time varying trade elasticity in computational model
- Adjustment frictions with stochastic opportunity to switch supplier
- Short-term dynamics deviate from long-term steady-state

Concrete Insights

- Micro-founded Ricardian model with gradual trade adjustment:
  - nest Eaton Kortum 02 as limiting long-run case,
  - structural equation for trade elasticity estimation by horizon,
  - new formula for time-varying gains from trade.
- Quantitative re-evaluation of US-China trade war:
  - short-term overshooting (China) or undershooting (United States),
  - dynamics for third countries: short-run losses, long-run gains.

Related Literature

- **International elasticity puzzle**. Ruhl 08; Fontaigne et al 18, 22
- **Time-varying elasticity estimation**. Yilmaz 19; deSouza et al. 22; Anderson Yotov 23; Boehm et al 23
- **Staggered trade contracts and decisions**. Kollintzas Zhou 92; Calvo 83; Arkolakis et al 11
- **Sisyphos process**. Montero Villarroel 16 (directed random walk with random restarts)

Agenda

- Model
- Formulas
- Estimation
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Model Setup

- Eaton-Kortum trade model with input-output linkages
- Sourcing decisions subject to friction
  - when possible, choose cheapest global supplier
  - possibility to choose suppliers arises at random times
- *Consequence*: Trade flows adjust gradually to trade shocks

Households

- N countries $s, d \in \mathcal{N}$; I industries $i, j \in \mathcal{I}$; time periods t

- L_d consumers supply one unit of labor, maximize consumption $C_{d,t}$

$$C_{d,t} = \prod_{i \in \mathcal{I}} \left(C_{di,t} \right)^{\eta_{di}}$$

  - $C_{di,t}$: consumption of industry i's composite good (non-traded)
  - η_{di}: consumption expenditure share of industry i in d

- Consumer price index: $P_{d,t} = \prod_{i \in \mathcal{I}} \left(P_{di,t} / \eta_{di} \right)^{\eta_{di}}$

Intermediate Varieties

- Continuum of intermediate varieties $\omega \in [0, 1]$ in each industry i

- Production technology in country s:

$$y_{si}(\omega) = z_{si}(\omega)\ell^{\alpha_{si}} \prod_j (M_{sji})^{\alpha_{sji}}$$

  - $z_{si}(\omega)$: perpetual productivity of firm producing ω
  - ℓ, M_{sji} : domestic labor, composite goods from other industries
  - CRS: $\sum_j \alpha_{sji} = 1 - \alpha_{si}$

- Perfect competition, no firm-to-firm trade

Assembly of Intermediate Varieties

- Arrival rate of firms with efficiency $z_{si}(\omega) \geq z$: Poisson$(A_{si} z^{-\theta_i})$
  - A_{si} governs absolute advantage
  - θ_i governs comparative advantage
- Assemblers aggregate intermediate varieties into composite goods:

$$Y_{di,t} = \left(\int_{[0,1]} y(\omega)^{\frac{\sigma_i - 1}{\sigma_i}} \mathrm{d}\omega \right)^{\frac{\sigma_i}{\sigma_i - 1}} = \sum_{j \in \mathcal{I}} M_{dij,t} + C_{di,t}$$

  - σ_i is elasticity of substitution

Sourcing Choice of Assemblers

- Variable trade cost: $\tau_{sdi,t}$
- Permission to choose: $x_{i,t}(\omega) \in \{0, 1\}$
  - $P\left[x_{i,t}(\omega) = 1\right] = \zeta_i$
  - If $x_{i,t}(\omega) = 1$, then choose supplier in least costly source country
  - If $x_{i,t}(\omega) = 0$, then keep supplier as in $t - 1$
  - No contractual advantage of entering assemblers
- ζ_i is *supplier adjustment probability* (search friction)

Trade Flows: Newly Sourced Varieties

- Measure $\mu_{i,t}(0) = \zeta_i$ of varieties from least costly source country

- Share of expenditure in d on *newly sourced* varieties (0) from s:

$$\lambda^0_{sdi,t} = \frac{A_{sj}\left(c_{sdi,t}\right)^{-\theta_i}}{\Phi^0_{di,t}}, \text{ where } \Phi^0_{di,t} \equiv \sum_{n\in\mathcal{N}} A_{ni}\left(c_{ndi,t}\right)^{-\theta_i}$$

- Unit cost component: $c_{sdi,t} \equiv \Theta_{si}\tau_{sdi,t}\left(w_{s,t}\right)^{\alpha_{si}}\prod_j (P_{sj,t})^{\alpha_{sji}}$.
  Market access term: $\Phi^0_{di,t}$ (encodes average price paid)

- Trade elasticity: θ_i (Fréchet shape parameter as in Eaton-Kortum)

Trade Flows: Prices of Legacy Varieties

- Measure $\mu_{i,t}(k) = (1-\zeta_i)\mu_{i,t-1}(k-1)$ of legacy varieties sourced from same country as $t-k$ periods ago

- Price of legacy variety ω: $p^k_{sdj,t}(\omega) = \frac{c_{sdi,t-k} \prod_{\varsigma=t-k+1}^{t} \widehat{c}_{sdi,\varsigma}}{z_{si}(\omega)}$ for $\widehat{c}_{sdi,t} \equiv c_{sdi,t}/c_{sdi,t-1}$.

- Price from k periods ago adjusted for cumulative change in unit cost

Trade Flows: Shares of Legacy Varieties

- Share of expenditure in d on *legacy* varieties (k) from s:

$$\lambda^{k}_{sdi,t} = \frac{\lambda^{0}_{sdi,t-k}\left(\prod_{\varsigma=t-k+1}^{t}\widehat{c}_{sid,\varsigma}\right)^{-(\sigma_i-1)}}{\Phi^{k}_{di,t}}$$

where $\Phi^{k}_{di,t} \equiv \sum_{n\in\mathcal{N}}\lambda^{0}_{ndi,t-k}\left(\prod_{\varsigma=t-k+1}^{t}\widehat{c}_{nid,\varsigma}\right)^{-(\sigma_i-1)}$

and $\lambda^{0}_{sdi,t-k}$ encodes distribution of prices at $t-k$

- Trade elasticity: $\sigma_i - 1$ (elasticity of substitution as in Armington)

- *Intuition*: Demand for legacy varieties adjusts at intensive margin only

Aggregation

- Partial price index for *newly sourced* varieties

$$P^0_{di,t} = \Gamma_i \, \mu_{i,t}(0)^{-1/(\sigma_i-1)} \left(\Phi^0_{di,t}\right)^{-\frac{1}{\theta_i}}$$

- Partial price index for *legacy* varieties last chosen at $t-k$

$$P^k_{di,t} = P^0_{di,t-k} \cdot \left(\frac{\mu_{i,t}(k)}{\mu_{i,t-k}(0)} \Phi^k_{di,t}\right)^{-1/(\sigma_i-1)} , k \geq 1$$

- Aggregate trade flows in industry i

$$\lambda_{sdi,t} = \sum_{k=0}^{\infty} \left(\frac{P^k_{di,t}}{P_{di,t}}\right)^{-(\sigma_i-1)} \lambda^k_{sdi,t}$$

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Trade Elasticity by Time Horizon

- Elasticity of total exports at $t+h$ w.r.t. trade cost $\tau_{sdi,t}$ at t:

$$\varepsilon_i^h \equiv \frac{\partial \ln \lambda_{sdi,t+h}}{\partial \ln \tau_{sdi,t}} = -\theta_i \left[1-(1-\zeta_i)^{h+1}\right] - (\sigma_i - 1)(1-\zeta_i)^{h+1}$$

for steady state at $t-1$ (up to a first order)

  - increases in absolute value over time (for $\theta_i > \sigma_i - 1$)
  - converges to θ_i as $h \to \infty$
  - with rate of convergence $\ln(1-\zeta_i)$
  - structural analogue to reduced-form estimation by Boehm et al 23

Welfare Formula

- Real wage response to trade shock at $t = 0$:

$$\widehat{W}_d^h = \prod_{i,j \in \mathcal{I}} \left[\left(\frac{\lambda_{ddj,h}}{\lambda_{ddj,-1}} \right)^{-\frac{1}{\theta_j}} \left(\Xi_{dj,h} \right)^{\frac{1}{\sigma_j - 1}} \right]^{\eta_i \bar{a}_{sji}}$$

$$\Xi_{dj,h} \equiv (1 - \zeta_j)^{h+1} \left(\frac{\lambda_{ddj,h}}{\lambda_{ddj,-1}} \right)^{\chi_j} + \sum_{\varsigma=0}^{h} \zeta_j (1 - \zeta_j)^{\varsigma} \left(\frac{\lambda_{ddj,h}}{\lambda^0_{ddj,h-\varsigma}} \right)^{\chi_j}$$

  - $\chi_i \equiv -[\theta_j - (\sigma_j - 1)]/\theta_j$: short- vs. long-run flexibility of trade. $\bar{a}_{sji}$: (j, i)-th element of Leontief inverse $(\mathbf{I} - \boldsymbol{A}_d)^{-1}$
  - *Distortion term* $\Xi_{dj,h}$ varies by age of supply relationship $\lambda_{\cdot,h}/\lambda^0_{\cdot,h-k}$. ACR formula long-run limit: $\lim_{h \to \infty} \Xi_{dj,h} = 1$

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Implementations

- Identification based on tariff changes in third-party countries

- Current

  - Reduced-form estimates from Boehm et al 23

  - Recover θ, σ, ζ
    using horizon-h trade elasticities ε^h (minimum distance)

- Future

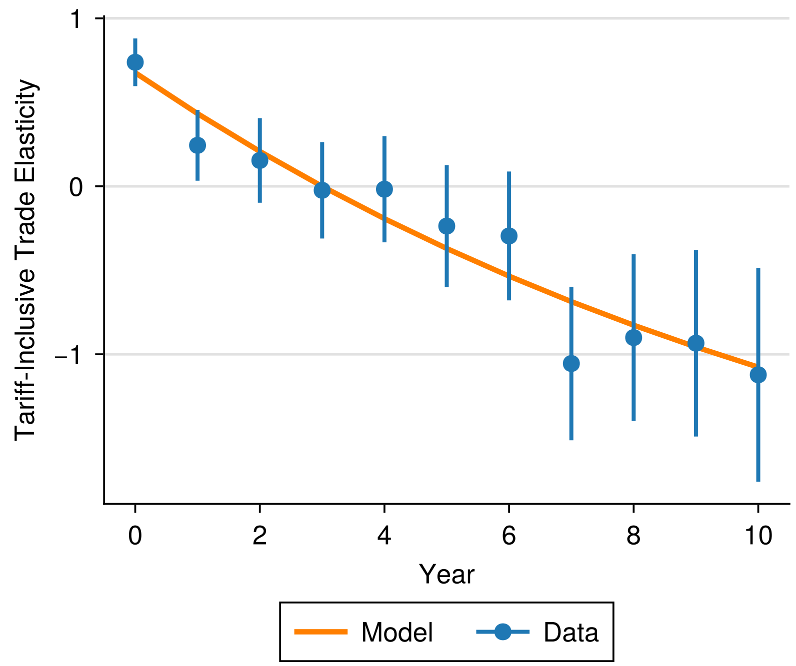
  - Pool horizons, use non-linear least squares to recover θ_i, σ_i, ζ_i

Results for All HS Product Categories

	Targeted Trade Elasticity Coefficients		
	Baseline BLP	Excl. horz. 5-6	Excl. horz. 4-8
Long-run Trade Elasticity $-\theta$	-2.54 (2.06)	-2.17 (1.29)	-1.51 (.63)
Short-run Trade Elasticity $-(\sigma-1)$	.81 (.09)	.84 (.10)	.89 (.11)
Supplier adjustment probability ζ	.08 (.06)	.10 (.06)	.14 (.06)

Source: Horizon-h trade elasticities by Boehm et al 23 (BLP), using tariff-inclusive trade values for all time horizons in baseline column and excluding select time horizons in subsequent columns.
Notes: Parameters θ, σ–1, ζ from minimum distance estimator based on trade elasticity formula. Standard errors from asymptotic distribution in parenthesis, using standard error estimates from BLP to obtain diagonal variance-covariance matrix. Model-based trade elasticity at impact: $\varepsilon^0 < -(\sigma-1)$ for $\theta > \sigma-1$. Trade elasticity at impact based on tariff-exclusive trade value in BLP: -0.76; transformed to trade elasticity at impact for tariff-inclusive trade value: 0.24.

Implied Trade Elasticity



Source: Horizon-h trade elasticities by Boehm et al 23 (BLP), using all time horizons in baseline.
Note: Parameters θ, $\sigma - 1$, ζ from minimum distance estimator based on trade elasticity formula. Confidence bands from BLP.

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Application: US–China Trade War 2018

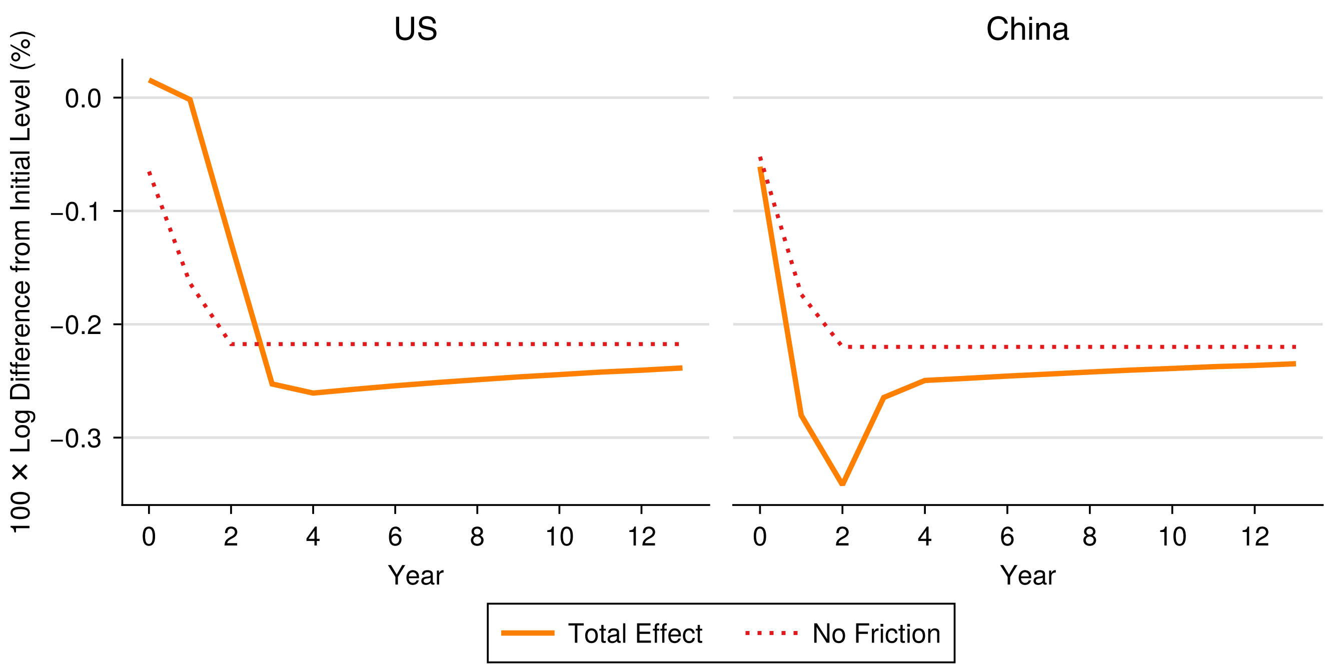
- Data: OECD ICIO (77 regions, 45 industries aggregated to 32)

- Calibrate: initial steady state, trade flows in 2017

- Shock: changes in US-CHN tariffs from Fajgelbaum et al 20
  (average increase of 10%, ranging from 3% to 18%)

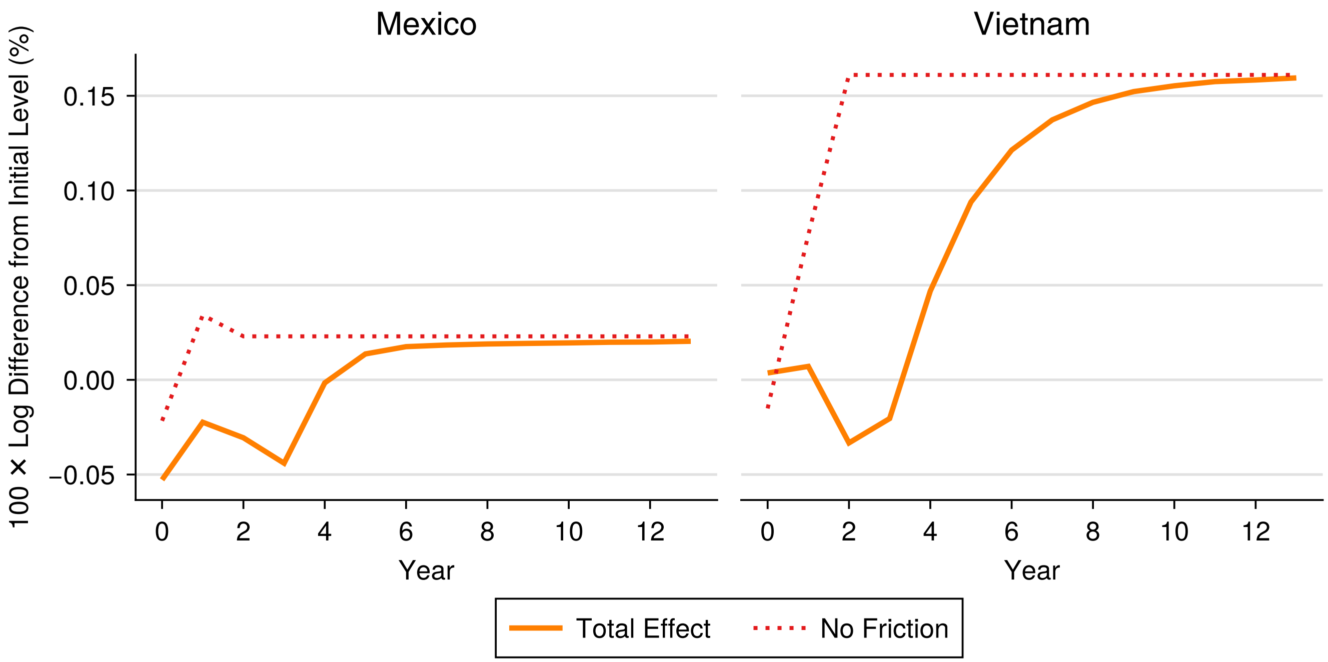
- Solve: dynamic hat algebra (Dekle Eaton Kortum 07),
  trade and wage responses over time

Changes in Welfare



Sources: OECD ICIO, tariffs from Fajgelbaum et al 20.
Notes: Changes relative to initial shock. De-facto tariff changes over initial three years. *Total Effect* simulates welfare for $\theta = 2.54$, $\sigma = .19$ and $\zeta = .08$. *No Friction* refers to simulation with $\zeta = 1$.

Changes in Welfare



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Concluding Remarks

- Framework to accommodate changing trade elasticity over time
  Reconcile long-run supply (Ricardian) and short-run demand (Armington) forces
- Adjustment frictions matter, qualitatively and quantitatively
- To reconcile changing trade elasticity, probability of supplier switches
- Simulations suggest differential short-run and long-run welfare effects

BACKUP

Equilibrium

- Market clearing as in Caliendo Parro 15, given trade flows $\lambda_{sdi,t}$
- *Short-run dynamics*: Trade flows and wages reflect fading shocks
- *Long-run steady state*:
  - trade shares equalize across k, regardless of adjustment status
  - legacy varieties from supplier for k periods: $\mu_{i,t}(k) = \zeta_i(1 - \zeta_i)^k$ (stationary measure)
- For equal fundamentals, long-run allocations as in Eaton-Kortum

Rationale of Future Implementation

- Pool horizons, use $\varepsilon_i^h = -\theta_i + [\theta_i - (\sigma_i - 1)]\,(1 - \zeta_i)^{h+1}$, estimate

$$\ln\left(\frac{X_{sdi,t+h}}{X_{sdi,t-1}}\right) = \bar{\gamma}_i \ln\left(\frac{\bar{\tau}_{sdi,t}}{\bar{\tau}_{sdi,t-1}}\right) + \gamma_i^h \ln\left(\frac{\bar{\tau}_{sdi,t}}{\bar{\tau}_{sdi,t-1}}\right) + \ldots,$$

and recover (under approximation error)

$$\begin{aligned}
\theta_i &= -\bar{\gamma}_i \\
\sigma_i &= 1 - \frac{\gamma_i^0}{1 - \zeta_i} - \bar{\gamma}_i \\
\zeta_i &= 1 - \exp\left\{\frac{\sum_{m=0}^{H} \ln\left(\gamma_i^m / \gamma_i^0\right)}{\sum_{m=0}^{H} m}\right\}
\end{aligned}$$

Future Estimation

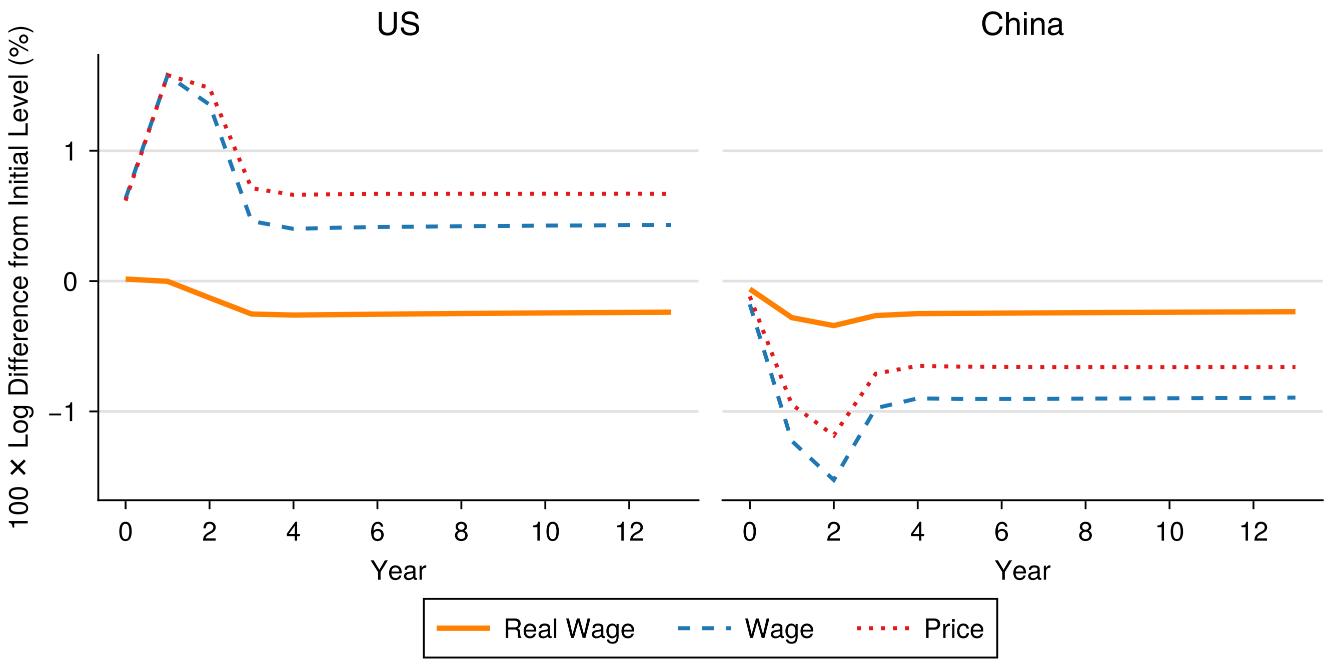
- Estimate horizon-h trade elasticity ε_i^h with $\widehat{\beta}_i^h$

$$\ln\left(\frac{X_{sdi,t+h}}{X_{sdi,t-1}}\right) = \beta_i^h \ln\left(\frac{\bar{\tau}_{sdi,t}}{\bar{\tau}_{sdi,t-1}}\right) + \delta_{si,t+h} + \delta_{di,t+h} + u_{sdi,t+h}$$

  - bilateral exports $X_{sdi,t+h}$, ad-valorem tariff $\bar{\tau}_{sdi,t}$, fixed effects
  - use trade elasticity formula ε_i^h to recover θ_i, $\sigma_i - 1$, ζ_i (with minimum distance estimator)

$$\beta_i^h = \varepsilon_i^h = -\theta_i + [\theta_i - (\sigma_i - 1)]\,(1 - \zeta_i)^{h+1}$$

Changes in Real Wages, Wages and Consumer Prices



Sources: OECD ICIO, tariffs from Fajgelbaum et al 20.
Notes: Changes relative to initial shock. De-facto tariff changes over initial three years. Simulations for $\theta = 2.54$, $\sigma = .19$ and $\zeta = .08$.

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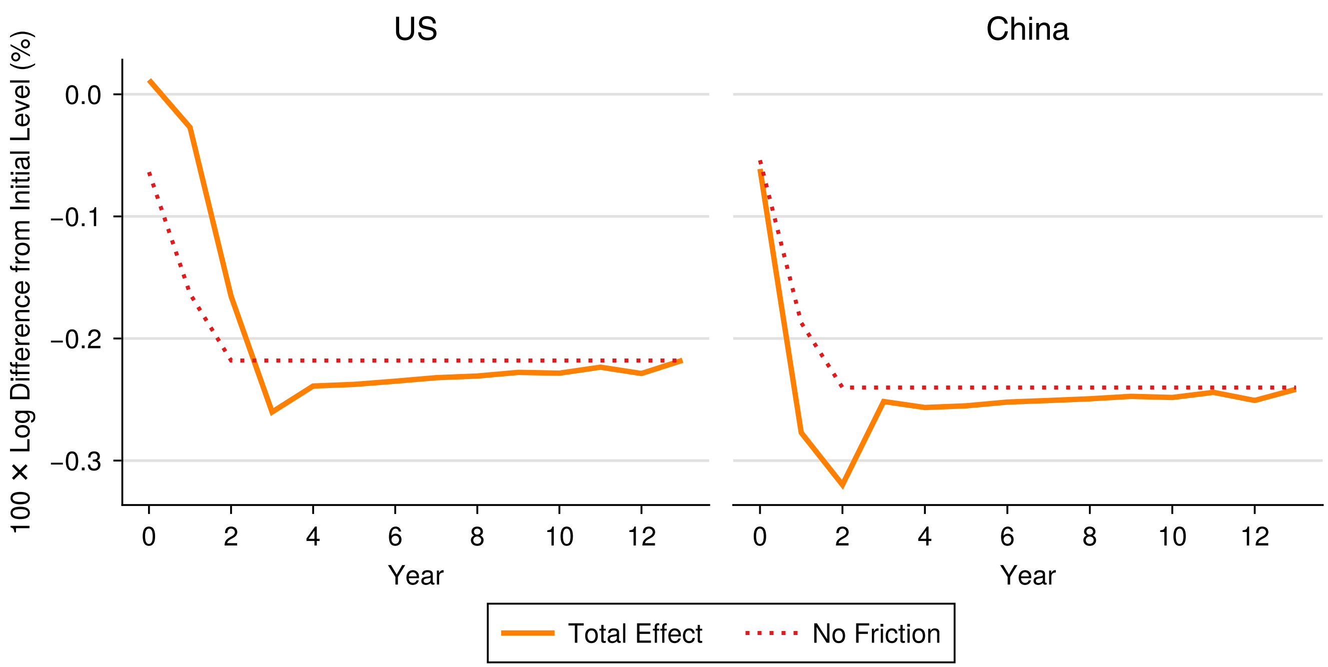
Changes in Welfare: Alternative Estimates



Sources: OECD ICIO, tariffs from Fajgelbaum et al 20.
Notes: Changes relative to initial shock. De-facto tariff changes over initial three years. *Total Effect* simulates welfare for $\theta = 1.51$, $\sigma = .11$ and $\zeta = .14$. *No Friction* refers to simulation with $\zeta = 1$.