New-Keynesian Trade: Understanding the Employment and Welfare Effects of Sector-Level Shocks

Andrés Rodríguez-Clare, Mauricio Ulate, and José P. Vásquez

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Motivation

- ADH: higher exposure to China shock $\rightarrow$ larger decline in $E$

- Quantitative trade model: all effects on $W$ rather than $E$

- How does downward-nominal wage rigidity (DNWR) matter for the effects of the China shock on $E$ and welfare?
Starting Point

- Caliendo-Parro (2015) + home production (with EoS $\kappa$)
- Exact hat algebra for counterfactual analysis
- Calibrate China shock to match pred. US imports from China
- Model cannot generate ADH effects on $E$
Nominal Wage Rigidity

- Add DNWR as in Schmitt-Grohe and Uribe (2016)
  - Wage can fall by no more than $100(1-\delta)\%$ per year
- Pick $\delta, \kappa$ to match ADH on unemployment and participation
- Study implications for $E$ and welfare
Preview of Findings

- Two states have ↓ in ToT and lower $E$ in new steady state
- Eight states suffer a decline in welfare
- 43 states experience temporary unemployment
- China shock responsible for 0.8 pp of U.S. unemp. in 2004
- DNWR reduces avg U.S. welfare gain from 0.36% to 0.30%
Literature

- Standard model + mobility frictions + home prod: CDP
- Standard model + wage rigidities: EK+Neiman (2014)
- Shocks in a SOE: Schmitt-Grohe and Uribe (2016)
- Heterogenous regions with nominal rigidities...
Outline

▶ Model

▶ Data

▶ Calibration

▶ Results
Basic Assumptions

- \( I \) regions (\( M \) in the U.S., \( I - M \) outside), \( S \) sectors
- Production uses labor and intermediate inputs
- Perfect mobility across sectors, no mobility across regions
- Upward sloping labor supply, through home production
- Preferences and technology:

\[
P_{i,t} \propto \prod_{s=1}^{S} P_{i,s,t}^{\alpha_{i,s}}
\]

\[
P_{j,k,t}^{1-\sigma_k} = \sum_{i=1}^{I} \left( \tau_{ij,k} A_{i,k,t}^{-1} W_{i,t}^{\phi_{i,k}} \prod_{s=1}^{S} P_{i,s,t}^{\phi_{i,sk}} \right)^{1-\sigma_k}
\]
Market Clearing

- Exogenous trade imbalances: \( P_{i,t} C_{i,t} = W_{i,t} L_{i,t} + D_{i,t} \)
- Equilibrium in sector \( s \), country \( i \), at time \( t \):

\[
R_{i,s,t} = \sum_{j=1}^{I} \lambda_{ij,s,t} \left( \alpha_{j,s} (W_{j,t} L_{j,t} + D_{j,t}) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right)
\]

where

\[
\lambda_{ij,k,t} \equiv \frac{(\tau_{ij,k,t} A_{ij}^{-1} W_{i,t}^{\phi_{i,k}} \prod_{s=1}^{S} P_{i,s,t}^{\phi_{i,sk}})^{1-\sigma_k}}{\sum_{r=1}^{I} (\tau_{rj,k,t} A_{rj}^{-1} W_{r,t}^{\phi_{r,k}} \prod_{s=1}^{S} P_{r,s,t}^{\phi_{r,sk}})^{1-\sigma_k}}
\]

- Labor market clearing:

\[
W_{i,t} L_{i,t} = \sum_{s=1}^{S} \phi_{i,s} R_{i,s,t}
\]

- Standard model: \( L_{i,t} = \bar{L}_{i,t} \)
Home Production

- Random preference draws for home production or work

- Labor supply is now $\ell_{i,t} = \pi_{i,t} \bar{L}_{i,t}$ where

\[
\pi_{i,t} = \frac{\omega_{i,t}^\kappa}{\mu_i^\kappa + \omega_{i,t}^\kappa}
\]

- With no rigidities

\[
\omega_{i,t} \equiv \frac{W_{i,t}}{P_{i,t}}
\]

- With rigidities we may have unemployment and so

\[
\omega_{i,t} \equiv \frac{L_{i,t}}{\ell_{i,t}} \frac{W_{i,t}}{P_{i,t}}
\]
Nominal Wage Rigidity

- **DNWR**: $W_{i,t}^{LCU} \geq \delta W_{i,t-1}^{LCU}$

- Maximum employment: $\sum_{s=1}^{S} L_{i,s,t} = L_{i,t} \leq \ell_{i,t}$

- Complementary slackness:
  
  $$(\ell_{i,t} - L_{i,t})(W_{i,t}^{LCU} - \delta W_{i,t-1}^{LCU}) = 0$$
Nominal Wage Rigidity in Dollars

- For regions outside of the U.S. DNWR implies
  \[ W_{i,t} \geq \frac{E_{i,t}}{E_{i,t-1}} \delta W_{i,t-1} \]

- ER flexibility implies \( L_{i,t} = \ell_{i,t} \ \forall i > M \)

- So unemployment only in US states (i.e. \( i \leq M \))
Nominal Anchor

- World aggregate demand in dollars grows at $\gamma$:

$$\sum_{i=1}^{l} W_{i,t} L_{i,t} = \gamma \sum_{i=1}^{l} W_{i,t-1} L_{i,t-1}$$

- Some desirable properties:
  - Can capture fixed level of aggregate demand in global ZLB
  - Unemployment even with two single-region countries
  - Motivates “currency wars” for countries to bring demand home
Equilibrium System in Levels

\[ R_{i,s,t} = \sum_{j=1}^{I} \lambda_{ij,s,t} \left( \alpha_{j,s} (W_{j,t}L_{j,t} + D_{j,t}) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right) \quad \forall \, i, \forall \, s \]

\[
\lambda_{ij,k,t} = \frac{(\tau_{ij,k,t}A_{i,k}^{-1} W_{i,t} \prod_{s=1}^{S} P_{i,s,t}^{\phi_{i,sk}})^{1-\sigma_k}}{\sum_{r=1}^{I}(\tau_{rj,k,t}A_{r,k,t}^{-1} W_{r,t} \prod_{s=1}^{S} P_{r,s,t}^{\phi_{r,sk}})^{1-\sigma_k}} \quad \forall \, i, \forall \, s
\]

\[
P_{i,s,t}^{1-\sigma_s} = \sum_{j=1}^{I} \left( \tau_{ji,s,t}A_{j,s,t}^{-1} W_{j,t} \prod_{k=1}^{S} P_{j,k,t}^{\phi_{j,ks}} \right)^{1-\sigma_s} \quad \forall \, i, \forall \, s
\]

\[
W_{i,t}L_{i,t} = \sum_{s=1}^{S} \phi_{i,s} R_{i,s,t} \quad \forall \, i
\]

\[
L_{i,t} \leq \ell_{i,t}, \quad W_{i,t} \geq \delta_{i} W_{i,t-1}, \quad CS \quad \forall \, i
\]

\[
\ell_{i,t} = \frac{(W_{i,t}L_{i,t} / (P_{i,t} \ell_{i,t}))^\kappa}{\mu_{i}^\kappa + (W_{i,t}L_{i,t} / (P_{i,t} \ell_{i,t}))^\kappa} \quad \forall \, i
\]

\[
P_{i,t} = constant \cdot \prod_{s=1}^{S} P_{i,s,t}^{\alpha_{i,s}} \quad \forall \, i
\]

\[
\sum_{i=1}^{I} W_{i,t}L_{i,t} = \gamma \sum_{i=1}^{I} W_{i,t-1}L_{i,t-1} \quad \text{single}
\]
Exact Hat Algebra

- Enough free parameters so model matches all 2000 data
- Implicit calibration of all those parameters
- Follow DEK and CDP
Equilibrium System in Hats

\[
\hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{I} \hat{\lambda}_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} R_{j,k,t-1} \right)
\]

\[
\hat{\lambda}_{ij,k,t} = \frac{\left( \hat{r}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{P}_{i,s,t} \right)^{1-\sigma_{k}}}{\sum_{r=1}^{I} \lambda_{rj,k,t-1} \left( \hat{r}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{P}_{r,s,t} \right)^{1-\sigma_{k}}}
\]

\[
\hat{P}_{i,s,t}^{1-\sigma_{s}} = \sum_{j=1}^{I} \lambda_{ji,s,t-1} \left( \hat{r}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \prod_{k=1}^{S} \hat{P}_{j,k,t} \right)^{1-\sigma_{s}}
\]

\[
\hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{i,sk} \hat{R}_{i,s,t} R_{i,s,t-1}
\]

\[
\hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{l}_{i,q} \leq \hat{\ell}_{i,t} \prod_{q=1}^{t-1} \hat{l}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad CS
\]

\[
\hat{\ell}_{i,t} = \frac{\left( \hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}) \right)^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1} \left( \hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}) \right)^{\kappa}}
\]

\[
\hat{P}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}}
\]

\[
\gamma \sum_{i=1}^{I} Y_{i,t-1} = \sum_{i=1}^{I} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1}
\]
Equilibrium System in Hats

\[ \hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{l} \hat{\lambda}_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} R_{j,k,t-1} \right) \]

\[ \hat{\lambda}_{ij,k,t} = \frac{\left( \hat{\tau}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{P}_{i,s,t} \phi_{i,sk} \right)^{1-\sigma_k}}{\sum_{r=1}^{l'} \lambda_{rj,k,t-1} \left( \hat{\tau}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{P}_{r,s,t} \phi_{r,sk} \right)^{1-\sigma_k}} \]

\[ \hat{P}_{i,s,t}^{1-\sigma_s} = \sum_{j=1}^{l} \lambda_{ji,s,t-1} \left( \hat{\tau}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \prod_{s=1}^{S} \hat{P}_{j,sk} \phi_{j,ks} \right)^{1-\sigma_s} \]

\[ \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{i,sk} \hat{R}_{i,s,t} R_{i,s,t-1} \]

\[ \hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{L}_{i,q} \leq \hat{\ell}_{i,t} \prod_{q=1}^{t-1} \hat{\ell}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad \text{CS} \]

\[ \hat{\ell}_{i,t} = \frac{(\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1} (\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\kappa}} \]

\[ \hat{P}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}} \]

\[ \gamma \sum_{i=1}^{l'} Y_{i,t-1} = \sum_{i=1}^{l'} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} \]
Equilibrium System in Hats

\[ \hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{l} \hat{\lambda}_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} R_{j,k,t-1} \right) \]

\[ \hat{\lambda}_{ij,k,t} = \left( \frac{\hat{\tau}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\phi_{i,sk}}}{\sum_{r=1}^{l} \lambda_{rj,k,t-1} \left( \hat{\tau}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{P}_{r,s,t}^{\phi_{r,sk}} \right)^{1-\sigma_{k}}} \right)^{1-\sigma_{k}} \]

\[ \hat{p}_{i,s,t}^{1-\sigma_{s}} = \sum_{j=1}^{l} \lambda_{ji,s,t-1} \left( \frac{\hat{\tau}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \prod_{s=1}^{S} \hat{P}_{j,s,t}^{\phi_{j,ks}}}{\hat{W}_{i,t} \hat{L}_{i,t} \prod_{s=1}^{t} \hat{\ell}_{i,q} \leq \hat{\ell}_{i,t} \prod_{q=1}^{t-1} \hat{\ell}_{i,q}, \hat{W}_{i,t} \geq \delta_{i}, \text{ CS}} \right)^{1-\sigma_{s}} \]

\[ \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{i,sk} \hat{R}_{i,s,t} R_{i,s,t-1} \]

\[ \hat{\ell}_{i,t} = \frac{(\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1}(\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\kappa}} \]

\[ \hat{p}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}} \]

\[ \gamma \sum_{i=1}^{l} Y_{i,t-1} = \sum_{i=1}^{l} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} \]
Equilibrium System in Hats

\[ \hat{R}_{i,s,t} \hat{R}_{i,s,t-1} = \sum_{j=1}^{I} \hat{\lambda}_{ij,s,t} \hat{\lambda}_{ij,s,t-1} \left( \alpha_{j,s} (\hat{W}_{j,t} \hat{L}_{j,t} \gamma_{j,t-1} + \hat{D}_{j,t} \gamma_{j,t-1}) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} \hat{R}_{j,k,t-1} \right) \]

\[ \hat{\lambda}_{ij,k,t} = \frac{\sum'_{r=1} \lambda_{rj,k,t-1} \left( \hat{r}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \phi_{r,k} \prod_{s=1}^{S} \hat{P}_{r,s,t} \right)^{1-\sigma_k}}{\sum_r \lambda_{rj,k,t-1} \left( \hat{r}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \phi_{r,k} \prod_{s=1}^{S} \hat{P}_{r,s,t} \right)^{1-\sigma_k}} \]

\[ \hat{\lambda}_{ij,s,t-1} = \sum_{j=1}^{I} \left( \hat{r}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \phi_{j,s} \prod_{k=1}^{S} \hat{P}_{j,k,t} \right)^{1-\sigma_s} \]

\[ \hat{W}_{i,t} \hat{L}_{i,t} \gamma_{i,t-1} = \sum_{s=1}^{S} \phi_{i,sk} \hat{R}_{i,s,t} \hat{R}_{i,s,t-1} \]

\[ \hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{L}_{i,q} \leq \hat{\ell}_{i,t} \prod_{q=1}^{t-1} \hat{\ell}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad CS \]

\[ \hat{\ell}_{i,t} = \frac{(\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\gamma}}{1 - \pi_{i,t-1} + \pi_{i,t-1} (\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{\ell}_{i,t}))^{\gamma}} \]

\[ \hat{P}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}} \]

\[ \gamma \sum_{i=1}^{I} Y_{i,t-1} = \sum_{i=1}^{I} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} \]
Equilibrium System in Hats

\[
\hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{l} \hat{\lambda}_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} R_{j,k,t-1} \right)
\]

\[
\hat{\lambda}_{ij,k,t} = \left( \frac{\hat{\tau}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{p}_{i,s,t}^{\phi_{i,sk}}}{\sum_{r=1}^{l} \hat{\lambda}_{rj,k,t-1} \left( \hat{\tau}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{p}_{r,s,t}^{\phi_{r,sk}} \right)^{1-\sigma_{k}} \prod_{s=1}^{S} \hat{p}_{i,s,t}^{\phi_{i,sk}} \prod_{k=1}^{l} \hat{p}_{j,k,t}^{\phi_{j,ks}} \right)^{1-\sigma_{s}}}
\]

\[
\hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{i,s} \hat{R}_{i,s,t} R_{i,s,t-1}
\]

\[
\hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{l}_{i,q} \leq \hat{l}_{i,t} \prod_{q=1}^{t-1} \hat{l}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad CS
\]

\[
\hat{l}_{i,t} = \frac{(\hat{W}_{i,t} \hat{L}_{i,t}/(\hat{p}_{i,t} \hat{l}_{i,t}))^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1}(\hat{W}_{i,t} \hat{L}_{i,t}/(\hat{p}_{i,t} \hat{l}_{i,t}))^{\kappa}}
\]

\[
\hat{p}_{i,t} = \prod_{s=1}^{S} \hat{p}_{i,s,t}^{\alpha_{i,s}}
\]

\[
\gamma \sum_{i=1}^{l} Y_{i,t-1} = \sum_{i=1}^{l} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1}
\]
Equilibrium System in Hats

\[
\hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{I} \lambda_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{j,sk} \hat{R}_{j,k,t} R_{j,k,t-1} \right)
\]

\[
\hat{\lambda}_{ij,k,t} = \frac{\left( \hat{r}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{P}_{i,s,t} \right)^{1-\sigma_k}}{\sum_{r=1}^{I} \lambda_{rj,k,t-1} \left( \hat{r}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{P}_{r,s,t} \right)^{1-\sigma_k}}
\]

\[
\hat{p}_{i,s,t}^{1-\sigma_s} = \sum_{j=1}^{I} \lambda_{ji,s,t-1} \left( \hat{r}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \prod_{k=1}^{S} \hat{P}_{j,k,t} \right)^{1-\sigma_s}
\]

\[
\hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{i,sk} \hat{R}_{i,s,t} R_{i,s,t-1}
\]

\[
\hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{L}_{i,q} \leq \hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{L}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad CS
\]

\[
\hat{L}_{i,t} = \frac{(\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{L}_{i,t}))^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1} (\hat{W}_{i,t} \hat{L}_{i,t} / (\hat{P}_{i,t} \hat{L}_{i,t}))^{\kappa}}
\]

\[
\hat{P}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}}
\]

\[
\gamma \sum_{i=1}^{I} Y_{i,t-1} = \sum_{i=1}^{I} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1}
\]
Equilibrium System in Hats

\[
\hat{R}_{i,s,t} R_{i,s,t-1} = \sum_{j=1}^{I} \lambda_{ij,s,t} \lambda_{ij,s,t-1} \left( \alpha_{j,s} \left( \hat{W}_{j,t} \hat{L}_{j,t} Y_{j,t-1} + \hat{D}_{j,t} D_{j,t-1} \right) + \sum_{k=1}^{S} \phi_{jk,s} \hat{R}_{j,k,t} R_{j,k,t-1} \right)
\]

\[
\hat{\lambda}_{ij,k,t} = \frac{\left( \hat{r}_{ij,k,t} \hat{A}_{i,k,t}^{-1} \hat{W}_{i,t} \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\phi_{i,s,k}} \right)^{1-\sigma_{k}}}{\sum_{r=1}^{I} \lambda_{rj,k,t-1} \left( \hat{r}_{rj,k,t} \hat{A}_{r,k,t}^{-1} \hat{W}_{r,t} \prod_{s=1}^{S} \hat{P}_{r,s,t}^{\phi_{r,s,k}} \right)^{1-\sigma_{r}}}
\]

\[
\hat{p}_{i,s,t}^{1-\sigma_{s}} = \sum_{j=1}^{I} \lambda_{ji,s,t-1} \left( \hat{r}_{ji,s,t} \hat{A}_{j,s,t}^{-1} \hat{W}_{j,t} \prod_{k=1}^{S} \hat{P}_{j,k,t}^{\phi_{j,k,s}} \right)^{1-\sigma_{s}}
\]

\[
\hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1} = \sum_{s=1}^{S} \phi_{is} \hat{R}_{i,s,t} R_{i,s,t-1}
\]

\[
\hat{L}_{i,t} \prod_{q=1}^{t-1} \hat{L}_{i,q} \leq \hat{\ell}_{i,t} \prod_{q=1}^{t-1} \hat{\ell}_{i,q}, \quad \hat{W}_{i,t} \geq \delta_{i}, \quad CS
\]

\[
\hat{\ell}_{i,t} = \frac{\left( \hat{W}_{i,t} \hat{L}_{i,t} / \left( \hat{P}_{i,t} \hat{\ell}_{i,t} \right) \right)^{\kappa}}{1 - \pi_{i,t-1} + \pi_{i,t-1} \left( \hat{W}_{i,t} \hat{L}_{i,t} / \left( \hat{P}_{i,t} \hat{\ell}_{i,t} \right) \right)^{\kappa}}
\]

\[
\hat{P}_{i,t} = \prod_{s=1}^{S} \hat{P}_{i,s,t}^{\alpha_{i,s}}
\]

\[
\gamma \sum_{i=1}^{I} Y_{i,t-1} = \sum_{i=1}^{I} \hat{W}_{i,t} \hat{L}_{i,t} Y_{i,t-1}
\]
Data Sources

Need data for $R_{i,s}$, $\lambda_{ij,s}$, $Y_j$, $D_j$, and $\pi_i$ at the beginning of the period for $i & j \in \text{U.S. states } \cup \text{ all other countries}$

Data Sources

- WIOD: 35 sectors for 40 countries for 2000
- 2002 CFS: trade flows across U.S. States for 43 commodities
- 2008 U.S. Census: trade between U.S. states and other countries
- BEA: state-level production and consumption in services for 2000
- BLS and OECD: labor force participation for 2000
Data: Region-Level Trade Flows

87 regions: 50 U.S. states, 36 other countries, and an aggregate RoW
13 sectors: 12 in manufacturing and a catch-all services sector

- Bilateral manuf. flows bw U.S. states for 2000 using CFS
- Census data on sector-by-state-by-country trade starts in 2008
  - Use prop. assumption to construct trade matrix for 2000
- Construct bilateral flows in services consistent with gravity structure
- Apportion trade shares by region-sector to match U.S. flows in WIOD
Calibration: Parameters

- $\phi_{i,s}$ labor shares from dataset + BEA on GDP by state (*)
- $\phi_{i,ks}$ intermediate shares from WIOD
- $\alpha_{i,s}$ from dataset after accounting for intermediates
- $\sigma_s = \sigma = 6$ (trade elasticity of 5 in all sectors)
Calibration: Chinese Technology Changes

- Need $\hat{A}_{China,s,t}$ for $s = 1, \ldots, 12$ and $t = 2001, \ldots, 2007$

- Set $\hat{A}_{China,s,t} = \hat{A}_{China,s}^1 \hat{A}_{China,t}^2$ (19 parameters instead of 84)

- Predict $\Delta X$ in USA using $\Delta X$ from other countries:

  \[
  \Delta X_{C,US,s}^{2007-2000} = \beta \Delta X_{C,OC,s}^{2007-2000} + \epsilon_s
  \]

  \[
  \Delta X_{C,US,t} = a + b \Delta X_{C,OC,t} + \epsilon_t
  \]

- \{\hat{A}_{China,s}^1\},\{\hat{A}_{China,t}^2\} to match \{\Delta \hat{X}_{C,US,s}^{2007-2000}\},\{\Delta \hat{X}_{C,US,t}\}
Exposure to China

Model-consistent measure:

\[
\text{Exposure}_i \equiv \sum_{s=1}^{S} \frac{\text{VA}_{i,s,2000}}{\text{VA}_{i,2000}} \frac{\Delta^{2007}_{2000} X_{C,OC,s}}{R_{US,s,2000}},
\]

- \(\text{VA}_{i,s,2000} \equiv W_{i,2000} L_{i,s,2000}\)
- \(R_{US,s,2000} = \text{U.S. sales in sector } s \text{ in year } 2000\)
- \(\Delta^{2007}_{2000} X_{C,OC,s} = \text{change in imports from China to other high-income countries from 2000 to 2007 in sector } s\)
- Re-normalize to have the same mean as the measure in ADH
Calibration: $\delta$ and $\kappa$

- Set $\gamma = 1$, burden is on $\delta$
- Match ADH on unemployment and participation:
  - $0.22 \uparrow$ in unemp. and $0.55 \downarrow$ in LFP for each $1000$ of exposure to China shock
- Result is $\delta \approx 0.982$ and $\kappa \approx 7.2$
- Wages can fall $\approx 1.8\%$/year $\approx$ Schmitt-Grohe and Uribe
Increase in unemployment vs exposure to China for different deltas and kappa = 7.2
Identification

Decrease in labor force participation vs exposure to China for different kappas and delta=0.982

- Kappa=5.2, Coefficient=0.42
- Kappa=6.2, Coefficient=0.49
- Kappa=7.2, Coefficient=0.55
- Kappa=8.2, Coefficient=0.61
- Kappa=9.2, Coefficient=0.67
Manufacturing Employment

Change in manufacturing employment to population ratio vs exposure to China

- Delta=0.980, Coefficient=-0.31
- Delta=0.981, Coefficient=-0.35
- Delta=0.982, Coefficient=-0.40
- Delta=0.983, Coefficient=-0.45
- Delta=0.984, Coefficient=-0.51
Non-manufacturing Employment

Change in non-manufacturing employment to population ratio vs exposure to China

![Graph showing the relationship between change in non-manufacturing employment to population ratio and exposure to China. The graph includes multiple lines with different Delta values and coefficients.]
This table compares employment effects in ADH (table 5, panel b, all education levels) with those in our model. The employment effects represent the 2007-2000 change in a given employment category regressed on exposure to China. The exposure measure is very similar in both papers and has the same mean (2.63 thousands of dollars of imports from china per worker). The 2007-2000 changes are converted into decadal changes by multiplying by 10/7.
Average Employment

Path of cumulative changes in employment

USA average change in employment, in %

Year

Average Participation

Path of cumulative changes in LFP

USA average change in LFP, in %

Year

Average Unemployment

Path of cumulative changes in unemployment

USA average change in unemployment, in %

Year

Welfare vs Exposure

Welfare change in percent vs exposure to China across US states
### Table: Welfare gains for different discount factors

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$\delta = 0$</th>
<th>cal. $\delta$</th>
<th>% dec.</th>
<th>$\delta = 0$</th>
<th>cal. $\delta$</th>
<th>% dec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99</td>
<td>0.394</td>
<td>0.371</td>
<td>5.82</td>
<td>0.276</td>
<td>0.256</td>
<td>7.47</td>
</tr>
<tr>
<td>0.98</td>
<td>0.379</td>
<td>0.335</td>
<td>11.55</td>
<td>0.265</td>
<td>0.226</td>
<td>14.82</td>
</tr>
<tr>
<td>0.97</td>
<td>0.363</td>
<td>0.300</td>
<td>17.31</td>
<td>0.255</td>
<td>0.198</td>
<td>22.27</td>
</tr>
<tr>
<td>0.96</td>
<td>0.349</td>
<td>0.268</td>
<td>23.05</td>
<td>0.244</td>
<td>0.172</td>
<td>29.68</td>
</tr>
<tr>
<td>0.95</td>
<td>0.335</td>
<td>0.238</td>
<td>28.77</td>
<td>0.234</td>
<td>0.147</td>
<td>37.08</td>
</tr>
<tr>
<td>0.94</td>
<td>0.321</td>
<td>0.210</td>
<td>34.47</td>
<td>0.225</td>
<td>0.125</td>
<td>44.44</td>
</tr>
<tr>
<td>0.93</td>
<td>0.308</td>
<td>0.184</td>
<td>40.12</td>
<td>0.215</td>
<td>0.104</td>
<td>51.78</td>
</tr>
<tr>
<td>0.92</td>
<td>0.295</td>
<td>0.160</td>
<td>45.75</td>
<td>0.206</td>
<td>0.084</td>
<td>59.15</td>
</tr>
<tr>
<td>0.91</td>
<td>0.283</td>
<td>0.137</td>
<td>51.37</td>
<td>0.198</td>
<td>0.066</td>
<td>66.46</td>
</tr>
<tr>
<td>0.90</td>
<td>0.272</td>
<td>0.117</td>
<td>56.94</td>
<td>0.190</td>
<td>0.049</td>
<td>73.75</td>
</tr>
</tbody>
</table>
Welfare in Different Scenarios

Welfare change vs exposure to China across US states

Welfare change, in percent vs Exposure to China

Legend:
- delta=0.010, kappa=0.00
- delta=0.986, kappa=0.00
- delta=0.010, kappa=7.22
- delta=0.982, kappa=7.22
- delta=0.010, kappa=198.00
Utility Paths in Different Scenarios

Paths of cumulative change in per period utility for USA

Cumulative change in per period utility, in percent

Year


kappa = 0.00, delta = 0.010
kappa = 0.00, delta = 0.986
kappa = 7.22, delta = 0.010
kappa = 7.22, delta = 0.982
kappa = 198.00, delta = 0.010