International Trade and Macro:
Caliendo, Dvorkin, Parro (2019)

Question

- How does a rise in productivity in China affect the local labor markets in the United States?
- One answer: Autor, Dorn, and Hanson run DiD regressions. Show that locations with more exposure to Chines trade did worse.
  - Cannot do counterfactuals, measure welfare...
- Approach in CDP: Model locations with moving costs, general equilibrium.

Geography

- N locations (n, i; across different countries)
- J sectors (j, k)
- A labor market is a location-sector pair
- Perfectly competitive labor market and goods markets

Households

- L_t^{nj} = mass of households in sector j location n
- Preferences over **local final goods**

$$C_t^{nj} = \prod_{k=1}^{J} (c_t^{nj,k})^{\alpha^k}$$

- Consumption price index at n

$$P_t^n = \prod_{k=1}^{J} (P_t^{nk})^{\alpha^k}$$

- P^{nk} = price index of goods purchased from k for final cons. in n
- Household can be employed or non-employed
- Non-employed have home production $b^n > 0$ in sector 0: $C_t^{n0} = b^n$

Migration

- Additive relocation costs (measured in utility): $\tau^{nj,ik} \geq 0$
- Idiosyncratic moving costs: ϵ_t^{ik}
  - Frechet distributed with parameter ν
- Timing: Observe variables at all locations; observe realizations of ϵ; work or home production; decide where to live/work next period

$$v_t^{nj} = U(C_t^{nj}) + \max_{i,k}\{\beta E_\epsilon[v_{t+1}^{ik}] - \tau^{nj,ik} + \nu\epsilon_t^{ik}\}$$

- Note that ϵ is the only uncertainty

Migration patterns

- Take expectations over the value function. Frechet implies

$$V_t^{nj} = U(C_t^{nj}) + \nu \log \left(\sum_{i=1}^{N} \sum_{k=0}^{J} \exp \left(\beta V_{t+1}^{ik} - \tau^{nj,ik} \right)^{\frac{1}{\nu}} \right)$$

- V_t^{nj} is the expected lifetime utility before realization of ϵ
- Share of labor that moves from *nj* to *ik* is

$$\mu_t^{nj,ik} = \frac{\exp \left(\beta V_{t+1}^{ik} - \tau^{nj,ik} \right)^{\frac{1}{\nu}}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \exp \left(\beta V_{t+1}^{mh} - \tau^{nj,mh} \right)^{\frac{1}{\nu}}}$$

- Move to places with higher expected utility net of costs
- $1/\nu$ is the elasticity of migration

Migration patterns

- The distribution of people across labor markets is the endogenous state variable

$$L_{t+1}^{nj} = \sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t^{ik,nj} L_t^{ik}$$

- Amount of labor supply is known at the beginning of each period

Intermediate goods

- Continuum of varieties in each sector-location: **intermediate goods**
- Productivity is aggregate A_t^{nj} and idiosyncratic z^{nj}

$$q_t^{nj} = z^{nj} \left(A_t^{nj} (h_t^{nj})^{\xi^n} (l_t^{nj})^{1-\xi^n} \right)^{\gamma^{nj}} \prod_{k=1}^{J} \left(M_t^{nj,nk} \right)^{\gamma^{nj,nk}}$$

- h = structures, owned by immobile rentiers, l is local labor
- $M_t^{nj,nk}$ = material inputs from k demanded by a firm in j
- All the γ sum to one; constant returns to scale

Intermediate goods: prices

- Denote $x_t^{nj}(r_t^{nj}, w_t^{nj}, \overline{P}_t^{nk})$ = unit cost of the input bundle
- Trade costs are icebergs: $\kappa_t^{nj,ij} \geq 1$
- The price of a variety of j in n is

$$p_t^{nj}(z^j) = \min_i \left\{ \frac{\kappa_t^{nj,ij} x_t^{ij}}{z^{ij}(A_t^{ij})^{\gamma^{ij}}} \right\}$$

- Where a variety is defined as $z^j = [z^{1j}, z^{2j}, \ldots z^{Nj}]$
- The joint distribution over z^j is

$$\phi^j(z^j) = \exp(-\sum_{n=1}^{N} (z^{nj})^{-\theta^j})$$

- Note that θ is only j specific

Local sectoral aggregate goods

- This good is an input into the intermediate goods production and consumed by the HH
- The **local sectoral good** purchases intermediate varieties from (potentially) all locations

$$Q_t^{nj} = \left(\int (\tilde{q}_t^{nj}(z^j))^{1-1/\eta^{nj}} d\phi^j(z^j) \right)^{\frac{\eta^{nj}}{\eta^{nj}-1}}$$

- Perfect competition, so nothing interesting here
- The share of total expenditure in *nj* on goods from *ij* is

$$\pi_t^{nj,ij} = \frac{(x_t^{ij} \kappa_t^{nj,ij})^{-\theta^j} (A_t^{ij})^{\theta^j \gamma^{ij}}}{\sum_{m=1}^{N} (x_t^{mj} \kappa_t^{nj,mj})^{-\theta^j} (A_t^{mj})^{\theta^j \gamma^{mj}}}$$

Market clearing

- Goods markets. X_t^{nj} is expenditure on j in n

$$X_t^{nj} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \pi_t^{ik,nk} X_t^{ik} + \alpha^j \left(\sum_{k=1}^{J} w_t^{nk} L_t^{nk} + \iota^n \chi_t \right)$$

- $\iota^n \chi_t$ is spending by the rentiers
- Labor markets.

$$L_t^{nj} = \frac{\gamma^{nj}(1 - \xi^n)}{w_t^{nj}} \sum_{i=1}^{N} \pi_t^{ij,nj} X_t^{ij}$$

- Structures. The supply of structures is fixed.

$$H^{nj} = \frac{\gamma^{nj} \xi^n}{r_t^{nj}} \sum_{i=1}^{N} \pi_t^{ij,nj} X_t^{ij}$$

Equilibrium

- Time varying *fundamentals*: $\Theta_t = (A_t^{nj}, \kappa_t^{nj,ij})$
- Constant fundamentals: $\overline{\Theta}_t = (\tau^{nj,ik}, H^{nj}, b^n)$
- A bunch of constant parameters: $\gamma^{nk,nj}, \xi^n, \alpha^j, \beta, \theta^j, \nu$
- A *temporary equilibrium*: given $(L_t, \Theta_t, \overline{\Theta})$, find wages and prices to solve the static "trade equilibrium"
- A *sequential equilibrium*: given $(L_0, \{\Theta_t\}, \overline{\Theta})$, find sequences of (L_t, μ_t, V_t) and wages and prices such that the dynamic household problems are solved and there is a temporary equilibrium at each time t
- A *stationary equilibrium* is a sequential equilibrium where (L_t, μ_t, V_t, w_t) are constant

Computation

- (at least) Two problems
  1. Want lots of labor markets $\rightarrow$ big state space
  2. Lots of parameters and fundamentals to identify
- Solve the model in “differences“ (exact hat algebra)
- In a static model, Dekle, Eaton, and Kortum (2008)
- Extend it here to a dynamic setting (a methodological contribution)
- Boils down to solving a nonlinear system
- Do not need to identify levels of fundamentals

Dynamic exact hat algebra

- Perfect foresight
- Let $\dot{y}_{t+1} = (y^1_{t+1}/y^1_t, \ldots,)$
- Prop 1: Given an allocation (L_t, π_t, X_t) we can solve for the **change** in the temporary equilibrium from $(\dot{L}_{t+1}, \dot{\Theta}_{t+1})$ without knowing the levels of the fundamentals
- Prop 2: Given an initial allocation $(L_0, \pi_0, X_0, \mu_{-1})$ we can solve for the sequential equilibrium (in changes) as long as $\lim_{t\to\infty} \dot{\Theta}_t = 1$ and utility is $\log$. We do not need to know the levels of fundamentals.
- Let $\hat{y}_{t+1} = (\dot{y}^{1\prime}_{t+1}/\dot{y}^1_t, \ldots,)$
- Prop 3: Given a baseline economy $\{L_t, \mu_{t-1}, \pi_t, X_t\}_{t=0}^{\infty}$ and a counterfactual sequence of convergent fundamentals $\hat{\Theta}_t$ we can solve for the counterfactual sequential equilibrium without knowing the levels of fundamentals.

The China shock counterfactual

- What would US labor markets look like if the China shock had not occurred?
- Model China shock as increase in A in Chinese manufacturing the increases imports into US as observed in data
- Step 1: Compute baseline economy in which China shock happens
  - Need data on: gross migration flows, trade, expenditures
  - Assume the economy converges to a steady state
- Step 2: Compute counterfactual economy in which productivity did not change (even though agents expected it to)
  - Need data on: Size of China shock relative to the baseline (a part of $\hat{\Theta}_t$)

Data and parameters

- 50 US states + 37 other countries + ROW; 22 sectors + non-employment
- Need data on: $\pi^{nj,ij}, w^{nj}L^{nj} + r^{nj}H^{nj}, \mu^{nj,ik}, L^{nj}$
- Need parameters: $\gamma^{nj,nk}, \xi^{n}, \alpha^{j}, \theta^{j}, \nu, \beta$

Migration

- No cross-country migration in the model
- In the US data, significant heterogeneity, persistence
- Estimate $1/\nu = 0.2$

TABLE I

U.S. INTERSTATE AND INTERSECTORAL LABOR MOBILITY[a]

Probability	p25	p50	p75
Changing sector but not state	3.58%	5.44%	7.93%
Changing state but not sector	0.04%	0.42%	0.73%
Changing state and sector	0.02%	0.03%	0.05%
Staying in the same state and sector	91.4%	93.9%	95.8%

[a] Quarterly transitions. Data sources: ACS and CPS.

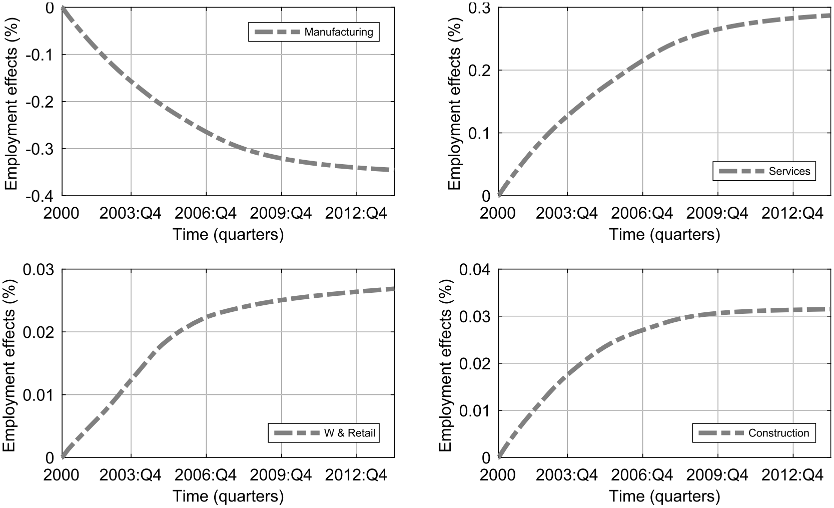
The China shock

- How much did Chinese imports in US change relative to other advanced economies

$$\Delta M_{US,j} = a_1 + a_2 \Delta M_{\text{other},j} + u_j$$

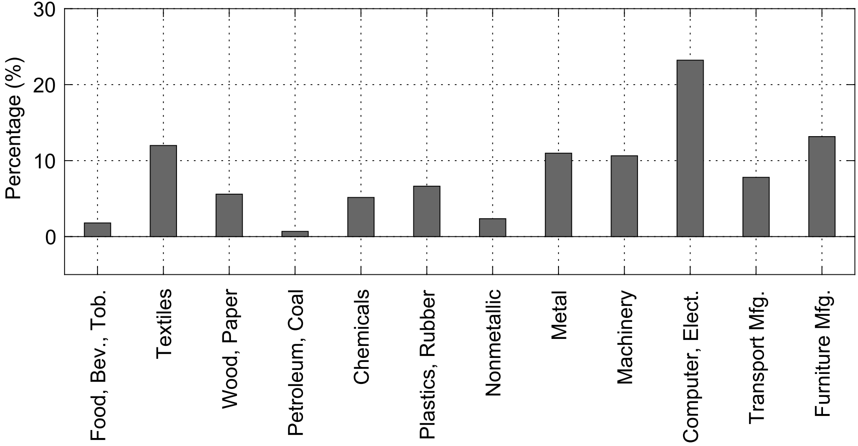
- j are the 12 manufacturing sectors, 2000–2007
- $\hat{a}_2 \Delta M_{\text{other},j}$ are the counterfactual imports — how much imports from China would have changed in the US if the China shock had not occurred
- Find $\{\hat{A}_t^{\text{China},j}\}_{j=1,t=2000}^{12,2007}$ so that in the counterfactual economy, US imports are matched with the counterfactual imports

China shock effect on total employment levels



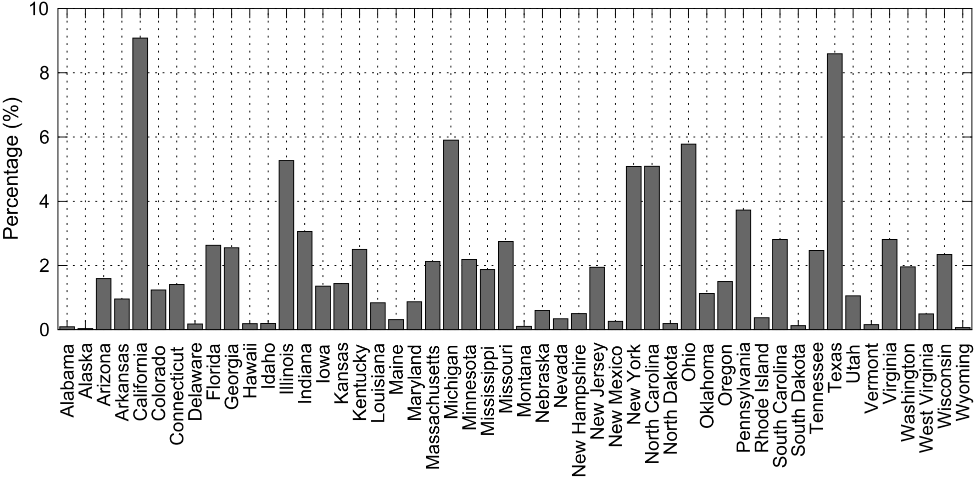
- Manufacturing falls, non-manufacturing rises

Contribution to total man. employment decline by industry



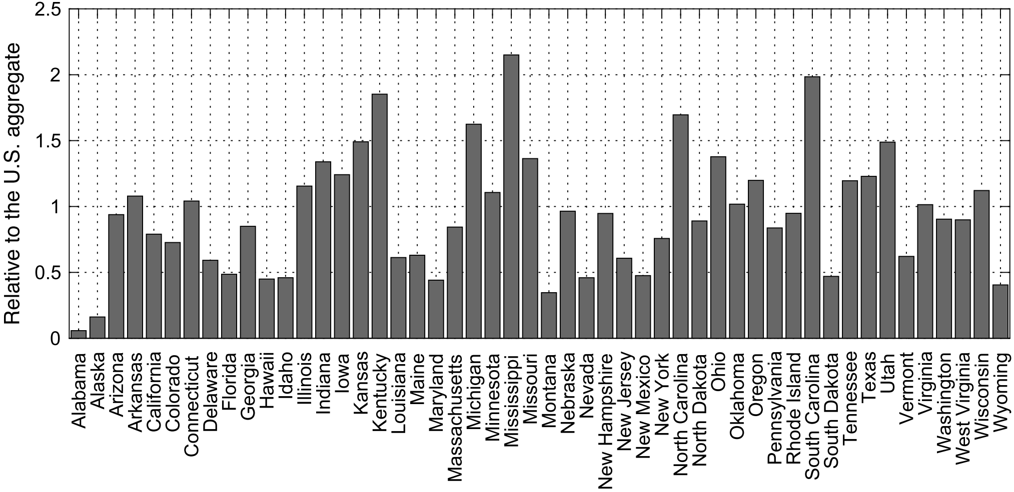
- More exposed industries (textiles, computers, furniture) contribute more
- I wish this was a scatter plot

Contribution to total man. employment decline by state



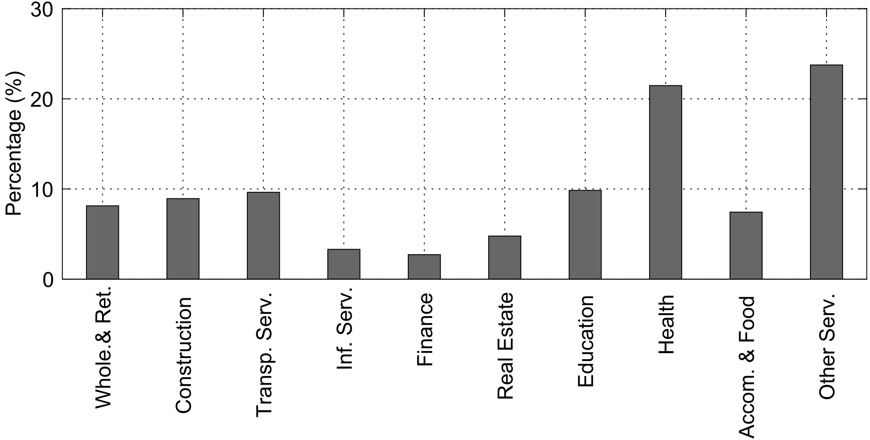
- Big states contribute the most

Contribution to total man. employment decline by state (normalized)



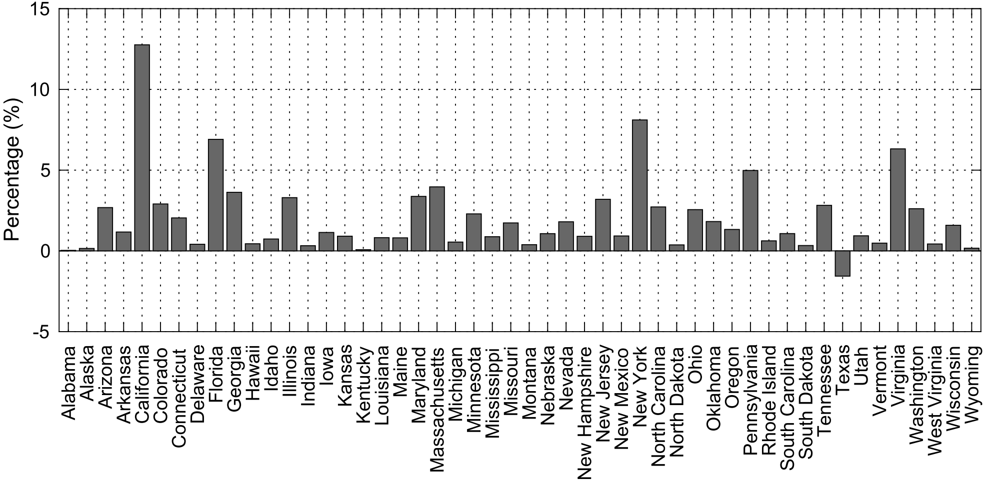
- Normalize by importance of industry in state employment
- If >1 disproportionately effected

Contribution to total non-man. employment increase by industry



- Other services…

Contribution to total non-man. employment increase by state

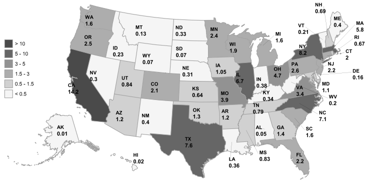


- Big places lost the most and gained the most, too

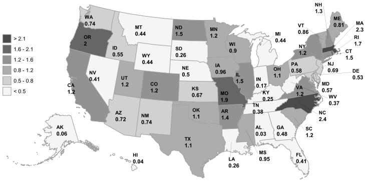
1. Contribution to industry employment decline in the U.S. (%)

2. Normalized by regional employment share

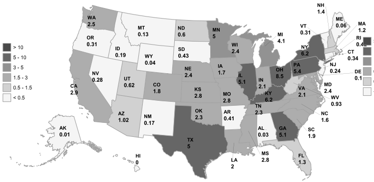
a.1: Computer and electronics



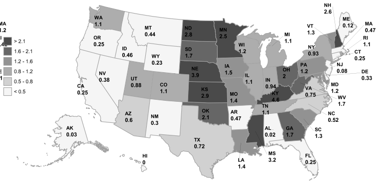
a.2: Computer and electronics



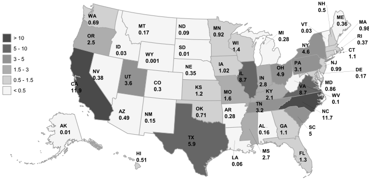
b.1: Machinery



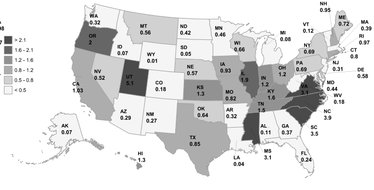
b.2: Machinery



c.1: Textiles

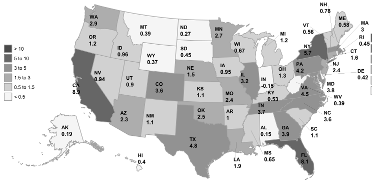


c.2: Textiles

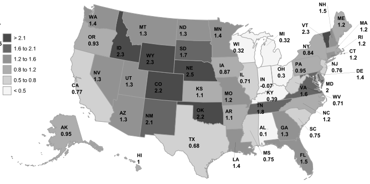


1. Contribution to industry employment increase in the U.S. (%) 2. Normalized by regional employment share

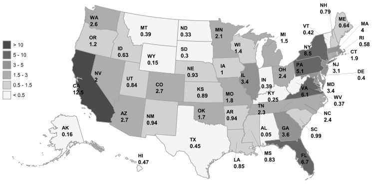
a.1: Construction



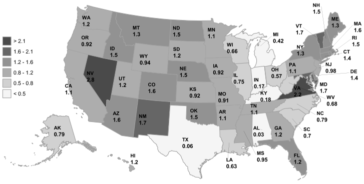
a.2: Construction



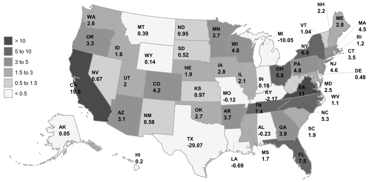
b.1: Services



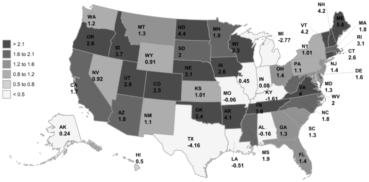
b.2: Services



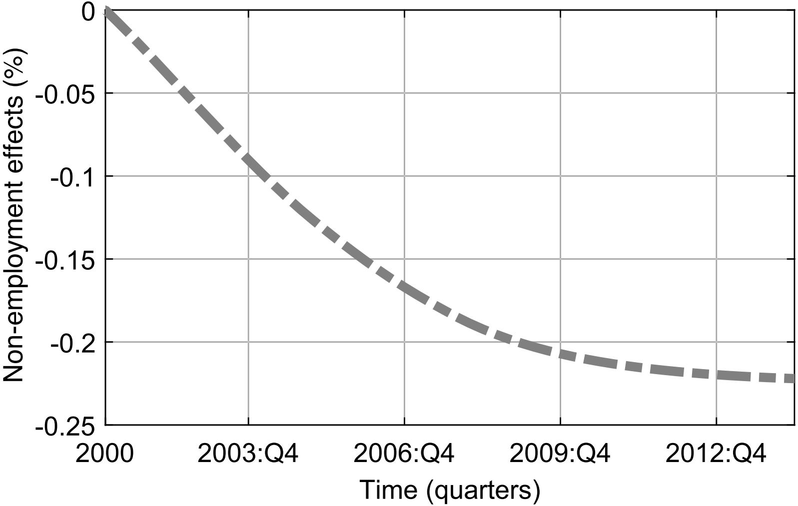
c.1: Whole. & Retail



c.2: Whole. & Retail



Growth in the non-employed sector



- Cheaper intermediate goods → boom in non-man. → growth in total employment

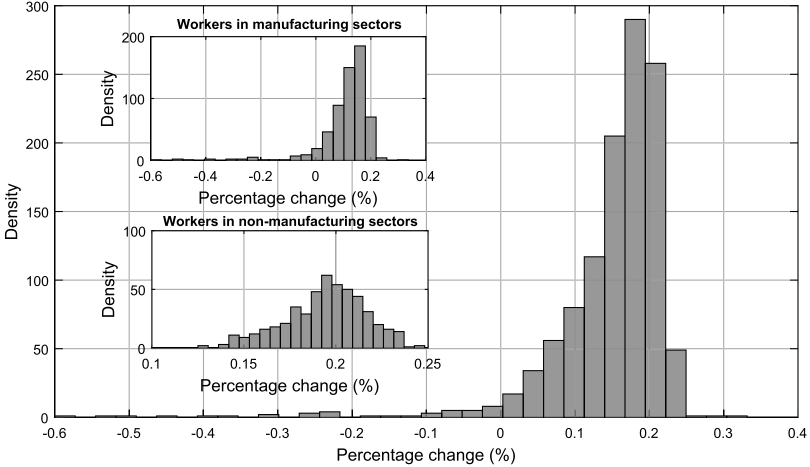
Welfare

- The compensating differential for a household in *nj*

$$\hat{W}^{nj} = \sum_{s=1}^{\infty} \beta^{s} \log \left(\frac{\hat{C}_{s}^{nj}}{\left(\hat{\mu}_{s}^{nj,nj}\right)^{\nu}} \right)$$

- Depends on difference in consumption if in *nj* and probabilities of staying in *nj*
- The μ have all the discounted value of changing labor market and behaving optimally thereafter
- Aggregate (employment-share weighted) welfare grows by 0.2 percent
- But welfare changes are heterogeneous

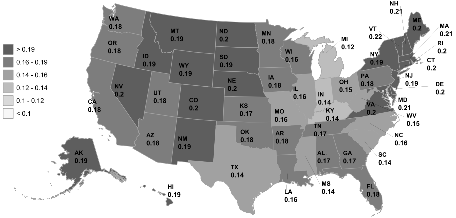
Welfare changes from China shock



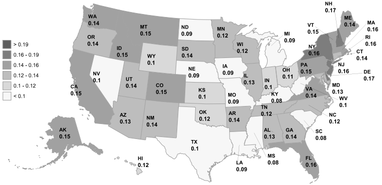
- More dispersion in manufacturing industries
- Not the same household in the sector before/after shock

Welfare changes from China shock

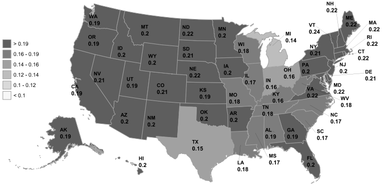
a.1: Regional



a.2: Manufacturing



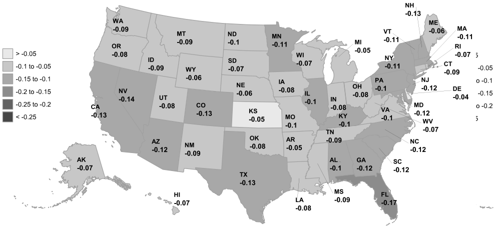
a.3: Non-manufacturing



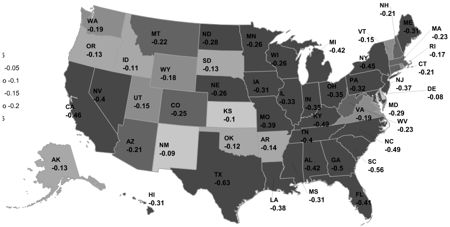
- Biggest winners in NE and Mountains, driven by non-manufacturing

Dynamics of the response (man. real wages)

a.1: One quarter after 2000



a.2: From 2000 to 2007



- Population distribution is only endogenous state variable
- Seven years later things are worse as adjustment is not complete
- Only in the long run is manufacturing doing better