

Lecture 7: Adding Dynamics in Labor Markets

Economics 552

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Caliendo, Dvorkin and Parro

- Aggregate trade shocks can have different disaggregate effects (across locations, sectors, locations-sectors) depending on
 - ▶ degree of exposure to foreign trade
 - ▶ indirect linkages through internal trade, sectoral trade
 - ▶ labor reallocation process - Migration
- Understanding and quantifying the effects of various shocks requires taking into account all these channels
- They develop a model of trade and labor market dynamics that explicitly recognizes the role of labor mobility frictions, goods mobility frictions, I-O linkages, geographic factors, and international trade

This paper

- Models with large # of unknown fundamentals: productivity, mobility frictions, trade frictions, and more...
- Propose a new method to solve dynamic discrete choice models
 - ▶ Solve the model and perform large scale counterfactuals without estimating *level* of fundamentals
 - ▶ By expressing the equilibrium conditions of the model in relative time differences
- Study how China's import competition impacted U.S. labor markets
 - ▶ 38 countries, 50 U.S. regions, and 22 sectors version of the model
 - ▶ Employment and welfare effects across more than 1000 labor markets
 - ★ Employment: approx. 0.8 MM manuf. jobs lost, reallocation to services
 - ★ Welfare: aggregate gains; very heterogeneous effects across labor markets; transition costs reflect the importance of dynamics

Literature

- Substantial progress in recent quantitative trade models, including Eaton and Kortum (2002) and its extensions: multiple sectors, spatial economics, and other extensions (example, Caliendo, Parro, Rossi-Hansberg, Sarte (2015))
 - ▶ One limitation is their stylized treatment of the labor market (static models, labor moves costlessly or does not move)
- We build on advances that underscore the importance of trade and labor market dynamics: Artuç and McLaren (2010), Artuç Chaudhuri and McLaren (2010), Dix-Carneiro (2014)
- Relates to dynamic discrete choice models in IO, labor, macro literature Rust(1987, 1994), Hotz and Miller (1993), Berry (1994), Kennan and Walker (2011)
- Relates to recent research on the labor market effects of trade
 - ▶ Because of direct import exposure: Autor, Dorn and Hanson (2013), and sectoral linkages: Acemoglu, Autor, Dorn and Hanson (2015), other channels Handley and Limao (2015) Pierce and Schott (2015)

Households' problem

- N locations (index n and i) and each has J sectors (index j and k)
- The value of a household in market nj at time t given by

$$v_t^{nj} = u(c_t^{nj}) + \max_{\{i,k\}_{i=1,k=0}^{N,J}} \left\{ \beta E \left[v_{t+1}^{ik} \right] - \tau^{nj,ik} + v \epsilon_t^{ik} \right\},$$

$$s.t. u(c_t^{nj}) \equiv \begin{cases} \log(b^n) & \text{if } j = 0, \\ \log(w_t^{nj} / P_t^n) & \text{otherwise,} \end{cases}$$

- ▶ $\beta \in (0, 1)$ discount factor
- ▶ $\tau^{nj,ik}$ additive, *time invariant* migration costs to ik from nj
- ▶ ϵ_t^{ik} are stochastic *i.i.d idiosyncratic* taste shocks
 - ★ $\epsilon \sim$ Type-I Extreme Value distribution with zero mean
 - ★ $v > 0$ is the dispersion of taste shocks
- *Unemployed* obtain home production b^n
- *Employed* households supply a unit of labor inelastically
 - ▶ Receive the competitive market wage w_t^{nj}
 - ▶ Consume $c_t^{nj} = \prod_{k=1}^J (c_t^{nj,k})^{\alpha^k}$, where P_t^n is the local price index

Households' problem - Dynamic discrete choice

- Using properties of Type-I Extreme Value distributions one obtains:
- The expected (expectation over ϵ) lifetime utility of a worker at nj

$$V_t^{nj} = u(c_t^{nj}) + v \log \left[\sum_{i=1}^N \sum_{k=0}^J \exp \left(\beta V_{t+1}^{ik} - \tau^{nj,ik} \right)^{1/v} \right]$$

- Fraction of workers that reallocate from market nj to ik

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

- Evolution of the distribution of labor across markets

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

► Frechet and Multiplicative costs

Production - Static sub-problem

- Notice that at each t , labor supply across markets is fully determined
 - ▶ We can then solve for wages such that labor markets clear, using a very rich static spatial structure (CPRHS 2015)
- In each n, j there is a continuum of intermediate good producers with technology as in Eaton and Kortum (2002)
 - ▶ Perfect competition, CRS technology, *idiosyncratic* productivity $z^{nj} \sim \text{Fréchet}(1, \theta^j)$, deterministic sectoral regional TFP A^{nj}

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

- Each n, j produces a final good (for final consumption and materials)
 - ▶ CES (elasticity η) aggregator of sector j goods from the lowest cost supplier in the world subject to $\kappa^{nj, ij} \geq 1$ “iceberg” bilateral trade cost

▶ Intermediate goods

▶ Final goods

Production - Static sub-problem - Equilibrium conditions

- Sectoral price index,

$$P_t^{nj}(\mathbf{w}_t) = \Gamma^{nj} \left[\sum_{i=1}^N A^{ij} [x_t^{ij}(\mathbf{w}_t) \kappa^{nj,ij}]^{-\theta^j} \right]^{-1/\theta^j}$$

- Let $X_t^{ij}(\mathbf{w}_t)$ be total expenditure. Expenditure shares given by

$$\pi_t^{nj,ij}(\mathbf{w}_t) = \frac{[x_t^{ij}(\mathbf{w}_t) \kappa^{nj,ij}]^{-\theta^j} A^{ij}}{\sum_{m=1}^N [x_t^{mj}(\mathbf{w}_t) \kappa^{nj,mj}]^{-\theta^j} A^{mj}},$$

where $x_t^{ij}(\mathbf{w}_t)$ is the unit cost of an input bundle

- Labor Market clearing

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

where $\gamma^{nj}(1 - \zeta^n)$ labor share

Sequential and temporary equilibrium

- State of the economy = distribution of labor $L_t = \{L_t^{nj}\}_{n=1,j=0}^{N,J}$
 - ▶ Let $\Theta \equiv (\{A^{nj}\}, \{\kappa^{nj,ij}\}, \{\tau^{nj,ik}\}, \{H^{nj}\}, \{b^n\})_{n=1,j=0,i=1,k=0}^{N,J,J,N}$

Definition

Given (L_t, Θ) , a **temporary equilibrium** is a vector of $w_t(L_t, \Theta)$ that satisfies the equilibrium conditions of the static sub-problem

Definition

Given (L_0, Θ) , a **sequential competitive equilibrium** of the model is a sequence of $\{L_t, \mu_t, V_t, w_t(L_t, \Theta)\}_{t=0}^{\infty}$ that solves HH dynamic problem and the temporary equilibrium at each t

- With $\mu_t = \{\mu_t^{nj,ik}\}_{n=1,j=0,i=1,k=0}^{N,J,J,N}$, and $V_t = \{V_t^{nj}\}_{n=1,j=0}^{N,J}$

Solving the model

- Solving for an equilibrium of the model requires information on Θ
 - ▶ Large # of unknowns $N + 2NJ + N^2J + N^2J^2$
 - ▶ Productivity, endowments of local structures, labor mobility costs, home production, and trade costs
- As we increase the dimension of the problem—adding countries, regions, or sectors—the number of parameters grows geometrically
- We solve this problem by computing the equilibrium dynamics of the model in time differences
- Why is this progress?
 - ▶ As in DEK (2008), CP (2015), and CRC (2015) by conditioning on observables one can solve the model without knowing the *levels* of Θ
 - ★ We apply this idea to a dynamic economy
 - ▶ Condition on last period migration flows, trade flows, and production
 - ★ Solve for the value function in time differences

Equilibrium conditions

- Expected lifetime utility

$$V_t^{nj} = \log\left(\frac{w_t^{nj}}{p_t^n}\right) + \nu \log \left[\sum_{i=1}^N \sum_{k=0}^J \exp\left(\beta V_{t+1}^{ik} - \tau^{nj,ik}\right)^{1/\nu} \right]$$

- Transition matrix (migration flows)

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

Equilibrium conditions

- Transition matrix (migration flows) at $t = -1$, Data

$$\mu_{-1}^{nj,ik} = \frac{\exp(\beta V_0^{ik} - \tau^{nj,ik})^{1/v}}{\sum_{m=1}^N \sum_{h=0}^J \exp(\beta V_0^{mh} - \tau^{nj,mh})^{1/v}}$$

- Transition matrix (migration flows) at $t = 0$, Model

$$\mu_0^{nj,ik} = \frac{\exp(\beta V_1^{ik} - \tau^{nj,ik})^{1/v}}{\sum_{m=1}^N \sum_{h=0}^J \exp(\beta V_1^{mh} - \tau^{nj,mh})^{1/v}}$$

- Take the time difference

$$\frac{\mu_0^{nj,ik}}{\mu_{-1}^{nj,ik}} = \frac{\frac{\exp(\beta V_1^{ik} - \tau^{nj,ik})^{1/v}}{\exp(\beta V_0^{ik} - \tau^{nj,ik})^{1/v}}}{\sum_{m=1}^N \sum_{h=0}^J \frac{\exp(\beta V_1^{mh} - \tau^{nj,mh})^{1/v}}{\sum_{m'=1}^N \sum_{h'=0}^J \exp(\beta V_0^{m'h'} - \tau^{nj,m'h'})^{1/v}}}$$

Equilibrium conditions

- Take the time difference

$$\frac{\mu_0^{nj,ik}}{\mu_{-1}^{nj,ik}} = \frac{\frac{\exp(\beta V_1^{ik} - \tau^{nj,ik})^{1/v}}{\exp(\beta V_0^{ik} - \tau^{nj,ik})^{1/v}}}{\sum_{m=1}^N \sum_{h=0}^J \frac{\exp(\beta V_1^{mh} - \tau^{nj,mh})^{1/v}}{\sum_{m'=1}^N \sum_{h'=0}^J \exp(\beta V_0^{m'h'} - \tau^{nj,m'h'})^{1/v}}}$$

- Simplify

$$\frac{\mu_0^{nj,ik}}{\mu_{-1}^{nj,ik}} = \frac{\exp(V_1^{ik} - V_0^{ik})^{\beta/v}}{\sum_{m=1}^N \sum_{h=0}^J \frac{\exp(\beta V_1^{mh} - \tau^{nj,mh})^{1/v}}{\sum_{m'=1}^N \sum_{h'=0}^J \exp(\beta V_0^{m'h'} - \tau^{nj,m'h'})^{1/v}}}$$

- Use $\mu_{-1}^{nj,mh}$ once again

$$\mu_0^{nj,ik} = \frac{\mu_{-1}^{nj,ik} \exp(V_1^{ik} - V_0^{ik})^{\beta/v}}{\sum_{m=1}^N \sum_{h=0}^J \mu_{-1}^{nj,mh} \exp(V_1^{mh} - V_0^{mh})^{\beta/v}}$$

Equilibrium conditions

- Expected lifetime utility

$$V_t^{nj} = \log\left(\frac{w_t^{nj}}{P_t^n}\right) + \nu \log \left[\sum_{i=1}^N \sum_{k=0}^J \exp\left(\beta V_{t+1}^{ik} - \tau^{nj,ik}\right)^{1/\nu} \right]$$

- Transition matrix

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

Equilibrium conditions - Time differences

- Expected lifetime utility

$$V_{t+1}^{nj} - V_t^{nj} = \log\left(\frac{w_{t+1}^{nj}/w_t^{nj}}{P_{t+1}^n/P_t^n}\right) + \nu \log \left[\sum_{i=1}^N \sum_{k=0}^J \mu_t^{nj,ik} \exp\left(V_{t+2}^{ik} - V_{t+1}^{ik}\right)^{\beta/\nu} \right]$$

- Transition matrix

$$\frac{\mu_{t+1}^{nj,ik}}{\mu_t^{nj,ik}} = \frac{\exp\left(V_{t+2}^{ik} - V_{t+1}^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^N \sum_{h=0}^J \mu_t^{nj,mh} \exp\left(V_{t+2}^{mh} - V_{t+1}^{mh}\right)^{\beta/\nu}}$$

where $\frac{w_{t+1}^{nj}/w_t^{nj}}{P_{t+1}^n/P_t^n}$ is the solution to the temporary equilibrium in time differences

Temporary equilibrium conditions

How to solve for the temporary equilibrium in time differences?

- Price index

$$P_t^{nj}(\mathbf{w}_t) = \Gamma^{nj} \left[\sum_{i=1}^N A^{ij} [x_t^{ij}(\mathbf{w}_t) \kappa^{nj,ij}]^{-\theta^j} \right]^{-1/\theta^j},$$

- Trade shares

$$\pi_t^{nj,ij}(\mathbf{w}_t) = \frac{[x_t^{ij}(\mathbf{w}_t) \kappa^{nj,ij}]^{-\theta^j} A^{ij}}{\sum_{m=1}^N [x_t^{mj}(\mathbf{w}_t) \kappa^{nj,mj}]^{-\theta^j} A^{mj}},$$

Temporary equilibrium - Time differences

How to solve for the temporary equilibrium in time differences?

- Price index

$$\hat{P}_{t+1}^{nj}(\hat{\mathbf{w}}_{t+1}) = \left[\sum_{i=1}^N \pi_t^{nj,ij} [\hat{x}_{t+1}^{ij}(\hat{\mathbf{w}}_{t+1})]^{-\theta^j} \right]^{-1/\theta^j},$$

- Trade shares

$$\pi_{t+1}^{nj,ij}(\hat{\mathbf{w}}_{t+1}) = \frac{\pi_t^{nj,ij} [\hat{x}_{t+1}^{ij}(\hat{\mathbf{w}}_{t+1})]^{-\theta^j}}{\sum_{m=1}^N \pi_t^{nj,mj} [\hat{x}_{t+1}^{mj}(\hat{\mathbf{w}}_{t+1})]^{-\theta^j}},$$

- Where $\hat{P}_{t+1}^{nj} = P_{t+1}^{nj} / P_t^{nj}$, $\hat{x}_{t+1}^{ij} = x_{t+1}^{ij} / x_t^{ij}$, $\hat{\mathbf{w}}_{t+1} = \mathbf{w}_{t+1} / \mathbf{w}_t$
- Same “hat trick” applies to all equilibrium conditions

Solving the model

Proposition

Given $(L_0, \mu_{-1}, \pi_0, VA_0, GO_0)$, (ν, θ, β) , solving the equilibrium in time differences does not require the level of Θ , and solves

$$Y_{t+1}^{nj} = (\hat{w}_{t+1}^{nj} / \hat{P}_{t+1}^n)^{1/\nu} \sum_{i=1}^N \sum_{k=0}^J \mu_t^{nj,ik} [Y_{t+2}^{ik}]^\beta,$$

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik} [Y_{t+2}^{ik}]^\beta}{\sum_{m=1}^N \sum_{h=0}^J \mu_t^{nj,mh} [Y_{t+2}^{mh}]^\beta},$$

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

where $\hat{w}_{t+1}^{nj} / \hat{P}_{t+1}^n$ solves the temporary equilibrium given \hat{L}_{t+1} , where $Y_{t+1}^{ik} \equiv \exp(V_{t+1}^{ik} - V_t^{ik})^{1/\nu}$.

► Example

Solving for counterfactuals

- Want to study the effects of changes in fundamentals $\hat{\Theta} = \Theta' / \Theta$
 - ▶ Recall that $\Theta \equiv (\{A^{nj}\}, \{\kappa^{nj,ij}\}, \{\tau^{nj,ik}\}, \{H^{nj}\}, \{b^n\})_{n=1, j=0, i=1, k=0}^{N, J, J, N}$
 - ▶ TFP, trade costs, labor migration costs, endowments of local structures, home production
- We can use our solution method to study the effects of changes in Θ
 - ▶ One by one or jointly
 - ▶ Changes across time and space

▶ Proposition

Welfare gains: Sufficient Statistic

- Let $W_t^{nj}(\hat{\Theta})$ be the welfare effect of change in $\hat{\Theta} = \Theta' / \Theta$
- One sector model with no materials and structures, $\hat{c}_t^n = \hat{w}_t^n / \hat{P}_t^n$

$$W_0^n(\hat{\Theta}) = \sum_{t=0}^{\infty} \beta^t \log \frac{(\hat{\pi}_t^{n,n})^{-1/\theta}}{(\hat{\mu}_t^{n,n})^\nu} = \frac{\text{gains from trade}}{\text{gains from migration}}$$

where $\hat{\mu}_t^{n,n}$ captures the change in the option value of migration

- Summarizes welfare equations in static trade models, ACR (2010), and dynamic models with exogenous trade as in ACM (2012)
- Sufficient statistic to measure welfare gains from trade and migration relative to autarky $\pi_t^{n,n} = 1$ and no migration $\mu_t^{n,n} = 1$

Application: The Rise of China

- U.S. imports from China almost doubled from 2000 to 2007
 - ▶ At the same time, manufacturing employment fell while employment in other sectors, such as construction and services, grew
- Several studies document that an important part of the employment loss in manufactures was a consequence of China's trade expansion
 - ▶ e.g., Pierce and Schott (2012); Autor, Dorn, and Hanson (2013), Acemoglu, Autor, Dorn, and Hanson (2014)
- We use our model, and apply our method, to quantify and understand the effects of the rise of China's trade expansion, "China shock"
 - ▶ Initial period is the year 2000
 - ▶ We calculate the sectoral, regional, and aggregate employment and welfare effects of the China shock

Identifying the China shock

- Follow Autor, Dorn, and Hanson (2013)

- ▶ We estimate

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

where j is a NAICS sector, $\Delta M_{USA,j}$ and $\Delta M_{other,j}$ are changes in U.S. and other adv. countries, imports from China from 2000 to 2007

- ▶ Find $a_2 = 1.27$

- Obtain predicted changes in U.S. imports with this specification
- Use the model to solve for the change in China's 12 manufacturing industries

TFP $\left\{ \hat{A}^{China,j} \right\}_{j=1}^{12}$ such that model's imports match predicted imports from China from 2000 to 2007

- ▶ With model's generated data obtain $a_2 = 1.52$
- ▶ We feed in to our model $\left\{ \hat{A}^{China,j} \right\}_{j=1}^{12}$ by quarter from 2000 to 2007 to study the effects of the shock

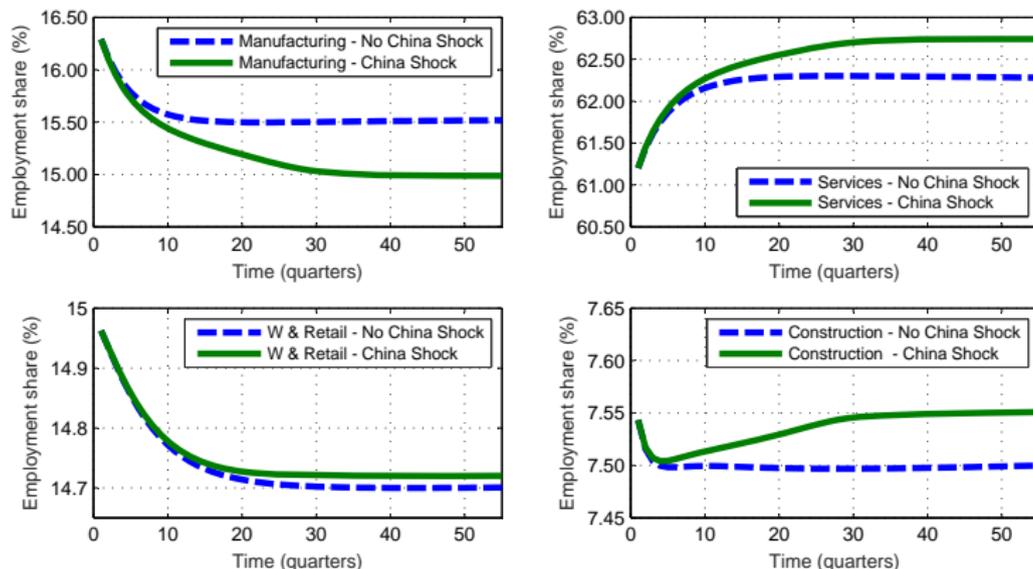
▶ Figure: shock and predicted imports

Taking the model to the data (quarterly)

- Model with 50 U.S. states, 22 sectors + unempl. and 38 countries
 - ▶ More than 1000 labor markets
- Need data for $(L_0, \mu_{-1}, \pi_0, VA_0, GO_0)$
 - ▶ L_0 : PUMS of the U.S. Census for the year 2000
 - ▶ μ_{-1} : Use CPS to compute intersectoral mobility and ACS to compute interstate mobility [▶ Details](#) [▶ Table](#)
 - ▶ π_0 : CFS and WIOD year 2000
 - ▶ VA_0 and GO_0 : BEA VA shares and U.S. IO, WIOD for other countries
- Need values for parameters (ν, θ, β)
 - ▶ θ : We use Caliendo and Parro (2015)
 - ▶ $\beta = 0.99$ Implies approximately a 4% annual interest rate
 - ▶ $\nu = 5.34$ (implied elasticity of 0.2) Using ACM's data and specification, adapted to our model [▶ Estimation](#)
- Need to deal with trade deficits. Do so similar to CPRHS [▶ Imbalances](#)

Employment effects

Figure: The Evolution of Employment Shares



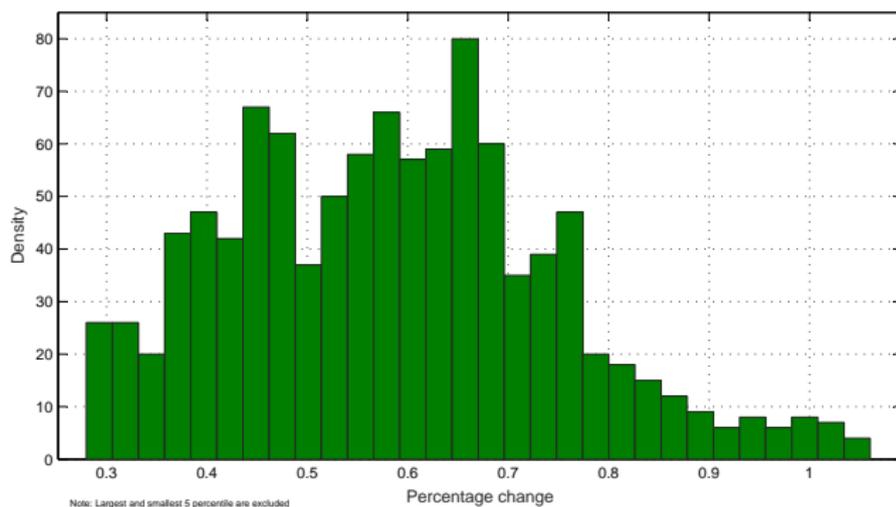
- Chinese competition reduced the share of manufacturing employment by 0.5% in the long run, ~ 0.8 million employment loss
 - ▶ About 50% of the change not explained by a secular trend

Manufacturing employment effects

- Sectors most exposed to Chinese import competition contribute more
 - ▶ 1/2 of the decline in manuf. employment originated in the Computer & Electronics and Furniture sectors ▶ Sectoral contributions
 - ★ 1/4 of the total decline comes from the Metal and Textiles sectors
 - ▶ Food, Beverage and Tobacco, gained employment
 - ★ Less exposed to China, benefited from cheaper intermediate goods, other sectors, like Services, demanded more of them (I-O linkages)
- Unequal regional effects ▶ Spatial distribution
 - ▶ Regions with a larger concentration of sectors that are more exposed to China lose more jobs ▶ Regional contributions
 - ★ California, the region with largest share of employment in Computer & Electronics, contributed to about 12% of the decline

Welfare effects across labor markets

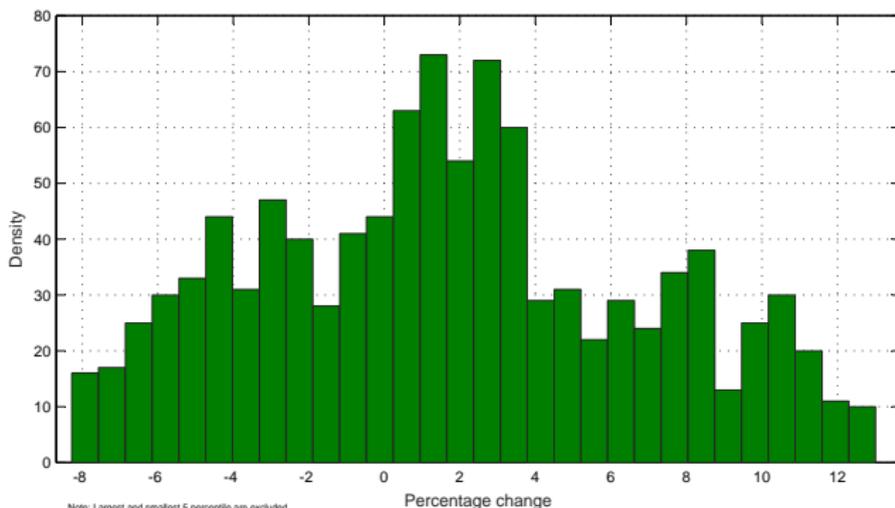
Figure: Welfare changes across labor markets



- Very heterogeneous response to the same aggregate shock ▶ welfare
 - ▶ Most labor markets gain as a consequence of cheaper imports from China
 - ▶ Unequal regional effects ▶ welfare reg

Transition cost to the steady state

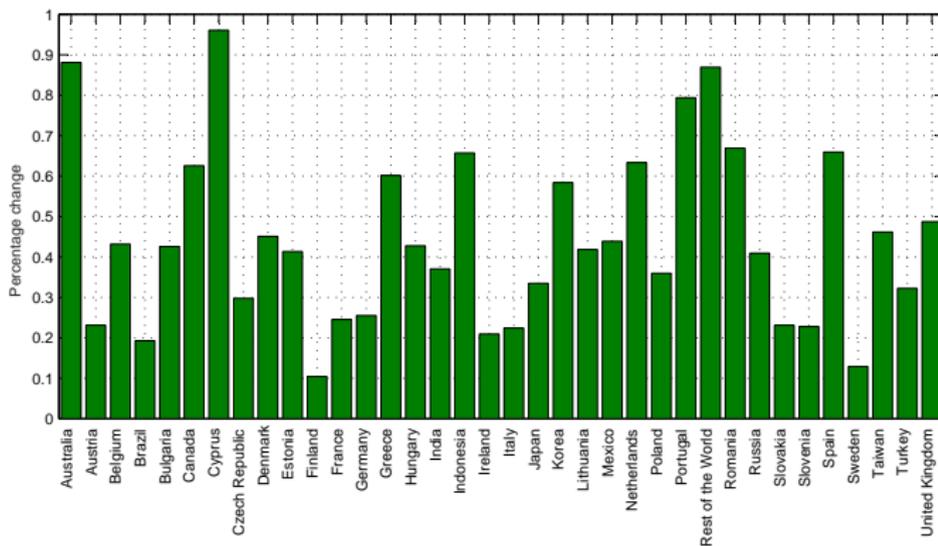
Figure: Transition cost to the steady state across labor markets



- Adjustment costs reflect the importance of labor market dynamics
 - ▶ With free labor mobility $AC=0$
- Heterogeneity shaped by trade and migration frictions as well as geographic factors.

Welfare effects across countries

Figure: Welfare effects across countries



Conclusion

- Develop a dynamic and spatial model to quantify the disaggregate effects of aggregate shocks
- Show how to perform counterfactual analysis in a very rich spatial model without having to estimate a large set of unobservables
- Dynamics and realistic structure matters for capturing very heterogenous effects at the disaggregate level
- Their model can be applied to answer a broader set of questions: changes in productivity or trade costs in any location in the world, commercial policies, and more...

Supplementary Material

Results with Fréchet and Multiplicative Costs

- Expected lifetime utility

$$V_t^{n,j} = u(c_t^{n,j}) + \left(\sum_{i=1}^N \sum_{k=0}^J \left(\beta V_{t+1}^{i,k} \tau^{n,j;i,k} \right)^{1/\nu} \right)^\nu,$$

- Measure of workers that reallocate (Choice equation)

$$\mu_t^{n,j;i,k} = \frac{\left(\beta V_{t+1}^{i,k} \tau^{n,j;i,k} \right)^{1/\nu}}{\sum_{m=1}^N \sum_{h=0}^J \left(\beta V_{t+1}^{m,h} \tau^{n,j;m,h} \right)^{1/\nu}}.$$

▶ Back

Information in CPS and ACS

		State A				State B			
		Ind 1	Ind 2	...	Ind J	Ind 1	Ind 2	...	Ind J
State A	Ind 1	x	x	...	x				
	Ind 2	x	x	...	x				
				
	Ind J	x	x		x				
	Total	y	y	...	y	y	y	...	y
State B	Ind 1					x	x	...	x
	Ind 2					x	x	...	x

	Ind J					x	x		x
	Total	y	y	...	y	y	y	...	y

▶ Back

Model - Intermediate goods

- Representative firms in each region n and sector j produce a continuum of intermediate goods with *idiosyncratic* productivities z^{nj}
 - ▶ Drawn independently across goods, sectors, and regions from a Fréchet distribution with shape parameter θ^j
 - ▶ Productivity of all firms is also determined by a deterministic productivity level A^{nj}
- The production function of a variety with z^{nj} and A^{nj} is given by

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

with $\sum_{k=1}^J \gamma^{nj,nk} = 1 - \gamma^{nj}$

Model - Intermediate good prices

- The cost of the input bundle needed to produce varieties in (nj) is

$$x_t^{nj} = B^{nj} \left[\left(r_t^{nj} \right)^{\zeta^n} \left(w_t^{nj} \right)^{1-\zeta^n} \right]^{\gamma^{nj}} \prod_{k=1}^J [P_t^{nk}]^{\gamma^{nj, nk}}$$

- The unit cost of a good of a variety with draw z^{nj} in (nj) is

$$\frac{x_t^{nj}}{z^{nj}} [A^{nj}]^{-\gamma^{nj}}$$

and so its price under competition is given by

$$p_t^{nj}(z^j) = \min_i \left\{ \frac{\kappa^{nj, ij} x_t^{ij}}{z^{ij} [A^{ij}]^{\gamma^{ij}}} \right\},$$

with $\kappa^{nj, ij} \geq 1$ are “iceberg” bilateral trade cost

Model - Final goods

- The production of final goods is given by

$$Q_t^{nj} = \left[\int_{\mathbb{R}_{++}^N} [\tilde{q}_t^{nj}(z^j)]^{1-1/\eta^{nj}} \phi^j(z^j) dz^j \right]^{\eta^{nj}/(\eta^{nj}-1)},$$

where $z^j = (z^{1j}, z^{2j}, \dots, z^{Nj})$ denotes the vector of productivity draws for a given variety received by the different n

- The resulting price index in sector j and region n , given our distributional assumptions, is given by

$$P_t^{nj} = \varrho \left[\sum_{i=1}^N [x_t^{ij} \kappa^{nj,ij}]^{-\theta^j} [A^{ij}]^{\theta^j \gamma^{ij}} \right]^{-1/\theta^j},$$

where ϱ is a constant

Data - Quarterly gross flows

- Current Population Survey (CPS) monthly frequency
 - ▶ Information on intersectoral mobility
 - ▶ Source of official labor market statistics
 - ▶ We match individuals surveyed three months apart and compute their employment (industry) or unemployment status
 - ★ Our 3-month match rate is close to 90%
- American Community Survey (ACS) to compute interstate mobility
 - ▶ Representative sample (0.5 percent) of the U.S. population for 2000
 - ▶ Mandatory and is a complement to the decennial Census
 - ▶ Information on current state and industry (or unemployment) and state they lived during previous year
 - ▶ Limitation: no information on workers past employment status or industry

▶ Table

▶ Back

Data - Quarterly gross flows

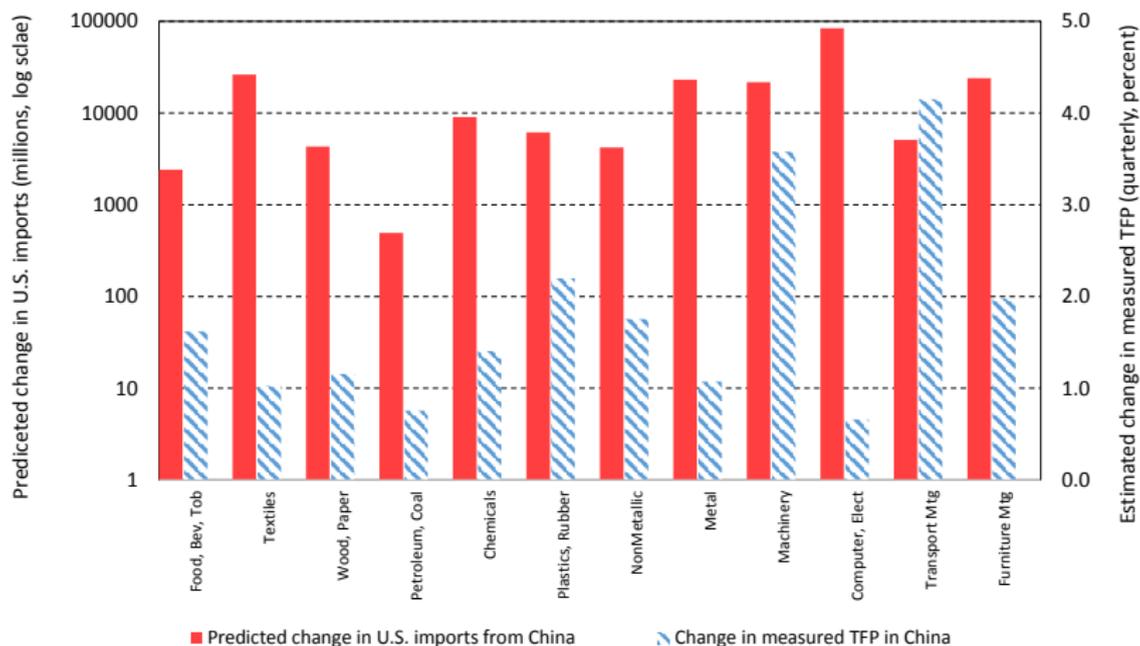
Table: U.S. interstate and intersectoral labor mobility

Probability	p25	p50	p75
Changing j in same n	3.74%	5.77%	8.19%
Changing n but not j	0.04%	0.42%	0.73%
Changing j and n	0.03%	0.04%	0.06%
Staying in same j and n	91.1%	93.6%	95.2%

Note: Quarterly transitions. Data sources: ACS and CPS

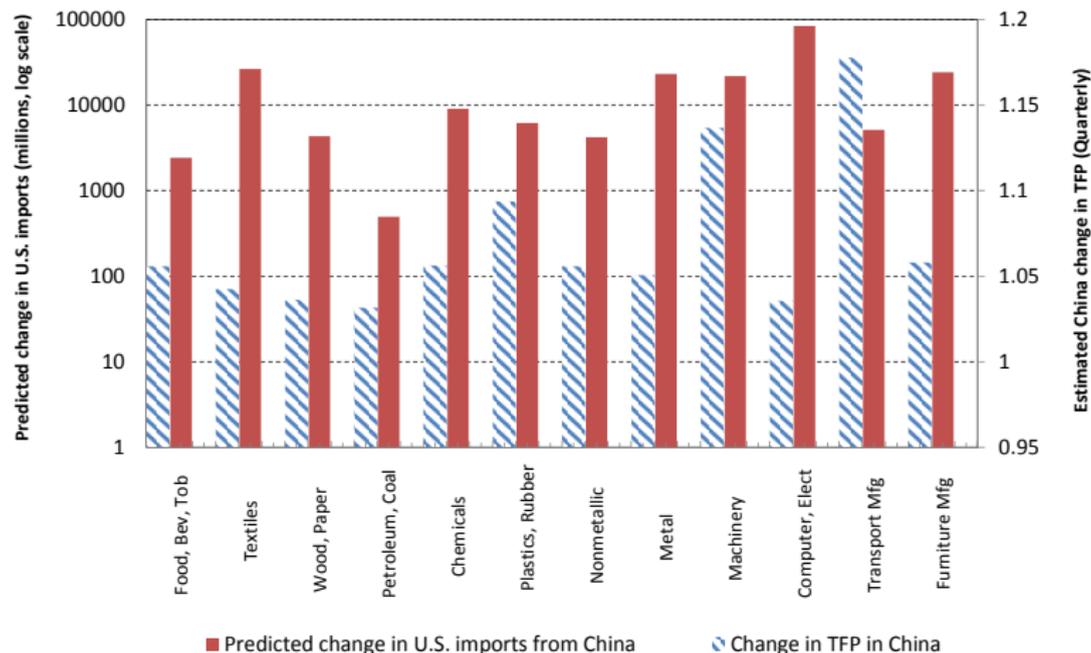
Identifying the China shock

Figure: Predicted change in imports vs. model-based Chinese TFP change



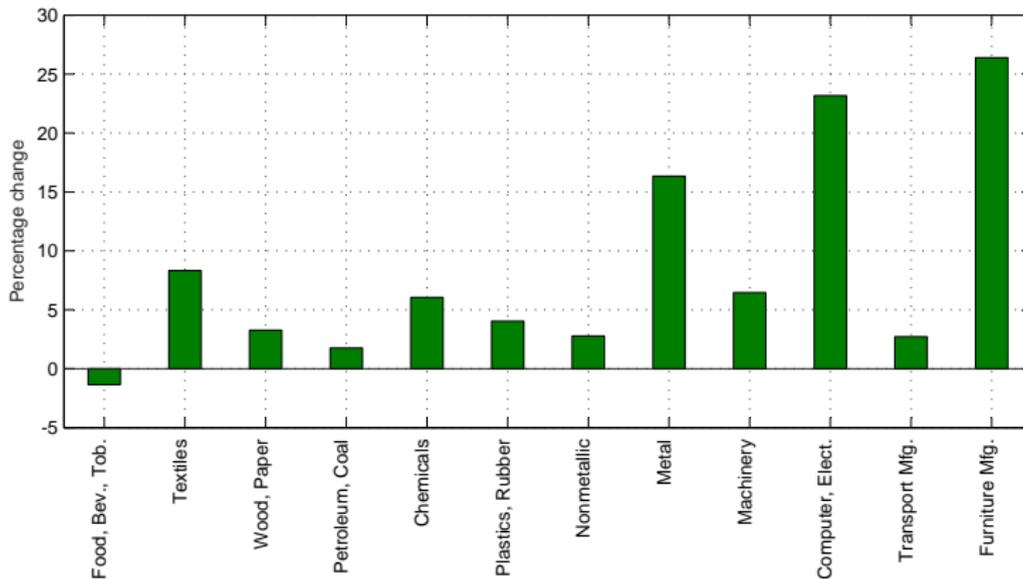
Identifying the China shock

Figure: Predicted change in imports vs. model-based Chinese TFP change



Manufacturing Employment Effects

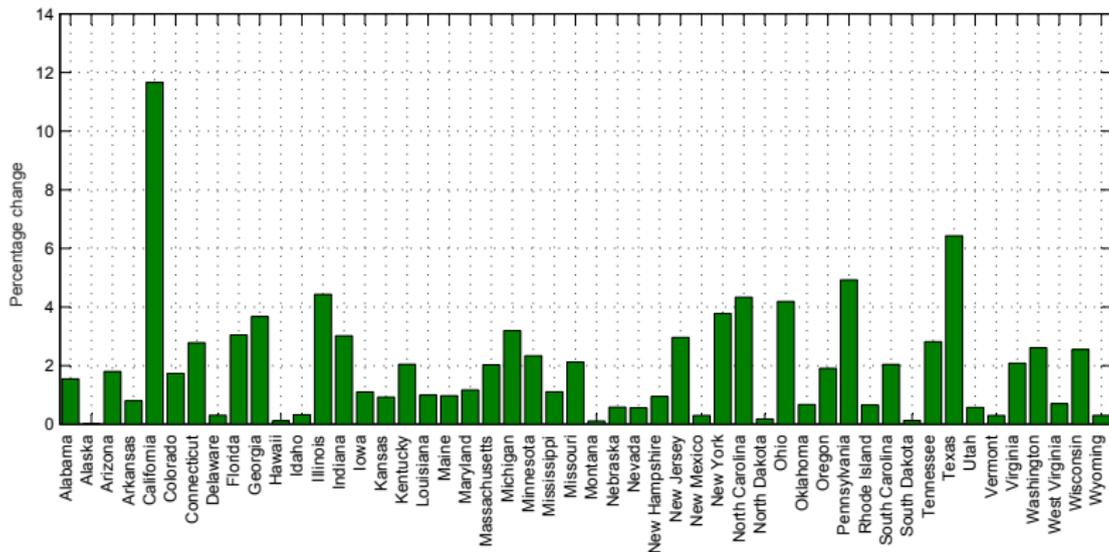
Figure: Sectoral contribution to the change in manuf. employment



▶ Back

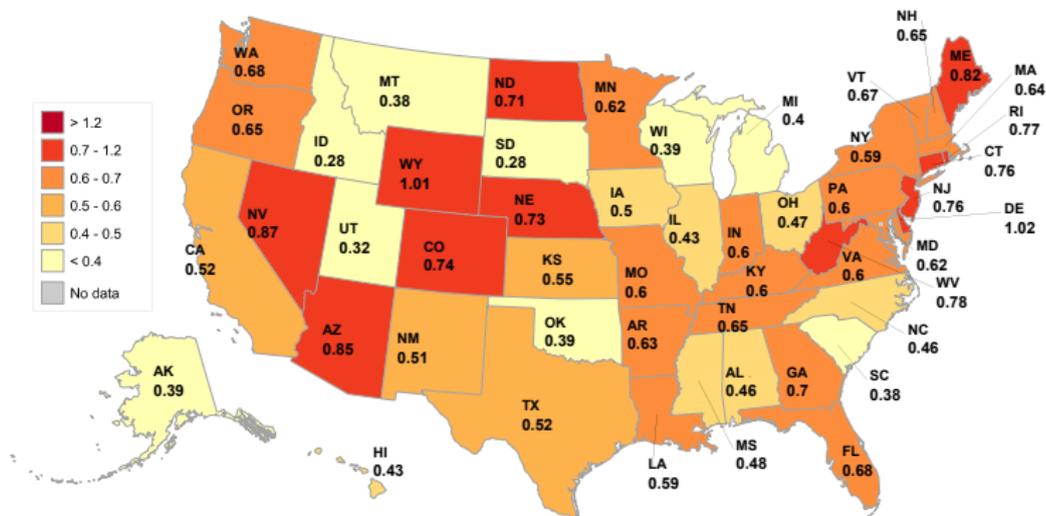
Manufacturing employment effects

Figure: Regional contribution to the change in manuf. employment



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Regional welfare effects



▶ Back

Sectoral and regional welfare effects

- Sectoral effects very different in the long run than in the short run
 - ▶ Services and Construction gain the most ▶ Sectoral effects
 - ★ Reasons: no direct exposure, benefit from cheaper intermediate inputs, increased inflow of workers from manufacturing
 - ▶ Welfare gains are more uniform in the long run
 - ★ Workers reallocate from depressed industries
- U.S. regions fare better in the short and the long run ▶ Regional effects
 - ▶ Regions benefit directly from cheaper intermediate goods from China
 - ★ and indirectly from the effect of imports on the cost of inputs purchased from other U.S. regions
 - ▶ The regional welfare distribution is more uniform in the long run
 - ★ workers reallocate from regions with lower real income
- Worst off individual labor markets
 - ▶ ★ Wood and Paper in Nevada, Transport and Equip. in Louisiana, and Wholesale and Retail in Alaska

Solving the model

Proposition

Given $(L_0, \mu_{-1}, \pi_0, VA_0, GO_0)$, (ν, θ, β) , and $\hat{\Theta} = \{\hat{\Theta}_t\}_{t=1}^{\infty}$, solving the equilibrium in time differences does not require Θ , and solves

$$Y_{t+1}^{nj} = (\tilde{w}_{t+1}^{nj} / \tilde{P}_{t+1}^n)^{1/\nu} \sum_{i=1}^N \sum_{k=0}^J \mu_t^{nj,ik} [Y_{t+2}^{ik}]^{\beta},$$

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik} [Y_{t+2}^{ik}]^{\beta}}{\sum_{m=1}^N \sum_{h=0}^J \mu_t^{nj,mh} [Y_{t+2}^{mh}]^{\beta}},$$

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

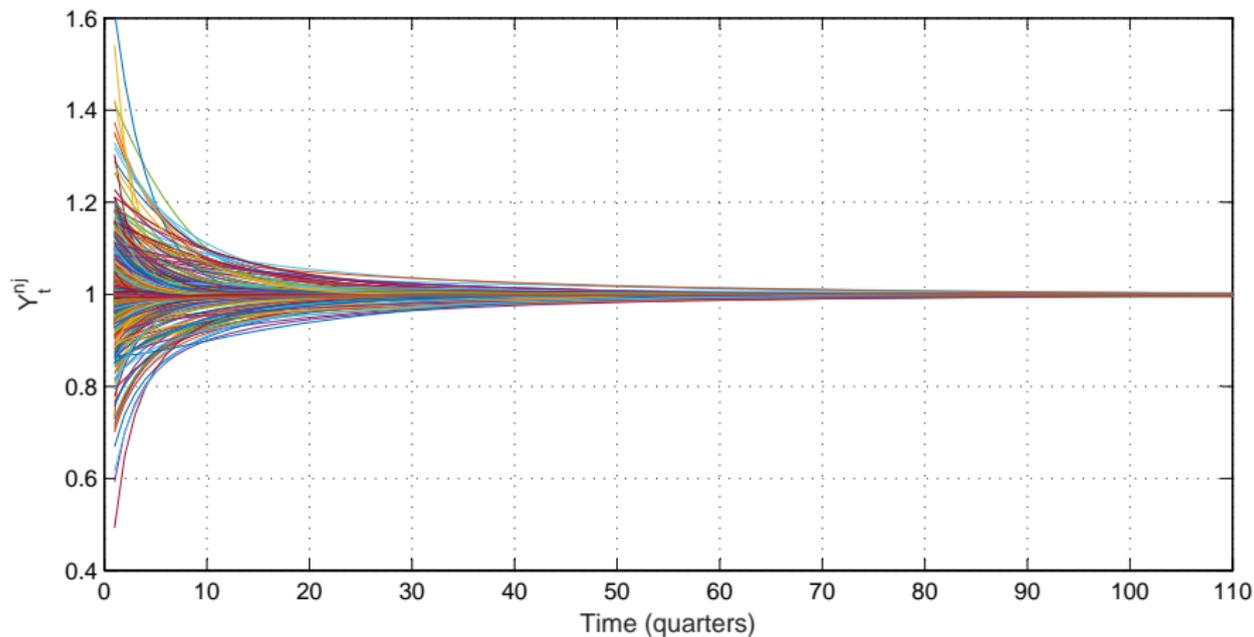
where $\tilde{w}_{t+1}^{nj} / \tilde{P}_{t+1}^n$ solves the temporary equilibrium at \tilde{L}_{t+1} given $\hat{\Theta}_{t+1}$, and $Y_{t+1}^{ik} \equiv \exp(V_{t+1}^{ik} - V_t^{ik})^{1/\nu}$

How to perform counterfactuals?

- Solve the model conditioning on observed data at an initial period
 - ▶ Value added, Trade shares, Gross production, all consistent with observed labor allocation across labor market at $t = 0$
 - ▶ Use the labor mobility matrix μ_{-1} . For this, we need to specify agents expectations at $t = -1$ about future policies
- **Assumption:** *Policy changes are unanticipated at $t = -1$*
 - ▶ Allows us to condition on observed data and solve for the sequential equilibrium with no policy changes
 - ▶ Let $\{V_t\}_{t=0}^{\infty}$ be the equilibrium sequence of values with constant policies, where $V_t = \{V_t^{i,k}\}_{i=1,k=1}^{N,J}$.
 - ▶ The assumption implies that the initial observed labor mobility matrix μ_{-1} is the outcome of forward looking behavior under $\{V_t\}_{t=0}^{\infty}$.

Solving the model (example)

Figure: Equilibrium Value Functions in Time Differences



► Proposition

Taking the model to the data (quarterly)

- $v = 5.34$ (implied elasticity of 0.2) Using ACM's data and specification, adapted to our model
 - ▶ Data: migration flows and real wages for 26 years between 1975-2000, using March CPS
 - ▶ We deal with two issues: functional forms, and timing
- Estimating equation

$$\log \mu_t^{nj,ik} / \mu_t^{nj,nj} = C + \frac{\beta}{v} \log w_{t+1}^{ik} / w_{t+1}^{nj} + \beta \log \mu_{t+1}^{nj,ik} / \mu_{t+1}^{nj,nj} + \omega_{t+1},$$

- ▶ We transform migration flows from five-month to quarterly frequency
- ▶ GMM estimation, past flows and wages used as instruments
- ▶ ACM estimate $v = 1.88$ (annual), $v = 2.89$ (five-month frequency)

Model validation

- Compare reduced-form evidence with model's predictions
 - ▶ First run second-stage regression in ADH with our level of aggregation
 - ▶ Then, run same regression with model generated data

Table: Reduced-form regression results

	ΔL_{it}^m		$\Delta \bar{u}_{it}$	
	data (1)	model (2)	data (3)	model (4)
ΔIPW_{uit}	-1.718 (0.194)	-1.124 (0.368)	0.461 (0.138)	0.873 (0.252)
Obs	49	50	49	50
R^2	0.51	0.16	0.13	0.20

- Results are largely aligned with those in ADH

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Adjustment costs

- We follow Dix-Carneiro (2014)'s measure of adjustment cost
- The steady-state change in the value function due changes in fundamentals is given by $V_{SS}^{nj}(\hat{\Theta}) - V_{SS}^{nj}$
- Therefore, the transition cost for market nj to the new long-run equilibrium, $AC^{nj}(\hat{\Theta})$, is given by

$$AC^{nj}(\hat{\Theta}) = \log \left(\frac{\frac{1}{1-\beta} \left(V_{SS}^{nj}(\hat{\Theta}) - V_{SS}^{nj} \right)}{\sum_{t=0}^{\infty} \beta^t \left(V_{t+1}^{nj}(\hat{\Theta}) - V_{t+1}^{nj} \right)} \right),$$

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Imbalances

- Assume that in each region there is a mass of one of Rentiers
 - ▶ Owners of local structures, obtain rents $\sum_{k=1}^J r_t^{ik} H^{ik}$
 - ▶ Send all their local rents to a global portfolio
 - ▶ Receive a constant share l^i from the global portfolio, with $\sum_{n=1}^N l^n = 1$
- Imbalances in region i given by

$$\sum_{k=1}^J r_t^{ik} H^{ik} - l^i \chi_t,$$

where $\chi_t = \sum_{i=1}^N \sum_{k=1}^J r_t^{ik} H^{ik}$ are the total revenues in the global portfolio

- Rentier uses her income to purchase local goods
 - ▶ Same preferences as workers

Welfare effects from changes in fundamentals

- Let $W_t^{nj}(\hat{\Theta})$ be the welfare effect of change in $\hat{\Theta} = \Theta' / \Theta$

$$W_t^{nj}(\hat{\Theta}) = \sum_{s=t}^{\infty} \beta^s \log \frac{\hat{c}_s^{nj}}{(\hat{\mu}_s^{nj, nj})^v},$$

- ▶ Note that this is a consumption equivalent measure of welfare
 - ▶ $(\hat{\mu}_s^{nj, nj})^v$ is the change in the option value of migration
- In our model, $\hat{c}_t^{nj} = \hat{w}_t^{nj} / \hat{p}_t^n$ is shaped by several mechanisms,

$$\hat{c}_t^{nj} = \frac{\hat{w}_t^{nj}}{\prod_{k=1}^J (\hat{w}_t^{nk})^{\alpha^k}} \prod_{k=1}^J \left(\frac{\hat{w}_t^{nk}}{\hat{p}_t^{nk}} \right)^{\alpha^k},$$

- ▶ First component reflects the unequal effects within a region
 - ▶ Second component is common to all HH residing in region n , given by

$$\sum_{k=1}^J \alpha^k \left(\log(\hat{\pi}_t^{nk, nk})^{-\gamma^{nk} / \theta^k} - \zeta^n \log \frac{\hat{L}_t^{nk}}{\hat{H}^{nk}} \right).$$

Welfare effects from changes in fundamentals

- Let $W_t^{nj}(\hat{\Theta})$ be the welfare effect of change in $\hat{\Theta} = \Theta' / \Theta$

$$W_t^{nj}(\hat{\Theta}) = \sum_{s=t}^{\infty} \beta^s \log \frac{\hat{c}_s^{nj}}{(\hat{\mu}_s^{nj,nj})^{\nu}},$$

- ▶ Note that this is a consumption equivalent measure of welfare
 - ▶ $(\hat{\mu}_s^{nj,nj})^{\nu}$ is the change in the option value of migration
- In a one sector model with no materials and structures, $\hat{c}_t^n = \hat{w}_t^n / \hat{P}_t^n$

$$W_t^n(\hat{\Theta}) = \sum_{s=t}^{\infty} \beta^s \log \frac{(\hat{\pi}_s^{n,n})^{-1/\theta}}{(\hat{\mu}_s^{n,n})^{\nu}},$$

- Similar to a ACM (2010) + ACR (2012)

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