Local Labor Markets

ECON245 - Winter 24

Local effects of aggregate shocks

- many phenomena/trends/events/… that are of interest to economists can be conceptualized as “aggregate” shocks
  - e.g.: monetary policy, tariffs, technological change, wars, migration…
- but impact of these shocks is “local” or may vary “in the cross-section”
  - e.g., differential effects on industries or regions or households or firms …
- at heart, focus on micro heterogeneity in macro-trade… is the importance of cross-sectional effects for macro outcomes
- Plan:
  - Bartik/shift -share instruments
  - Theory: When to use shift-share instruments?
  - Theory: Aggregating PE into GE effects

Local Labor Markets

- What are the employment effects of aggregate shocks when there is imperfect labor mobility between industries/across regions?
- the role of "local labor markets" in adjustment is relatively new
  - Historically, focus on differential impact on industries
  - Regional logic: if labor is immobile across space and region's differ in industry composition, then worker exposure differs across regions
- Bartik instruments are built around the very idea that adjustment to shocks is imperfectly flexible
  - first proposed: Bartik 1991
  - initially in trade: Kovac 2013, Autor Dorn Hanson 2013
  - now a fixture in macro, spatial

Shift-share IV: Brief intuition

- initially: used to estimate the elasticity of labor supply

$$w_r = \alpha_0 + \alpha_1 l_r + \epsilon_r$$

- location's wage growth rate w_r on employment growth rate l_r
- problem: simultaneity (labor demand and labor supply)
- proposition: instrument l_r with a shifter to labor demand

Shift-Share instruments

$$b_r = \sum_i s_{ri} g_i,$$

$s_{ri} \in [0,1]$ are exposure shares, g_i are shocks, often $\sum_i s_{ri} = 1$

- Bartik 91: regional wages and employment
  - g_i nat. empl. growth of industry i, s_{ri} lagged employment share
- Card 09: Relative employment of native and immigrant workers
  - g_i: National immigration growth from origin i, s_{ri} lagged employment population share of migrants from i in r
- Autor, Dorn, Hanson 13: Import competition and regional employment
  - g_i is growth of Chinese exports in industry i, s_{ri} is the 10-year lagged employment share

The importance of frictions

- trade shocks likely on an industry or an occupation
  - E.g.,: tariff reductions, offshoring technology
- if labor is perfectly mobile across regions, effects should be observed at the industry or occupation level, but not across space
- hence: some degree of imperfect mobility of labor across regions is key
- shift-share IV designs are powerful in that the logic applies in any environments where past is indicative of current exposure
  - sticky bank-firm relationships in financial markets
  - sticky costumer-seller relationships in trade networks
  - sticky worker-firm relationships in labor markets
  - ….

Applications in trade

- Allowing for limited geographic labor mobility, define a regional labor market as the regional unit where labor is mobile
- Then: could see effects at the local labor market level
- Example from Kovac 2013: Brazil’s import liberalization
- May expect a region heavily specialized in a previously tariff-protected “industry” to “do worse”
  - Wages/employment fall for everyone in the region, not just those employed in the industry
  - Wages of workers employed in the industry in the specialists region could fall by more than industry workers in a different region

Kovak 2013: Fixed-factors approach

- develops a simple stylized model to motivate the Bartik instrument
- empirical setting: Brazil's unilateral import competition
  - decades of high tariffs and non-tariff barriers on almost all industries leading up to 1990s
  - early 1990s: new administration abolishes non-tariff barriers and dramatically cuts tariffs
  - Industry-level variation: size of tariff reduction
- did the policy change have differential effects across space?

Fixed-factors approach

- Model a Brazilian local labor market as a “small open economy”
- Perfect labor mobility across industries within regions
- No labor mobility across regions
  - this generates local labor markets
- Industry-specific factors/capital, immobile across space
  - this generates ex-ante differences in industry structure across space
- Drop regional indexing for now

Fixed-factors approach

- Perfect competition and constant returns to scale technology

$$p_i = a_i^L w + a_i^k r_i$$

  - w: regional wage
  - r_i: rental rate of industry-specific capital
  - a_i^F: unit factor requirement in industry i, derived from cost-minimization and factor prices
- Factor market clearing

$$K_i = a_i^k Q_i \qquad L = \sum_i a_i^L Q_i$$

The effect of trade

- letting $\hat{x} = d \ln x$ and differentiating the system (first-order approximation)

$$\hat{p}_i = \theta_i^L(\hat{a}_i^L + \hat{w}) + \theta_i^k(\hat{a}_i^k + \hat{r}_i)$$

$$\hat{K}_i = \hat{a}_i^K + \hat{Q}_i \qquad \hat{L} = \sum_l \lambda_l(\hat{a}_i^L + \hat{Q}_i)$$

  - θ_i^F: The share of industry i costs paid to factor F
  - λ_i: The share of regional labor employment by industry i

- Solve the system in terms of $\hat{p}_i$, which is treated as exogenous
  - Note: $\hat{K}_i = 0$, $\theta_i^k \hat{a}_i^k + \theta_i^L \hat{a}_i{}^L = 0$ (CRTS, envelope)

The effects of trade

- If σ_i is the elasticity of factor substitution $\hat{a}_i^L - \hat{a}_i^K = \sigma_i(\hat{r}_i - \hat{w})$

$$\hat{w} = \sum_i \frac{\frac{\sigma_i}{\theta_i^K}\lambda_i}{\sum_j \frac{\sigma_j}{\theta_i^K}\lambda_j}\hat{p}_i - \frac{1}{\sum_j \frac{\sigma_i}{\theta_j^k}\lambda_j}\hat{L}$$

- With no cross-regional labor mobility: $\hat{L} = 0$
- Interpreting a trade shock as an exogenous change to prices, regional wages respond according to a weighted average of national shocks

Empirical exercise: Brazil

- Structural model implication with fixed regional labor

$$d\ln w_r = \sum_i \frac{\frac{\sigma_i}{\theta_i^k}\lambda_{ir}}{\sum_j \frac{\sigma_j}{\theta_j^k}\lambda_{jr}} d\ln p_i \equiv \sum_i \beta_{ir} d\ln p_i$$

- To calculate β_{ir} : Assume $\sigma = 1$ (CD technologies) with region-sector specific labor-share
- implied regression

$$\Delta \ln w_r = \alpha_0 + \alpha_1 \left[\sum_i \beta_{ir} \Delta \ln(1 + t_i) \right] + \epsilon_r$$

Results

- Coefficient estimate 0.44
  - Suppose region r has exposure 10% higher than region s
  - In response region r wage falls by 4.4% more than region s wage
- Interpretation: cross-sectional (exposure) variation identifies cross-sectional effects
- "Intercept effect" affecting all regions identically unidentified
  - E.g. national general equilibrium effect
- aggregate questions left unanswered

Autor Dorn Hanson 2013: “China Shock”

- Study the local labor market effects of China’s “manufacturing rise”
- Empirical setting:
  - “Pre-shock”: 0.6% total US spending on Chinese goods in 1991
  - “Post-shock”: 4.6% in 2007 (25% of all manufactured imports)
  - Coincides with US manufacturing employment share falling from 12.6% to 8.4%
  - Substantial industry level variation in Chinese import volumes
- Difference from Kovac: Instead of using a structural shock (tariffs), ADH will construct proxies for foreign export supply shocks

ADH 2013

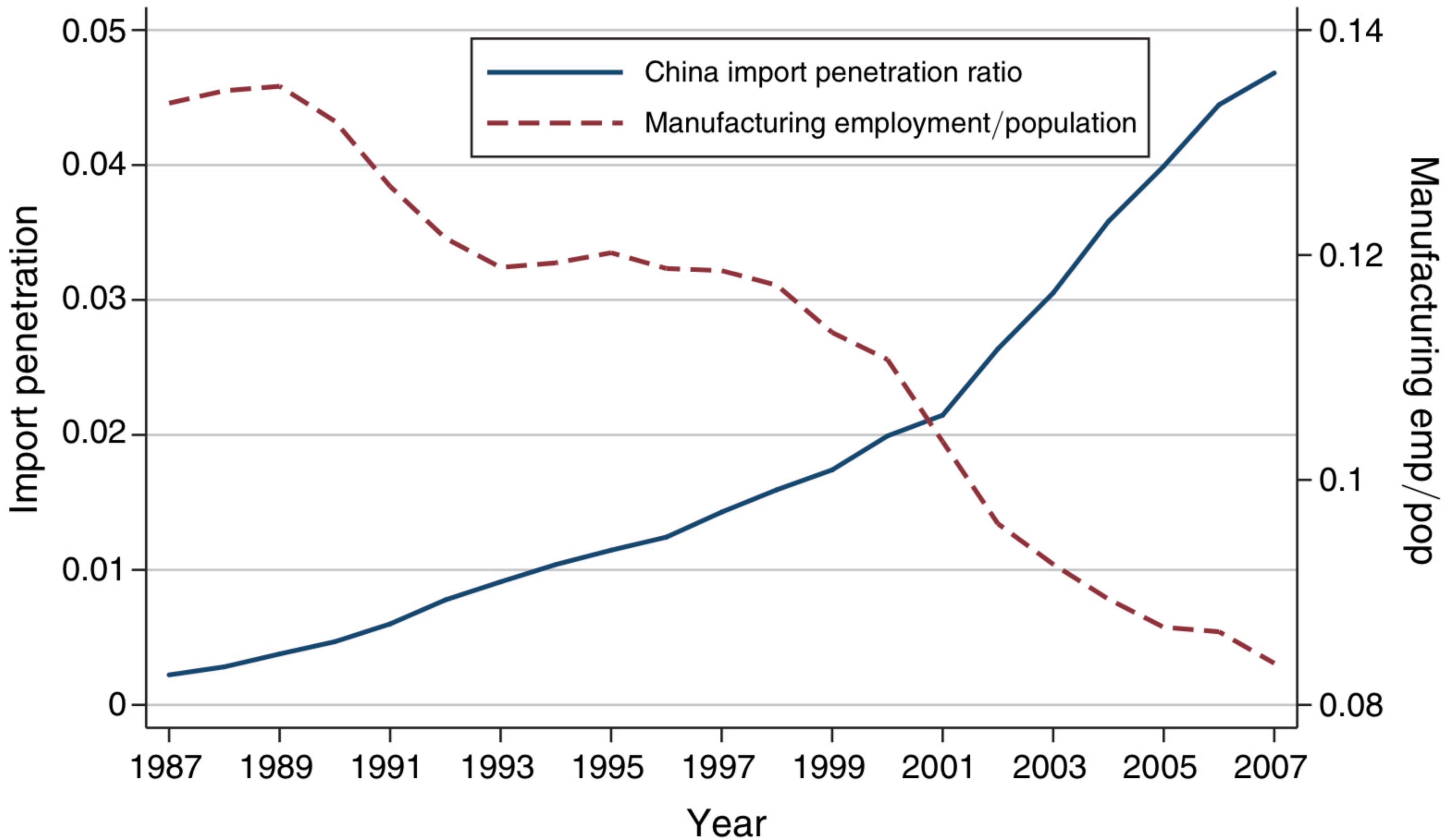


FIGURE 1. IMPORT PENETRATION RATIO FOR US IMPORTS FROM CHINA (*left scale*), AND SHARE OF US WORKING-AGE POPULATION EMPLOYED IN MANUFACTURING (*right scale*)

ADH 2013

- Model as China’s manufacturing export capabilities increasing
- Model details left to paper
  - Krugman 1980 style model with no labor mobility across regions
  - Predicts local drop in wages and manufacturing employment as China becomes more competitive
  - Also predicts that region‘s exposure to China‘s rising competitiveness differs across regions
- Mechanism: “local demand effects”

ADH 2013

- Structural equations

$$\hat{L}_{Tr} = -\alpha \sum_i \frac{L_{ir}}{L_{Tr}} \frac{X_{CiU}}{L_{iU}} \hat{A}_{Ci}$$

  - L_{ir}: region r employment in industry i (T total, U US)
  - X_{CiU}: trade flow from China to the US in industry i
  - A_{Ci}: Chinese export capability in industry i
- Bartik average of industry-level "Chinese shocks", weighted by initial Chinese imports and regional industry-employment shares
- proxy changes in export capability by import changes

$$IMP_{rt} = \sum_j \frac{L_{rj}}{L_{Tr}} \frac{\Delta M_{ujt}}{L_{Uj}}$$

ADH 2013

- Similar expressions for changes in regional wages and nontraded employment
- Identification argument:
  - Use change in US import volumes as a measure for $\hat{A}_{Ci}$
  - However: change in Chinese imports may be correlated with import-demand shocks
  - Use similarly constructed Bartik with change in Chinese imports by other developed countries as instrument
  - Use region's own employment numbers but lagged ten years
- Idea: Isolate China's supply side shocks separately from US import-demand shocks

ADH 2013: Results

- structurally-motivated results
  - Suppose region r has a \$1000 higher exposure than s
  - The regional manufacturing employment is 0.75p.p. lower in r than in s
  - The regional weekly earning is 0.76 log points lower than in s
- Departing from structurally-motivated estimations: Same regression design, but non-model variables
  - Number of unemployed workers is 4.9% higher in in r than in s
  - (government) transfers causally raised in region r compared to s

ADH 2013: Summary

- Suggests: local labor markets a nontrivial medium of adjustment to trade shocks
- Industrial (in)employment and wages key margins
- Highlights which government programs used during adjustment
- Only cross-sectional effects, omitting common effect

More and way forward

- A survey of China shock: Autor, Dorn, Hanson 2016
- A survey of Brazil: Dix-Carneiro 2019
- Now: the statistical vailidity of Bartik-style designs
  - Goldsmith-Pinkham Sorkin Swift 2020
  - Borusyak Hull Javarel 2021
- Then: general equilibrium effects
  - Galle Rodriguez-Clare Yi 2022
  - Caliendo Dvorkin Parro 2019 (will not cover this in lectures)

Identification

- Want to estimate for some change in outcomes y and x

$$y_r = \alpha_0 + \alpha_1 x_r + \epsilon_r$$

- General Bartik instrument:

$$b_r = \sum_i s_{ri} g_i$$

- Where does identification in Bartik instruments come from?

  1. exposure weights $\{s_{ri}\}$: Goldsmith-Pinkham et al 2020
  2. shocks $\{g_i\}$: Borusyak et al 2021

- Both papers provide equivalence results - under certain conditions the Bartik instrument can be rewritten in a way that greatly facilitates interpretation, and analyzing “what is happening under the hood”

Exogenous Shares: Sketch of Argument

- suppose there is only one time-period and two industries

$$b_r = s_{r1}g_1 + s_{r2}g_2 = g_2 + (g_1 - g_2)s_{r1}$$

- the first stage becomes:

$$x_r = \gamma_0 + \gamma_1 b_r + \eta_r = \gamma_0 + \gamma_1(g_1 - g_2)s_{r1} + \eta_r$$

- Bartik instrument is equivalent to the initial industry share
- identification: Initial industry share is exogenous to ϵ
- for a particular GMM weighting matrix, the Bartik instrument is numerically equivalent to using industry shares as instruments
- standard GMM tools then apply to establish statistical properties

Exogenous Shocks: Sketch of Argument

- Rewrite the validity condition at the shock-level

$$\mathbb{E}\left[\sum_r b_r \epsilon_r\right] = \mathbb{E}\left[\sum_r \sum_i s_{ri} g_i \epsilon_r\right] = \mathbb{E}\left[\sum_i s_i g_i \epsilon_i\right] = 0$$

where $\epsilon_i \equiv \sum_r s_{ri} \epsilon_r$ and $s_i = \sum_r s_{ir}$

- equivalent "shock-level regression", which is set in a standard IV setting

$$\hat{\alpha}_1 = \frac{\sum_r b_r y_r}{\sum_r b_r x_r} = \frac{\sum_i s_i g_i \tilde{y}_i}{\sum_i s_i g_i \tilde{x}_i}$$

where $\tilde{v}_i = \sum_r s_{ri} v_r$ = an exposure-weighted average of $v_i \in \{y_i, x_i\}$ across r

- Then establish plausibility of consistency in IV setting, equivalence implies consistency in SSIV setting
- exposure shares not required to be exogenous if sufficient shock variation

Exogenous Shocks vs Shares

- share exogeneity: NOT saying that "shares do not respond to the residual"
  - Instead: "All unobservables are uncorrelated with any local composition of shares"
- in many settings, case is difficult to make ex-ante
  - in ADH: Unobserved technology shocks across industries affect labor markets via lagged employment shares, along with supply shocks g_i
  - if ex-ante plausible, use the Goldsmith-Pinkham et al toolbox
- general rule of thumb: Shock vs share decision must be made ex-ante
  - ex-post tests only make sense if their respective assumptions are satisfied

Galle Rodriguez-Clare Yi 2022

- ADH can identifies relative effects
  - I.e.: Relative to a region that is 1% less exposed to rising imports, wages in another region fall by 0.5%
  - absolute effect of rising import competition on wages?
  - price effects?
- they provide a quantitative GE model to get at these missing effects
  - Frechet Galore,(i) response of trade flows to tariffs based in EK-Frechet, but multi-sector, input-output version (ii) response of workers to wages based on a Roy-Frechet
  - Roy-Frechet provides the imperfect mobility needed
- will use the structural model to "aggregate" PE diff-in-diff estimates

Gravity + Roy-Frechet

- standard multi-sector gravity: workers are perfectly mobile
- Other extreme: workers are stuck in their sectors (specific factors)
- they adapt a Roy-Frechet model which nests both extremes
  - Roy-Frechet: the labor market sibling of the CES family
  - Frechet parameter κ determines scope for reallocation
    - $\kappa \to \infty$: Perfectly mobile workers
    - $\kappa \to 1$: specific factors
- They estimate κ building on ADH's empirical results
- Examine between-group distributional effects of trade

Model

- N countries indexed i and j
- S sectors, indexed s and k
- G_i groups, indexed ig
- groups will be commuting zones

Model: Trade Side

- Each sector is modeled as in Eaton Kortum (2002)
- perfect competition in goods markets
- Preferences across sectors are Cobb-Douglas with shares β_{is}
- Trade shares take on gravity form (origin i, destination j)

$$\lambda_{ijs} = \frac{T_{is}\left(\tau_{ijs} w_{is}\right)^{-\theta_s}}{\gamma^{-\theta_s} P_{js}^{-\theta_s}}$$

$$\text{where } \gamma^{-\theta_s} P_{js}^{-\theta_s} = \sum_l T_{ls}\left(\tau_{ljs} w_{ls}\right)^{-\theta_s}$$

Model: Labor side

- Exogenous mass L_{ig} of workers of type g in country i
- A worker g has efficiency units z_s drawn i.i.d. from a Frechet distribution with $\kappa > 1$ and A_{igs}
- Workers maximize earnings (efficiency units times wage w_{is})
- The share of workers in group g who choose to work in sector s:

$$\pi_{igs} = \frac{A_{igs} w_{is}^{\kappa}}{\Theta_{ig}^{\kappa}} \text{ where } \Theta_{ig} \equiv \left(\sum_k A_{igk} w_{ik}^{\kappa} \right)^{1/\kappa}$$

- The sum of efficiency units supplied by group ig to sector s is:

$$Z_{igs} = \zeta_{ig} \frac{\Theta_{ig}}{w_{is}} \pi_{igs} L_{ig} \quad \text{and } \zeta_{ig} = \Gamma(1 - 1/\kappa_g)$$

Equilibrium

- The excess demand for efficiency units in sector i and country s:

$$ELD_{is} = \frac{1}{w_{is}} \sum_j \lambda_{ijs}\beta_{js}X_s - \sum_{g \in G_i} Z_{igs}$$

- Equilibrium: Find w_{is} that equalize demand and supply of efficiency units

- Worth noting: Expected labor income for group g in i:

$$Y_{ig} = \zeta_{ig}\Theta_{ig}L_{ig}$$

Θ_{ig}= equivalent to the price index in E-K, here a “wage index”

Group-level welfare effects

- $W_{ig} = Y_{ig}/(L_{ig}P_i)$: per-capita real wage of group g in country i
- with Cobb-Douglas preferences, this is simply equal to:

$$\hat{W}_{ig} = \hat{Y}_{ig} \prod_s \left(\hat{P}_{is}\right)^{-\beta_{is}}$$

- ACR formula: in response to "foreign shocks", the real wage of group g in country i can be written

$$\hat{W}_{ig} = \prod_s \left(\hat{\lambda}_{iis}\right)^{-\beta_{is}/\theta_s} \times \prod_s \left(\hat{\pi}_{igs}\right)^{-\beta_{is}/\kappa_g}$$

- intuition: common price effect + group-specific effect on real wages

Welfare Gains

$$\hat{W}_{ig} = \boxed{\prod_s \left(\hat{\lambda}_{iis}\right)^{-\beta_{is}/\theta_s}} \times \boxed{\prod_s \left(\hat{\pi}_{igs}\right)^{-\beta_{is}/\kappa_g}}$$

Country-wide gains **New Group-level Roy term**

- Country-wide gains measure gains from specialization
  - as you have seen, this formula is valid in a wide class of models
  - relevant welfare elasticity for price effects θ_i
- workers in group g gain less if sectors of their comparative advantage need to shrink
  - relevant welfare elasticity for labor demand effects: κ_g

Data

- Estimation: Closely follow the empirical setup in ADH
  - Define groups based on commuting zones (722 groups)
  - Time period: 1990 - 2007
  - Labor income from the American Community Survey
  - Employment from County Business Patterns
  - Trade data from UN Comtrade at the six-digit product level
- Simulations:
  - Trade data from the world input output database
  - 13 manufacturing and 1 non-manufacturing sector
  - Time period 2000-2007

Estimating Key Elasticities

- Estimation of θ is standard in the literature
- Key challenge is estimation of κ
- Model implies for the Non-manufacturing sector:

$$\ln(Y_{gt}/L_{gt}) = \ln \hat{w}_{NMt} - \frac{1}{\kappa} \ln \hat{\pi}_{gNM} + \epsilon_{gNM}$$

where $\epsilon_{gNM} = 1/\kappa \ln \hat{A}_{gNM}$

- Use “China shock” as instrument for ϵ_{gNM}
- Identical set of control variables as in ADH
- Preferred estimate $\hat{\kappa} = 1.5$

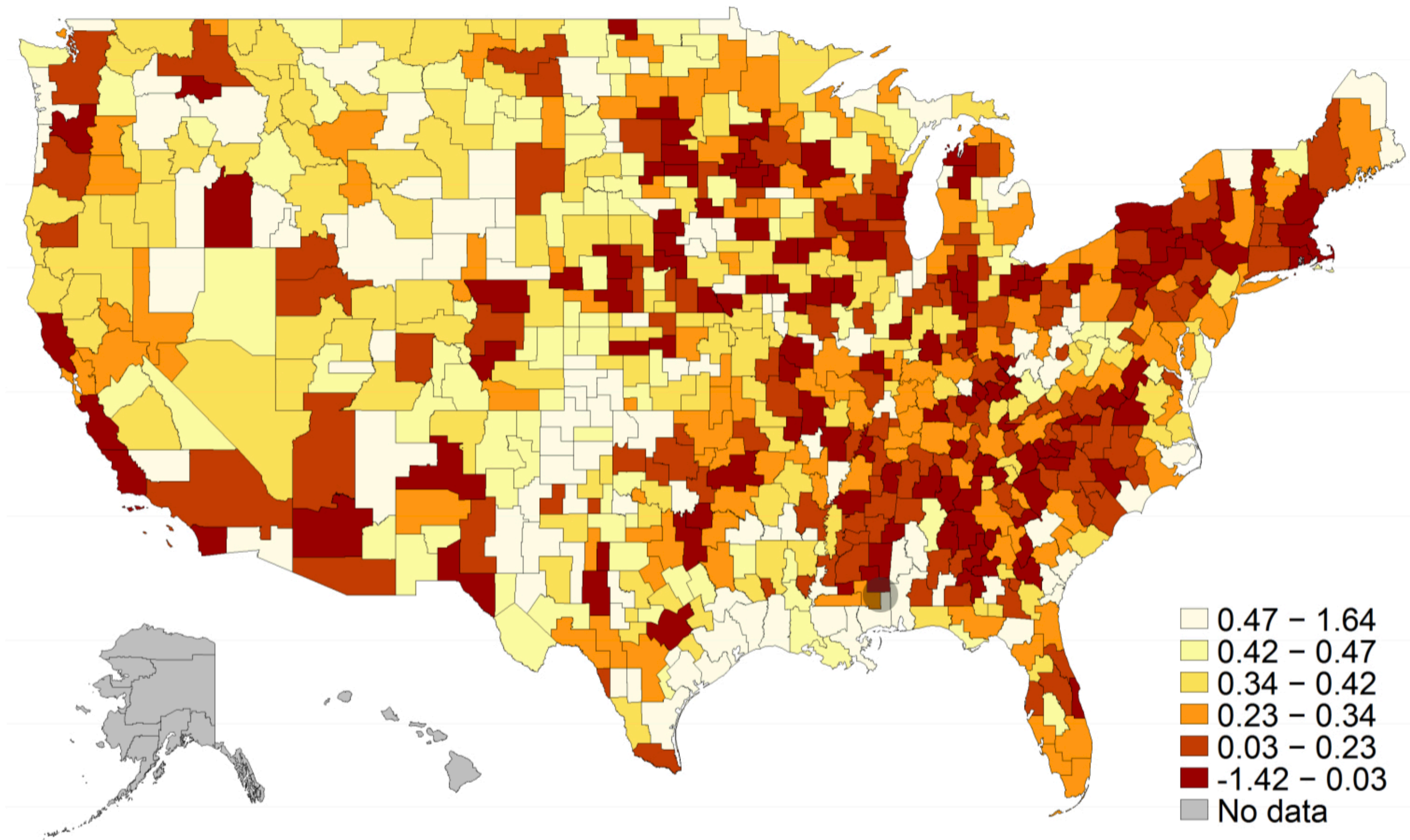
Counterfactuals

- China shock = sector-level productivity shocks $\hat{T}_{China,s}$
- To calibrate it, build on Caliendo, Dvorkin, Parro 2020
- Run a variation of ADH's first-stage regression

$$\hat{\lambda}_{China,US,s} = \alpha + \beta \hat{\lambda}_{China,Other,s} + \epsilon_s$$

- Then calibrate $\hat{T}_{China,s}$ so that model-implied changes in US expenditure shares on imports from china match the predicted values from this regression

Results



This figure plots the geographic distribution of $100(\hat{W}_g - 1)$, where $\hat{W}_g$ are the welfare effects for group g in the US from the counterfactual rise of China, for our preferred value of $\kappa = 1.5$.

Results

κ	$\widehat{W}_{US}$	Mean	CV	Min.	Max.	$\prod_s \widehat{\lambda}_s^{-\beta_s/\theta_s}$
$\to 1$	0.24	0.30	1.40	-1.73	2.32	0.14
1.5	0.22	0.27	1.16	-1.42	1.64	0.15
	(0.02)	*(0.03)*	*(0.25)*	*(0.35)*	*(0.58)*	*(0.01)*
3.0	0.20	0.24	0.80	-0.90	0.97	0.16
$\to \infty$	0.20	0.20	0	0.20	0.20	0.20

Extensions in the paper

- Unemployment: Modeled through home production and search and matching frictions
- Intermediate inputs
- Mobility across groups (geography)

Calliendo, Dvorkin and Parro (ECMA, 2020)

- The GE disaggregate effects (across locations, sectors, locations-sectors) of an aggregate shock (e.g., a trade shock) depend on
  - degree of exposure to foreign trade
  - Indirect linkages through internal trade
  - Labor reallocation process - Migration
- Need to account for all these channels to understand the aggregate effects, run counterfactuals
- CDP develop a model of trade and labor market dynamics that recognizes the role of labor market mobility frictions, goods mobility frictions, I-O linkages, geographic factors, and international trade

Quick detour: Dynamics in Trade/Spatial

- Modeling dynamics has been challenging for at least two reasons
    1. Trade/spatial models are very rich in the cross-section, even absent heterogeneity (think Eaton-Kortum with a representative HH making forward-looking capital investment decisions)
    2. Location decisions are made at the level of individual households/firms
- Both are quantitative problems in nature, but 2. is significantly more severe
    - For migration: Each location is populated by many people, each with potentially very different histories…
    - Similar for for firms
    - State space very quickly explodes - similar to heterogeneous agent models in macro, but adding many locations and potentially worker types

Solutions

- Literature so far has moved toward finding "modeling tricks," rather than improving computational efficiency
- E.g., to model capital investment, e.g., Kleinman-Liu-Redding (ECMA, 23)
  - Assume each location is inhabited by "capitalists" who accumulate and rent out the local capital stock, while workers have no access to savings ("hand-to-mouth").
  - With log inter-temporal preferences, capital investment is "optimally" myopic, i.e., characterized solely in terms of current prices.
- Many other approaches fit into this "optimally myopic" category
  - e.g., Desmet-Nagy-Rossi-Hansberg (JPE, 2018): Firms innovate, but profits are competed away every period, so problem is effectively static
- state-of-the-art models of migration decisions utilize logit-discrete choice to characterize bilateral aggregate flows of people
  - Intuition: In E-K, distribution of prices paid in a location is the same across all origins. With Extreme-value shocks, at any point in time, distribution of continuation values of people in a given location is the same across all "origins", i.e. histories do not matter.

Caliendo-Dvorkin-Parro

- Model with larger # of unknown fundamentals: Productivity, mobility frictions, and more
- A new method to solve dynamic discrete choice problems
  - No need to estimate levels of fundamentals
  - Equilibrium conditions can be written in relative time differences
- Quantitative study of how ADH "China Shock" affected local U.S. labor markets
  - 38 countries, 50 U.S. regions, and 22 sector version of the model
  - Employment and welfare effects across more than 1000 labor markets

Household's Problem

- N locations (index n and j) with J sectors each (j and k)
- Utility of a household in market nj at time t is given by

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

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

  - $\beta \in (0,1)$ discount factor
  - $\tau^{nj,ik}$ additive, time invariant migration cost to ik from nj
  - ϵ_t^{ik} are stochastic iid taste shocks, distributed Type-I extreme value with zero mean, ν is the dispersion of taste shocks
- Unemployed obtain home production b^n
- Employed households supply a unit of labor inelastically

Dynamic Discrete Choice

- Properties of Type-I Extreme Value distribution VERY helpful
- Expected (expectation over ϵ) lifetime utility of a worker at nj:

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

- Fraction of workers that reallocate from nj to ik

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

- Evolution of the distribution of workers across markets

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

Production - Static sub-problem

- At each t, labor supply across markets is fully determined
  - Solve for wages such that labor markets clear, using a rich spatial structure
- In each nj there is a continuum of goods producers
  - Perfect competition, CRS technology, idiosyncratic productivity $z^{nj} \sim$ Frechet$(1,\theta^{j})$, deterministic sectoral regional TFP A_t^{nj}

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

- Unit price of an input bundle is given by:

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

Production - Static sub-problem - Trade

- Shipping a variety good j from i to n subject to trade costs $\kappa_t^{nj,ij}$
- Price for a variety of good j in region n is the minimum unit cost across all regions (as in Eaton Kortum)

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

- Intermediate goods aggregated into a sectoral final good via a CES (elasticity η) with price index

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

Production - Static sub-problem - equilibrium

- Expenditure shares in nj on goods from ij

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

- Labor market clearing: Labor Income = Labor share × revenues

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

- X_t^{nj}: Total expenditures on sector j goods in region n
- $\gamma^{nj}(1-\zeta^n)$: Labor share

Sequential and temporary equilibrium

- State of the economy = distribution of labor $L_t = \left\{ L_t^{nj} \right\}_{n=1,j=0}^{N,J}$
- Time-varying and constant fundamentals Θ_t and $\overline{\Theta}$

DEFINITION

Given $(L_t, \Theta_t, \overline{\Theta})$, a temporary equilibrium is a vector of wages $w(L_t, \Theta, \bar{\theta})$ that satisfies the equilibrium conditions of the static sub-problem.

DEFINITION

Given $(L_0, \{\Theta_t\}_{t=0}^{\infty}, \overline{\Theta})$, a sequential equilibrium is a sequence $\{L_t, \mu_t, V_t, w(L_t, \theta_t, \overline{\Theta})\}_{t=0}^{\infty}$ that solves HH dynamic problem and the temporary equilibrium at t.

Solving the Model

Solving for an equilibrium of the model requires info on Θ_t, $\overline{\Theta}$

- large number of unknowns ($N + 2NJ + N^2J + N^2J^2$ at each t)

Solution: Compute equilibrium dynamics in time differences

- By conditioning on observable, can solve model without knowing levels of fundamentals
- Condition on last period migration flows, trade flows, and production
- Requires solving for the value function in time differences

Rewriting the Model in Changes: Dynamic Part

- Migration flows at $t = -1$: Data

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

- Migration flows at $t = 0$: Model

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

- Take time differences

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

Rewriting the Model in Changes - dynamic Part

- Time differences

$$\frac{\mu_o^{nj,ik}}{\mu_{-1}^{nj,ik}} = \frac{\dfrac{\exp\left(\beta V_1^{ik} - \tau^{nj,ik}\right)^{1/\nu}}{\exp\left(\beta V_0^{ik} - \tau^{nj,ik}\right)^{1/\nu}}}{\dfrac{\sum_{m=1}^{N}\sum_{h=0}^{J}\exp\left(\beta V_1^{mh} - \tau^{nj,mh}\right)}{\sum_{m=1}^{N}\sum_{h=0}^{J}\exp\left(\beta V_0^{mh} - \tau^{nj,mh}\right)}}$$

- Simplifying:

$$\frac{\mu_o^{nj,ik}}{\mu_{-1}^{nj,ik}} = \frac{\exp\left(V_1^{ik} - V_0^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^{N}\sum_{h=0}^{J}\dfrac{\exp\left(\beta V_1^{mh} - \tau^{nj,mh}\right)}{\sum_{m=1}^{N}\sum_{h=0}^{J}\exp\left(\beta V_0^{mh} - \tau^{nj,mh}\right)}}$$

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

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

Rewriting the model in changes - dynamic Part

- Expected lifetime utility

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

- Migration flows

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

- In time differences:

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

Solution to temporary equilibrium in changes

Solving for the Temporary Equilibrium in Changes

- Let $\hat{y}_{t+1} \equiv y_{t+1}/y_t$
- Price index

$$\hat{P}^{nj}_{t+1} = \left[\sum_{i=1}^{N} \pi^{nj,ij}_t \left[\hat{x}^{ij}_{t+1} \hat{\kappa}^{nj,ij}_{t+1} \right]^{-\theta^j} \left(\hat{A}^{ij}_{t+1} \right)^{\theta^j \gamma^{ij}} \right]^{-1/\theta^j}$$

- Trade shares

$$\pi^{nj,ij}_{t+1} = \pi^{nj,ij}_t \left(\frac{\hat{x}^{ij}_{t+1} \hat{\kappa}^{nj,ij}_{t+1}}{\hat{P}^{nj}_{t+1}} \right)^{-\theta^j} \left(\hat{A}^{ij}_{t+1} \right)^{\theta^j \gamma^{ij}}$$

- Unit cost

$$\hat{x}^{nj}_{t=1} = \left(\hat{L}^{nj}_{t+1} \right)^{\gamma^{nj} \zeta^n} \left(\hat{w}^{nj}_{t+1} \right)^{\gamma^{nj}} \prod_{k=1}^{S} \left(\hat{P}^{nk}_{t+1} \right)^{\gamma^{nj,nk}}$$

Key result

PROPOSITION

Conditional on an initial allocation of the economy, (L_o, π_0, X_0, π_1), given a sequence of changes in fundamentals $\{\hat{\Theta}_t\}_{t=1}^{\infty}$, solving the equilibrium in time differences does not require the level of fundamentals, and solves

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

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

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

Where $\hat{u}_{t+1}^{ik} = \exp(V_{t+1}^{ik} - V_t^{ik})$, $\hat{w}_{t+1}^{nj}/\hat{P}_{t+1}^{n}$ solves the static equilibrium given $\hat{L}_{t+1}$.

Questions that this model can answer

- Types of questions this framework can answer
  1. What will happen to the U.S. economy over the next 20 years, assuming fundamentals remain unchanged from today?
  2. What would happen to the U.S. economy over the next 20 years if Chinese productivity in manufacturing sectors grew 20 percent?
  3. What would have happened across U.S. labor markets if Chinese productivity, instead of growing as it did, would have grown 20% less per year from 2000 to 2007?
  4. What would have happened across U.S. labor markets if Chinese productivity had remain unchanged from 2000 to 2007, but all other changes in fundamentals had taken place?

Application to the China Shock

- One key "novel" elasticity: ν
- Given data on bilateral migration flows $\mu_t^{nj,ik}$, can estimate migration elasticity from a "ratio-estimator" (recall our gravity lectures)

$$\log(\mu_t^{nj,nk}/\mu_t^{nj,nj}) = \tilde{C} + \frac{\beta}{\nu}\log(w_{t+1}^{nk}/w_{t+1}^{nj}) + \beta\log(\log(\mu_{t+1}^{nj,nk}/\mu_{t+1}^{nj,nj}) + \bar{\omega}_{t+1}$$

  - Instrument wages and migration flows with their past-values
  - Implement combining data from the CPS (inter-sector mobility) and ACS (inter-state mobility) to estimate U.S.-state×industry migration flows
  - Estimated migration elasticity: 0.2, implying $\nu \approx 5$.
- Estimate Chinese export capacity growth by sector similarly as Galle et al.: Match reduced-form and model-implied responsiveness of Chinese exports to the US to Chinese exports to other rich countries
  - Estimate from 2000 to 2007, then assume constant annual growth of sectoral productivities in Chine between 2000 and 2007 for counterfactuals

Results: Long-run effects

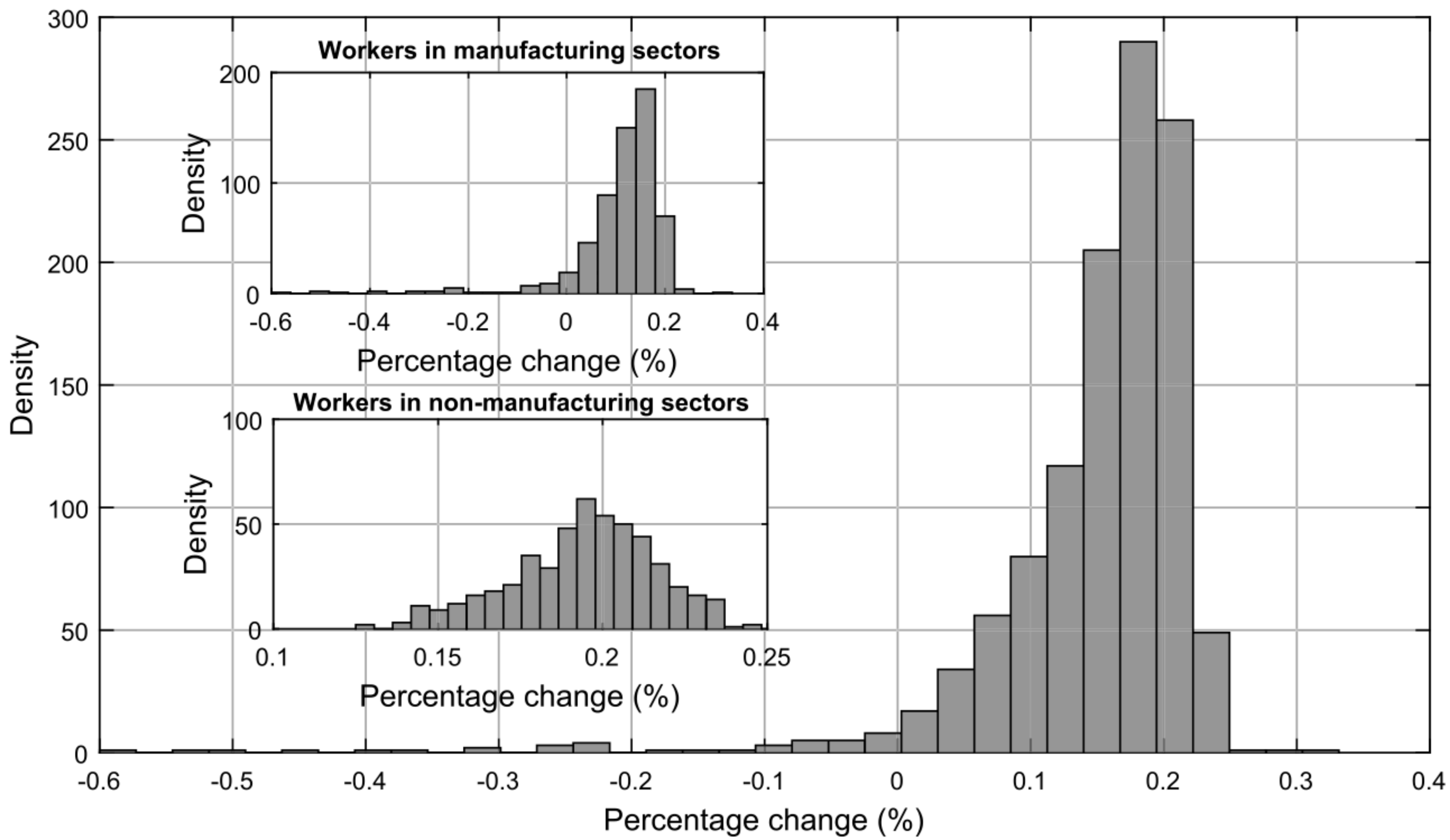


FIGURE 10.—Welfare effects of the China shock across U.S. labor markets. Note: The figure presents the change in welfare across all labor markets (central figure), for workers in manufacturing sectors (top-left panel), and for workers in non-manufacturing sectors (bottom-left panel) as a consequence of the China shock. The largest and smallest 1 percentile are excluded in each figure. The percentage change in welfare is measured in terms of consumption equivalent variation.

Note: Type 4 counterfactual: What ifs everything had changed as it did, except chinese export capacity (TFP) had not grown.

Results: Short-run effects

a.1: One quarter after 2000 a.2: From 2000 to 2007

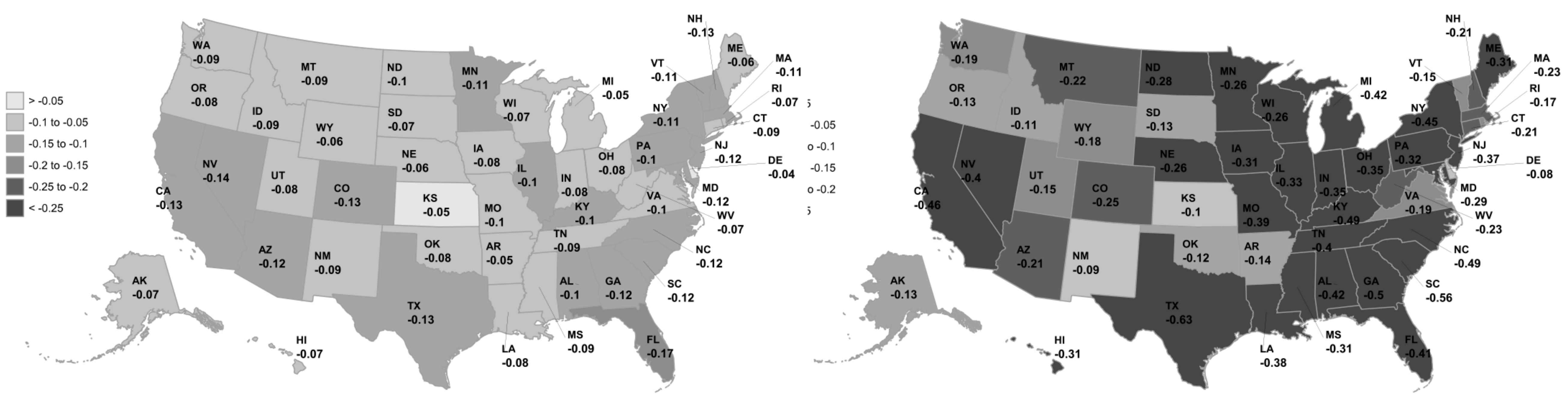


FIGURE 12.—Regional real wage changes in the manufacturing sector (percent). Note: The figure presents the change in real wages in the manufacturing sector across U.S. states. Panel a.1 presents the change in real wages at impact, one quarter after the China shock started. Panel a.2 presents the change in real wages from 2000 to 2007, during the entire period of the China shock. We aggregate the changes in real wages across labor markets within a state using employment shares for the initial year.