The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy

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Granularity and Production Networks in Macroeconomics
Introduction

- Fluctuations in aggregate economic activity are the result of a wide variety of disaggregated TFP changes
  - Sectoral: process or product innovations
  - Regional: natural disasters or changes in local regulations
  - Sectoral and regional: large corporate bankruptcy or bailout

- What are the mechanisms through which these changes affect the aggregate economy? What is their quantitative importance?
  - Input-output, trade and migration linkages
  - Differences in regional and sectoral TFP, local factors, and geography

- We model and calibrate these mechanisms for all 50 U.S. states and 26 traded and non-traded industries

- Aggregate real GDP elasticity to local productivity changes varies substantially:
  - 1.6 in NY, 1.3 in CA, but only 0.89 in FL and 0.34 in WI
Heterogeneity across U.S. states

- Differences in GDP and employment go beyond geographic size
  - GDP by regions
  - Regional employment

- GDP and Employment levels vary over time differentially across regions
  - GDP change 2002 - 2007
  - Employment change 2002 - 2007

- Why?
  - Local characteristics are essential to the answer

  - Differences in TFP changes
    - Heterogeneity in changes in regional measured TFP
    - Regional TFP
    - Regional TFP contrib.
    - Distribution of sectors across regions is far from uniform
    - Petroleum
    - Wood
    - Concentration
    - ... and changes in sectoral TFP varies widely across sectors
    - Sectoral TFP
    - Sectoral TFP contrib.

  - Differences in local factors
    - Local Factors

  - Differences in access to products from other regions
    - Regional Trade
Literature

- Literature has focused mainly on aggregate shocks as in Kydland and Prescott (1982) and the many papers that followed
  - ... and sometimes firms: Jovanovic (1987), and Gabaix (2011)

- Recent literature on international trade uses static, multi-sector, multi-country quantitative models to assess the gains from trade
  - For example, Arkolakis, et al. (2012), Costinot, Donaldson, and Komunjer (2012), Caliendo and Parro (2012) and more

- We adapt a multi-sector version of Eaton and Kortum (2002) to introduce labor mobility and local factors
  - Large scale quantitative exercise for 50 states and 26 industries
The Model

- The economy consists of $N$ regions, $J$ sectors, and two factors
  - Labor, $L_n^j$: mobile across regions and sectors
  - Land and structures, $H_n$: fixed across region but mobile across sectors

- The problem of an agent in region $n$ is given by

$$v_n \equiv \max \left\{ c_j^j \right\} \prod_{j=1}^J \left( c_n^j \right)^{\alpha_j} \text{ with } \sum_{j=1}^J \alpha_j = 1$$

such that

$$\sum_{j=1}^J P_n^j c_n^j = w_n + \frac{\sum_i \ell_i r_i H_i}{\sum_i L_i} + (1 - \iota_n) \frac{r_n H_n}{L_n} \equiv I_n.$$

- In equilibrium households are indifferent about living in any region so

$$v_n = \frac{I_n}{P_n} = U \text{ for all } n \in \{1, \ldots, N\}$$

where $P_n = \prod_{j=1}^J \left( P_n^j / \alpha_j \right)^{\alpha_j}$ is the ideal price index in region $n$
Model - Intermediate goods

- Representative firms in each region $n$ and sector $j$ produce a continuum of intermediate goods with *idiosyncratic* productivities $z^j_n$
  - Drawn independently across goods, sectors, and regions from a Fréchet distribution with shape parameter $\theta^j$
  - Productivity of all firms is also determined by a deterministic productivity level $T^j_n$

- The production function of a variety with $z^j_n$ and $T^j_n$ is given by

$$ q^j_n(z^j_n) = z^j_n \left[ T^j_n h^j_n(z^j_n)^{\beta_n} \right]^{\gamma^j_n} \prod_{k=1}^{J} M^j_{nk}(z^j_n)^{\gamma^j_{nk}} $$

- Importantly, $T^j_n$ affects value added and not gross output
Model - Intermediate good prices

- The cost of the input bundle needed to produce varieties in \((n,j)\) is

\[
x^j_n = B^j_n \left[ r^\beta_n w_n^{1-\beta_n} \right] \gamma^j_n \prod_{k=1}^J \left( P^k_n \right) \gamma^{jk}
\]

- The unit cost of a good of a variety with draw \(z^j_n\) in \((n,j)\) is then given by

\[
\frac{x^j_n}{z^j_n} \left( T^j_n \right)^{-\gamma^j_n}
\]

and so its price under competition is given by

\[
p^j_n (z^j) = \min_i \left\{ \frac{\kappa^j_{ni} x^j_i}{z^j_i} \left( T^j_i \right)^{-\gamma^j_i} \right\},
\]

where \(\kappa^j_{ni} \geq 1\) are “iceberg” bilateral trade cost
Model - Final goods

• The production of final goods is given by

\[
Q_{jn} = \left[ \int \tilde{q}_{jn}(z^j)^{1-\frac{1}{\eta^n}} \phi^j(z^j) \, dz^j \right]^{\eta^n / (\eta^n - 1)},
\]

where \( z^j = (z^j_1, z^j_2, \ldots, z^j_N) \) denotes the vector of productivity draws for a given variety received by the different \( n \) regions.

• The resulting price index in sector \( j \) and region \( n \), given our distributional assumptions, is given by

\[
P_{jn} = \xi^n j \left[ \sum_{i=1}^{N} x^j_i k^j_{ni} \right]^{-\theta^j} \left( T^j_i \right)^{\theta^j \gamma^j_i \nu^j_i} \right],
\]

where \( \xi^n j \) is a constant.
Migration

- Labor market clearing

\[ \sum_n \sum_{j=1}^{J} \int_0^\infty \mu_n^j(z) \phi_n^j(z) \, dz = \sum_n L_n = L \]

... plus firm optimization

\[ w_n L_n = \frac{1 - \beta_n}{\beta_n} r_n H_n \]

- Implies that

\[ L_n = \frac{H_n \left[ \frac{\omega_n}{P_n U} \right]^{1/\beta_n}}{\sum_{i=1}^{N} H_i \left[ \frac{\omega_i}{P_i U} \right]^{1/\beta_i}} L \]

where \( \omega_n \equiv (r_n / \beta_n)^{\beta_n} (w_n / (1 - \beta_n))^{(1 - \beta_n)} \)
Regional trade

- Total expenditure on goods in industry $j$ in region $n$

$$X_n^j = \sum_{k=1}^{J} \gamma_{nk}^j \sum_i \pi_{in}^k X_i^k + \alpha^j L_n L_n,$$

where $\pi_{in}^k$ denote the share of region $i$’s total expenditures on sector $k$’s intermediate goods purchased from region $n$.

- Then, as in Eaton and Kortum (2002),

$$\pi_{ni}^j = \frac{X_{n}^j}{X_{n}^j} = \frac{\left[ x_i^j \kappa_{ni}^j \right]^{-\theta^j} \left( T_i^j \right)^{\theta^j \gamma_i^j}}{\sum_{i'=1}^{N} \left[ x_{i'}^j \kappa_{ni'}^j \right]^{-\theta^j} \left( T_{i'}^j \right)^{\theta^j \gamma_{i'}^j}}$$

- Trade surplus/deficit in $n$ is given by

$$L_n \frac{\sum_i \tau_i r_i H_i}{\sum_i L_i} - \tau_n r_n H_n$$
Changes in measured TFP

- Using firm optimization and aggregating over all produced intermediate goods, total gross output in \((n,j)\) is given by

\[
\frac{Y_n^j}{P_n^j} = \frac{x_n^j}{P_n^j} \left[ (H_n^j)^{\beta_n} (L_n^j)^{(1-\beta_n)} \right] \gamma_n^j \prod_{k=1}^{J} \left( M_{nk}^{jk} \right)^{\gamma_n^{jk}}
\]

- \(\frac{Y_n^j}{P_n^j} = Q_n^j\) when \(j\) is a non-tradable good

- So the change in measured TFP as a result of \(\hat{T}_n^j\) is

\[
\ln \hat{A}_n^j = \ln \frac{\hat{x}_n^j}{\hat{P}_n^j} = \ln \frac{\left( \hat{T}_n^j \right)^{\gamma_n^j}}{\left( \hat{\pi}_{nn}^j \right)^{1/\theta_j}}
\]

- Aggregate measured TFP changes using gross output revenue shares

  - Leads to aggregate TFP measures similar to those of the OECD
Changes in real GDP

- The Cobb-Douglas production function in intermediates implies that

\[
\ln \hat{GDP}_j^n = \ln \hat{w}_n \hat{L}_j^n \hat{P}_j^n = \ln \hat{A}_j^n + \ln \hat{L}_j^n + \ln \left( \frac{\hat{w}_n}{\hat{r}_j} \right)
\]

- In the case without materials, the last term is simply

\[
\ln \left( \frac{\hat{w}_n}{\hat{x}_j^n} \right) = \beta_n \ln (\hat{w}_n/\hat{r}_n) = \beta_n \ln 1/\hat{L}_n
\]

... otherwise, a function of all final-good price changes

- We aggregate real GDP changes using value added shares
Changes in Welfare

- Welfare changes are given by

\[
\ln \hat{U}_n = \sum_{j=1}^{J} \alpha^j \left( \ln \hat{A}_n^j + \ln \left( \omega_n \hat{w}_n^j + (1 - \omega_n) \frac{\hat{\chi}^j}{\hat{\chi}_n^j} \right) \right),
\]

where \( \omega_n = \frac{(1 - \beta_n \iota_n) w_n}{(1 - \beta_n \iota_n) w_n + (1 - \beta_n) \chi} \)

- Note that if \( \iota_n = 0 \) for all \( n \), then \( \chi = 0 \) and \( \omega_n = 1 \). In that case

\[
\ln \hat{U}_n = \sum_{j=1}^{J} \alpha^j \left( \ln \hat{A}_n^j + \ln \frac{\hat{w}_n^j}{\hat{\chi}_n^j} \right).
\]

- ACR (2012) emphasize the case with one sector, no factor mobility, and no trade deficits where

\[
\ln \hat{U}_n = \ln \hat{A}_n
\]
Counterfactuals

- We need to calibrate and compute the model to assess the aggregate effect of regional shocks
  - We only compute the model in changes as a result of $\hat{T}_n$, parallel to Dekle, Eaton and Kortum (2008)
  - System of $2N + 3JN + JN^2 = 69000$ equations and unknowns

- Some issues:
  - We estimate $\iota_n$ to match 2007 regional trade imbalances, $S_n$
    - Not exact since $\iota_n \in [0, 1]$
    - So use counterfactual without unexplained deficits
  - No international trade: CFS provides data of expenditures on domestically produced goods
Data

- We need to find data for $I_n, L^n_j, S_n, \pi^n_j$ as well as values for the parameters $\theta^j, \alpha^j, \beta_n, \iota_n, \gamma^{jk}_n$
  - $L^n_j$: BEA, with aggregate employment across all states summing to 137.3 million in 2007
  - $I_n$: Total value added in each state in 2007
  - $\pi^n_j$, and $S_n$: CFS with total trade equal to 5.2 trillion in 2007
  - $\theta^j$: We use the numbers in Caliendo and Parro (2012)
  - $\alpha^j$: Calculated as the aggregate share of consumption
  - $\beta_n$: Labor share by region adjusted by $\beta_n = (\bar{\beta}_n - .17)/.83$
    - Share of equipment equal to .17 Greenwood, Hercowitz and Krusell (1997), which we group with materials
  - $\iota_n$: From $S_n$ using minimum least squares
  - $\gamma^{jk}_n$: Get $\gamma^n_j$ from BEA value added shares and use national IO table to compute $\gamma^{jk}_n = (1 - \gamma^n_j)\gamma^{jk}$
Aggregate and Local or Sectoral Elasticities

- We present all results using elasticities
  - All based on 10% changes ($\hat{T}_n^j = 1.1$)
    - Matters due to non-linearities
  - Aggregate elasticities calculated by dividing by share of state/sector and the size of the shock
    - So benchmark for aggregate TFP elasticity is 1 independent of the size of the state
  - Local/sectoral elasticities adjusted by the size of the shock only
    - So benchmark for local TFP elasticity in the affected state/sector is 1 too
Aggregate TFP elasticity of a local productivity change

\[ \ln \hat{A}_n^j = \ln \left( \frac{\hat{T}_n^j}{\hat{T}_n^{jn}} \right)^{1/\theta^j} \]
Aggregate GDP elasticity of a local productivity change

$$\ln \hat{GDP}_n^j = \ln \hat{A}_n^j + \ln \hat{L}_n^j + \ln \left( \frac{\hat{W}_n}{\hat{X}_n} \right)$$
Welfare elasticity of a local productivity change
Regional elasticity of a productivity change in California

**TFP elasticity**

**GDP elasticity**

**Employment elasticity**

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Caliendo, Parro, Rossi-Hansberg, Sarte

Regions, Sectors Trade and Productivity
Aggregate TFP elasticities to a sectoral change

Elasticity of aggregate TFP (model RS)

Ratio of elasticities in NRS vs RS

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Aggregate GDP elasticities to a sectoral change

Elasticity of aggregate GDP (model RS)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Services</td>
<td>1.6</td>
</tr>
<tr>
<td>Printing</td>
<td>1.4</td>
</tr>
<tr>
<td>Wood and Paper</td>
<td>1.2</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>1.1</td>
</tr>
<tr>
<td>Primary and Fabricated Metal</td>
<td>1.0</td>
</tr>
<tr>
<td>Chemical</td>
<td>0.95</td>
</tr>
<tr>
<td>Chemicals, and Food Services</td>
<td>0.9</td>
</tr>
<tr>
<td>Accommodation, and Food Services</td>
<td>0.85</td>
</tr>
<tr>
<td>Textile, Apparel, Leather</td>
<td>0.8</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>0.7</td>
</tr>
<tr>
<td>Wholesale and Retail Trade</td>
<td>0.6</td>
</tr>
<tr>
<td>Transportation Equipment</td>
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</tr>
<tr>
<td>Education</td>
<td>0.4</td>
</tr>
<tr>
<td>Construction</td>
<td>0.3</td>
</tr>
<tr>
<td>Health Care</td>
<td>0.2</td>
</tr>
<tr>
<td>Food, Beverage, Tobacco</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Ratio of elasticities in NRS vs RS

<table>
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<th>Sector</th>
<th>Ratio</th>
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<tbody>
<tr>
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<td>1.2</td>
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<tr>
<td>Printing</td>
<td>1.15</td>
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<td>Wood and Paper</td>
<td>1.1</td>
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<td>Finance and Insurance</td>
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</tr>
</tbody>
</table>
Welfare elasticity of a sectoral productivity change
An Application
The Productivity Boom in Computers and Electronics in California

- California, home of prominent information and technology firms
  - Apple, Cisco Systems, Hewlett-Packard, Intel and others
- In 2007, California accounted for 24% of all employment in Computers and Electronics
  - Texas 8%, Massachusetts 6%, other states (37) less than 2%
- From 2002-2007 California experienced a productivity boom in Computers and Electronics
  - An average of 31% annual fundamental TFP increase in that sector, which corresponds to a 14.6% yearly increase in measured TFP
  - The largest across all states and regions in the U.S. during that period
- We evaluate how productivity boom in that sector and state propagated to all other sectors and states of the U.S. economy
Productivity Boom in Comp. & Elec. in California

Regional TFP effects (percent)

Regional GDP effects (percent)

Regional Employment effects (percent)
Another Application
The Economic Impact of Hurricane Katrina

- On August 2005, Hurricane Katrina hit at the border of Louisiana and Mississippi. Structural damages were later estimated at 75.3 million, Burton and Hicks (2005).

- Structural damage estimates shared across Mississippi, Louisiana, and Alabama. We consider the effects of the destruction of structures in Louisiana, $\hat{H} = 0.748$.

- We find: Katrina reduced U.S. welfare by 0.24 percent, and GDP by 0.12 percent. Employment in Louisiana fell by 25 percent, or about 490 thousand workers.

- BLS (2008) estimates that Katrina resulted in a loss of population 1.1 million, of which 51 percent had employment status, corresponding to about 574,000 workers.
The Economic Impact of Hurricane Katrina

Regional Employment effects (percent)

- AL: 0.05
- AK: 0.4
- AZ: 0.34
- AR: 0.05
- CA: 0.39
- CO: 0.36
- CT: 0.36
- DE: 0.34
- FL: 0.45
- GA: 0.3
- HI: 0.2
- ID: 0.15
- IL: 0.45
- IN: 0.18
- IA: 0.08
- KS: 0.1
- KY: 0.18
- LA: -24.72
- ME: 0.26
- MA: 0.47
- MD: 0.45
- MA: 0.49
- ME: 0.26
- MI: 0.31
- MN: 0.34
- MS: -0.11
- MO: 0.27
- MT: 0.25
- NE: 0.07
- NV: 0.37
- NH: 0.35
- NJ: 0.49
- NM: 0.29
- NY: 0.49
- NC: 0.25
- ND: 0.22
- OH: 0.28
- OR: 0.27
- PA: 0.38
- RI: 0.33
- SC: 0.15
- SD: 0.13
- TN: 0.27
- TX: 0.38
- UT: 0.25
- VA: 0.41
- WA: 0.31
- WI: 0.1
- WV: 0.19
- WY: 0.3

Legend:
- > 0.41
- 0.35 to 0.41
- 0.2 to 0.35
- 0.1 to 0.2
- 0 to 0.1
- < 0
Trade costs

- The exercises above suggest that trade is important in determining the effect of productivity changes
  - But how important are regional trade barriers?
  - What portion of trade barriers is explained by physical distance?
    - Compute average miles per shipment for each region from CFS (996 for Indiana but 4154 for Hawaii)
  - What are the gains (TFP, GDP, welfare) from reducing distance versus other trade barriers?

- Following Head and Ries (2001) we can compute

\[
\frac{\pi_{ni}^j \pi_{in}^j}{\pi_{ii}^j \pi_{nn}^j} = \left( \kappa_{ni}^j \kappa_{in}^j \right)^{-\theta^j}
\]

- So given $\theta^j$, and assuming symmetry, we can identify $\kappa_{ni}^j$
Counterfactuals

- Decompose trade barrier using

\[
\log \kappa_{ni}^j = \delta^j \log \frac{d_{ni}^j}{d_{ni}^{j \text{min}}} + \eta_n + \varepsilon_{ni}^j
\]

- Then calculate counterfactuals:

<table>
<thead>
<tr>
<th>Effects of a reduction in trade cost across U.S. states</th>
<th>Distance</th>
<th>Other barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate TFP gains</td>
<td>50.98%</td>
<td>3.62%</td>
</tr>
<tr>
<td>Aggregate GDP gains</td>
<td>125.88%</td>
<td>10.54%</td>
</tr>
<tr>
<td>Aggregate Welfare gains</td>
<td>58.83%</td>
<td>10.10%</td>
</tr>
</tbody>
</table>
Conclusions

- Study the effects of disaggregated productivity changes in a model that recognizes explicitly the role of geographical factors
  - Calibrate for 50 U.S. states and 26 sectors
  - Ready to implement in other countries or regions
- Disaggregated productivity changes can have dramatically different aggregate quantitative implications
  - Elasticity of regional change on welfare varies from 1.7 in MN to 0.75 in TX and 0.5 in AK
  - Elasticity of sectoral productivity increases also varies from .98 in Chemicals to .92 in Transportation Equipment
    - And very heterogenous regional impact
- For future work:
  - Mobility frictions
  - Local factor accumulation
Economic activity in the U.S.
Share of GDP by region (%, 2007)
Economic activity in the U.S.
Change in GDP (%, 2002 to 2007)
Economic activity in the U.S.
Change in Employment (%, 2002 to 2007)
Change in measured TFP by region
Annualized rate (2002-2007, %)
Regional contribution

Regional contribution to the change in aggregate measured TFP (%)
Economic activity in the U.S. 
Petroleum and Coal concentration across regions (%, 2007)
Economic activity in the U.S.
Wood and Paper concentration across regions (%, 2007)
Regional concentration of economic activity across sectors
Herfindahl Index, 2007
Change in sectoral measured TFP

Annualized rate (2002-2007, %)

Diagram showing the change in sectoral measured TFP for various sectors from 2002 to 2007. The sectors are classified into different categories such as Computer and Electronics, Transportation Equipment, Food, Beverage, Tobacco, Information Services, etc. The diagram indicates the annualized rate of change in TFP for each sector, with negative values suggesting a decline and positive values indicating growth.
Sectoral contribution

Sectoral contribution to the change in aggregate measured TFP (%)
Per capita returns from local factors

- Depicts \( \frac{r_n H_n}{L_n} \) calculated using \( GDP_n = w_n L_n + r_n H_n \)
Regional Trade

- Regional trade much more important than international trade

<table>
<thead>
<tr>
<th></th>
<th>Exports</th>
<th>Imports</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International trade</strong></td>
<td>11.9</td>
<td>17.0</td>
<td>28.9</td>
</tr>
<tr>
<td><strong>Inter-regional trade</strong></td>
<td>33.4</td>
<td>33.4</td>
<td>66.8</td>
</tr>
</tbody>
</table>

Source: World Development indicators and CFS

- Still, calibrated trade costs are such that eliminating distance increases GDP by 125% and measured TFP by 50%
  - So geography of production determines prices and trade flows
### Economic activity by regions


<table>
<thead>
<tr>
<th>State</th>
<th>Net Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>12.4</td>
</tr>
<tr>
<td>AK</td>
<td>-3.09</td>
</tr>
<tr>
<td>AZ</td>
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<td>AR</td>
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<td>CA</td>
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Regional elasticity of a productivity change in California

TFP elasticity

- AL: 0.004
- AK: 0.00004
- AZ: 0.007
- AR: 0.005
- CA: 0.402
- CO: 0.003
- CT: 0.002
- DE: -0.001
- FL: 0.001
- GA: 0.0002
- HI: 0.002
- ID: 0.008
- IL: 0.001
- IN: 0.004
- IA: 0.003
- KS: 0.007
- KY: 0.001
- LA: -0.0005
- ME: 0.001
- MI: 0.003
- MN: 0.003
- MS: 0.0001
- MO: 0.006
- MT: 0.001
- NE: 0.007
- NV: 0.008
- NH: 0.007
- NJ: 0.001
- NM: 0.002
- NY: 0.001
- NC: 0.001
- ND: 0.002
- OH: 0.004
- OK: 0.003
- OR: 0.007
- PA: 0.003
- RI: 0.002
- SC: 0.001
- SD: 0.003
- TN: 0.002
- TX: 0.002
- UT: 0.009
- VA: 0.0005
- WA: 0.0004
- WV: 0.003
- WI: 0.004
- WY: 0.001
- WY: 0.001
- WY: 0.001
- WY: 0.001
Regional elasticity of a productivity change in California

GDP elasticity

Back
Regional elasticity of a productivity change in California

Employment elasticity

AL -0.37
AK -0.25
AZ -0.28
AR -0.35
CA 2.7
CO -0.31
CT -0.31
DE -0.21
FL -0.39
GA -0.32
HI -0.29
ID -0.32
IL -0.37
IN -0.33
IA -0.29
KS -0.31
KY -0.34
LA -0.26
ME -0.41
MA -0.43
MI -0.37
MN -0.4
MO -0.37
MS -0.3
MT -0.3
NE -0.3
NV -0.26
NY -0.36
NC -0.33
ND -0.33
OH -0.35
OK -0.35
OR -0.27
PA -0.41
RI -0.35
SC -0.35
SD -0.28
TN -0.33
TX -0.32
UT -0.29
VT -0.48
WA -0.28
WV -0.34
WI -0.4
WY -0.26

Sectoral elasticity of a productivity change in California

Elasticity of aggregate TFP

Elasticity of aggregate GDP
Aggregate elasticity of a local change: Real GDP

NRNS Model

Caliendo, Parro, Rossi-Hansberg, Sarte
Regions, Sectors Trade and Productivity
August 3, 2017
Central Bank of Chile
Granularity and Production Networks in Macroeconomics 50/28
Aggregate elasticity of a local change: Real GDP

RNS Model

Caliendo, Parro, Rossi-Hansberg, Sarte  Regions, Sectors Trade and Productivity
Aggregate elasticity of a local change: Real GDP

RS Model

Counterfactuals GDP
Aggregate elasticity of a local change: TFP

Model with no inter-regional trade and no inter-sectoral trade, NRNS
Then $\ln \hat{A}_n^j = \ln \hat{T}_n^j$
Aggregate elasticity of a local change: TFP

Model with inter-regional trade and no inter-sectoral trade, RNS

Then $\ln \hat{A}_n^j = \frac{\hat{T}_n^j}{(\hat{\rho}_nn^j)^{1/\theta^j}}$
Trade balances and contributions to the National Portfolio

Trade Balance: Model and data (2007 U.S. dollars, billions)

Observed trade balance
National Portfolio balance

Local rents on structures contributed to the National Portfolio ($\ell_n$)
Contributions to the National Portfolio

Local rents on structures contributed to the National Portfolio ($l_n$)
Regional elasticity of a productivity change in Florida

TFP elasticity

GDP elasticity

Employment elasticity