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

Lorenzo Caliendo, Yale University
Fernando Parro, Federal Reserve Board
Esteban Rossi-Hansberg, Princeton University
Pierre-Daniel Sarte, Richmond Fed

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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?
  - Heterogeneity of productivity across sectors and locations, regional trade, local factors, migration, and input-output linkages
  - The geographic component has been mostly ignored

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

- The geography of economic activity, and of TFP changes, is relevant
  - A 10% productivity change in N.Y. increases aggregate GDP by 0.64% but by -0.3% in Florida
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?
  - 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.
  - Stock of local factors also very different across locations
    - Local Factors
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>International trade</td>
<td>11.9</td>
<td>17.0</td>
<td>28.9</td>
</tr>
<tr>
<td>Inter-regional trade</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
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 based on Eaton and Kortum (2002) uses static, multi-sector, multi-country quantitative models to assess the gains for international trade
  
  - We adapt Caliendo and Parro (2012) to introduce labor mobility, local factors, and non-tradable services
  - Large scale quantitative exercise for 50 states and 26 industries
The Model

- The economy consists of $N$ regions, $J$ sectors, and two factors
  - Labor, $L^j_n$: 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

$$ v_n \equiv \max_{\{c^j_n\}_{j=1}^J} \prod_{j=1}^J (c^j_n)^{\alpha^j} \quad \text{with} \quad \sum_{j=1}^J \alpha^j = 1 $$

$$ \text{s.t.} \quad \sum_{j=1}^J P^j_n c^j_n = r_n H_n / L_n + w_n \equiv I_n $$

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

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

where $P_n = \prod_{j=1}^J \left( P^j_n / \alpha^j \right)^{\alpha^j}$ 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 \( z_n^j \).
  - 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 \( T_n^j \).

- The production function of a variety with \( z_n^j \) and \( T_n^j \) is given by

\[
q_n^j(z_n^j) = z_n^j \left[ T_n^j h_n^j(z_n^j)^{\beta_n} l_n^j(z_n^j)^{(1-\beta_n)} \right]^{\gamma_n^j} \prod_{k=1}^{J} M_n^{jk}(z_n^j)^{\gamma_n^jk}
\]

- Importantly, \( T_n^j \) affects value added and not gross output.
The cost of the input bundle needed to produce varieties in \((n, j)\) is

\[
x_n^j = B_n^j \left[ r_n^{\beta_n w_n^{1-\beta_n}} \right] \gamma_n^j \prod_{k=1}^{J} \left( P_n^k \right)^{\gamma_{nk}^j}
\]

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

\[
\frac{x_n^j}{z_n^j} \left( T_n^j \right)^{-\gamma_n^j}
\]

and so its price under competition is given by

\[
p_n^j (z^j) = \min_i \left\{ \frac{\kappa_{ni}^j x_i^j}{z_i^j} \left( T_i^j \right)^{-\gamma_i^j} \right\},
\]

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

- The production of final goods is given by

\[ Q_n^j = \left[ \int \tilde{q}_n^j (z^j)^{1-1/\eta_n^j} \phi^j (z^j) \, dz^j \right] ^{\eta_n^j / (\eta_n^j - 1)}, \]

where \( z^j = (z_1^j, z_2^j, ... z_N^j) \) 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

\[ P_n^j = \xi_n^j \left[ \sum_{i=1}^{N} \left[ x_i^j \kappa_{ni}^j \right] ^{-\theta_i} \left( T_i^j \right)^{\theta_i \gamma_i^j} \right] ^{-1/\theta_i}, \]

where \( \xi_n^j \) is a constant.
Changes in measured TFP

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

\[
\frac{Y^j_n}{P^j_n} = \frac{x^j_n}{P^j_n} \left[ (H^j_n)^{\beta_n} (L^j_n)^{(1-\beta_n)} \right] \gamma^j_n \prod_{k=1}^J (M_n^{jk}) \gamma_n^{jk}
\]

- \(Y^j_n/P^j_n = Q^j_n\) when \(j\) is a non-tradable good.

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

\[
\ln \hat{A}_n^j = \ln \frac{\hat{x}_n^j}{\hat{P}_n^j} = \ln \left( \frac{\hat{T}^j_n}{(\hat{T}^{nn}_n)^{1/\theta^j}} \right) \gamma^j_n
\]

- We aggregate measured TFP changes using gross output revenue shares.

  - Leads to aggregate TFP measures similar to those of the OECD.
GDP

- The Cobb-Douglas production function in intermediates implies that

\[
\ln \hat{GDP}_n^j = \ln \left( \frac{\hat{w}_n \hat{L}_n}{\hat{p}_n} \right)
\]

\[
= \ln \hat{A}_n^j + \ln \hat{L}_n^j + \ln \left( \frac{\hat{w}_n}{\hat{x}_n^j} \right)
\]

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

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

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

- We aggregate real GDP changes using value added shares
Welfare

- Welfare changes are given by

\[
\ln \hat{U} = \sum_{j=1}^{J} \alpha^j \left( \ln \hat{GDP}_n^j - \ln \hat{L}_n^j \right)
\]

\[
= \sum_{j=1}^{J} \alpha^j \left( \ln \hat{A}_n^j + \ln \frac{\hat{W}_n}{\hat{X}_n^j} \right)
\]

- Arkolakis, Costinot and Rodriguez-Clare (2012) emphasize the case with one sector and no factor mobility 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 $\hat{T}_n^j$, parallel to Dekle, Eaton and Kortum (2008)
  - Abstract from wealth effects and the implied heterogeneity that results from productivity changes
  - System of $2N + 3JN + JN^2 = 69000$ equations and unknowns

- Some issues:
  - Regional trade imbalances: Calibrate to 2007 imbalances, but use counterfactual without deficits to compute the effect of $\hat{T}_n^j$
  - No international trade: CFS provides data of expenditures on domestically produced goods
Aggregate impact of 10% local change: TFP

NRNS Model

RNS Model

Caliendo, Parro, Rossi-Hansberg, Sarte  
Regions, Sectors Trade and Productivity  
October 2013
Aggregate impact of 10% local change: Real GDP
Aggregate impact of 10% local change: Welfare

Caliendo, Parro, Rossi-Hansberg, Sarte

Regions, Sectors Trade and Productivity

October 2013

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Regional impact of 10% change in California

Change in TFP (%)

Change in GDP (%)

Change in Employment (%)
Regional impact of 10% change in Florida
Regional impact of 10% change in 5th District

Change in TFP (%)

AL 0.07
AK 0.003
AZ 0.02
AR 0.05
CA 0.01
CO 0.01
CT 0.03
DE 0.03
FL 0.03
GA 0.09
HI -0.001
ID 0.05
IL 0.02
IN 0.05
IA 0.02
KS 0.02
KY 0.08
LA 0.01
ME 0.04
MD 3.8
MA 0.04
MI 0.08
MN 0.02
MS 0.03
MO 0.05
MT 0.001
NE 0.03
NV 0.01
NH 0.07
NJ 0.03
NM 0.01
NY 0.02
NC 0.01
OH 0.06
OK -0.0001
OR 0.004
PA 0.07
RI 0.08
SC 0.33
SD 0.02
TN 0.09
TX 0.03
UT 0.01
VT 0.04
VA 3.8
WA 0.01
WV 0.03
WI 0.03
WY 0.003

Change in GDP (%)

AL -1.71
AK -1.23
AZ -1.85
AR -1.73
CA -1.87
CO -1.81
CT -1.6
DE -0.71
FL -2.12
GA -1.29
HI -1.66
ID -1.63
IL -2.1
IN -1.49
IA -1.2
KS -1.4
KY -1.64
LA -1.0
ME -2.16
MD 31.3
MA -2.5
MI -1.8
MN -2.4
MS -1.46
MO -2.01
MT -1.5
NE -1.69
NV -1.7
NH -2.35
NJ -2.17
NM -1.82
NY -2.11
NC 24.9
ND -1.75
OH -1.82
OK -1.93
OR -1.56
PA -2.12
RI -1.66
SC 25.3
SD -1.28
TN -1.31
TX -1.79
UT -1.78
VT -2.52
VA 29.4
WA -1.46
WV 26.6
WI -2.06
WY -1.31

Change in Employment (%)

AL -2.69
AK -2.24
AZ -2.84
AR -2.72
CA -2.87
CO -2.82
CT -2.28
DE -2.68
FL -2.04
GA -2.29
HI -1.67
IL -3.0
IN -2.27
IA -2.23
KS -2.4
LA -2.79
ME -3.16
MI -3.4
MN -3.4
MO -2.99
MS -2.69
MT -2.79
NE -2.68
OK -2.93
OR -2.72
PA -2.11
RI -2.65
SC -2.33
SD -2.68
TN -2.27
UT -2.78
WA -2.46
WV -2.75
WY -2.33

Aggregate Effects

- TFP = 0.38%, GDP = 0.89% and Welfare 1.04%
- Employment Share = 9.8% and GDP share = 9.5%
Counterfactuals

- Decompose trade barrier using

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

- 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>50.64%</td>
<td>3.64%</td>
</tr>
<tr>
<td>Aggregate Welfare gains</td>
<td>59.50%</td>
<td>9.65%</td>
</tr>
<tr>
<td>Aggregate GDP gains</td>
<td>124.75%</td>
<td>10.81%</td>
</tr>
</tbody>
</table>

Conclusions

- Study the effects of disaggregated productivity changes in a model that recognizes explicitly the role of geographical factors
  - Interactions between sectors over potentially large distances
    - Regional transport costs are large
  - Labor mobility and spatial distribution of local factors of production
- Calibrate for 50 U.S. states and 26 sectors
- Disaggregated productivity changes can have dramatically different aggregate quantitative implications
  - Regional productivity increases can lead to declines in aggregate GDP
  - Sectoral productivity increases always have positive effect
    - But very heterogeneous regional impact
- For future work:
  - Identification of productivity changes and decomposition
  - Local factor accumulation
  - Regional trade imbalances
Economic activity in the U.S.
Share of GDP by region (%, 2007)
Economic activity in the U.S.
Share of Employment 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, %)
Sectoral contribution

Sectoral contribution to the change in aggregate measured TFP (%)

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Per capita income from local factors

- Use $I_n = r_n H_n + w_n L_n$