The Aggregate Implications of Regional Business Cycles

Martin Beraja\textsuperscript{1}  Erik Hurst\textsuperscript{2}  Juan Ospina\textsuperscript{3}

\textsuperscript{1} MIT and NBER
\textsuperscript{2} U of Chicago and NBER
\textsuperscript{3} Banco de la Republica (Colombia)
From Regional to Aggregate

- Regional and aggregate economies differ:
  1. Shock *elasticities*
  2. Shock *realizations*

- Great Recession: cross-state patterns different than US aggregates.

- **Why?** Because of 1. and 2.

- But then...Can we learn anything about aggregates from regional data?

- **Yes!** Regional info + Theory $\implies$ identify shocks driving aggregates.
What We Do

1. Make wage and price indices at the state level. Document that:
   - Nominal and real wage growth were strongly positively correlated with economic activity across states.
   - Aggregate wage growth, less so.

2. Monetary Union Model
   - Regional v. aggregate shock elasticities.
   - Use regional data to estimate structural parameters in NKWPC
   - Impose those restrictions in aggregate DSGE model.
   - Shock decomposition for the Great Recession
Some Take Aways...

- Estimate that wages are fairly flexible (from cross-region variation).

  Hard to get “demand shocks” as THE drivers of aggregate employment.

- A modest role in the early part of the recession. None in the recovery.

- But, regional business cycles are mainly driven by local demand shocks. Remember Mian and Sufi (2014)
Part 1: Regional and Aggregate Business Cycles
Wage Data

- Data from the 2000 Census and 01-12 American Community Surveys.

- Hourly wage $\equiv$ earnings per hour for workers with $\geq 30$ hrs. per week.

- Examine patterns for unadjusted and “adjusted” wages.

- To adjust wages, we regress log wage rate on age, education, citizenship, black, and usual hours worked dummies.
  - Do this separately for each year.
  - Take residuals from regression. Add constant back. Average by state.

- Regional patterns for adjusted and unadjusted wages are very similar.
Data: *Nielsen’s Retail Scanner Database*

- Data from first week of January 2006 through last week of December 2011.
- Data at level of UPC*store*week. Includes number of units sold and average price per unit during week.
- Each store can be matched to a specific location (county, MSA, state) and to a specific chain.
- 75 billion unique observations (UPC*store*week)!
- In 2011, $\approx 36000$ participating stores and 86 participating chains (97 percent of sales come from grocery, drug, and mass merchandising stores).
- In 2011, $\approx 236$ billion dollars worth of sales ($\approx 30$ percent of food expenditures and $\approx 2$ percent of total expenditures).
- Large geographic coverage: Data from about 86 percent of U.S. counties.
Figure: State Employment Growth vs. State Wage Growth

Panel A: Nominal Wages

Panel B: Real Wages

1 pp diff in $\Delta$ emp growth $\implies$ 0.64 (0.72) pp diff in real (nominal) wage growth.
Table: Time Series Estimates of Wage Elasticities During the Great Recession

<table>
<thead>
<tr>
<th>Panel</th>
<th>CPS Data</th>
<th>ACS Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: Nominal Wages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-Trended Nominal Wage Growth, 2007-2010</td>
<td>-3.9 percent</td>
<td>-4.1 percent</td>
</tr>
<tr>
<td>Nominal Wage Elasticity, 2007-2010</td>
<td>0.51</td>
<td>0.54</td>
</tr>
<tr>
<td>Panel B: De-Trended Real Wages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-Trended Real Wage Growth, 2007-2010</td>
<td>-2.6 percent</td>
<td>-2.8 percent</td>
</tr>
<tr>
<td>Real Wage Elasticity, 2007-2010</td>
<td>0.34</td>
<td>0.37</td>
</tr>
</tbody>
</table>

- Smaller time series elasticities compared to regional ones
Part 2: A Monetary Union Model
Purpose

1. Highlight differences in aggregate v. regional shock elasticities.

2. Specify a structural equation. Wage setting.

3. Identify shocks in a state-of-the-art DSGE.
Model

- Economy composed of islands.
- Agents: households, firms and monetary authority.
- 2 sectors: final good and intermediates.
- One asset: one-period nominal bond.
- Sticky prices and wages a-la-Calvo
- 7 shocks with an island and aggregate level component
- DSGE bells-and-whistles: habits, investment adj. cost, etc.
Equilibrium characterization

- Log-linearize around zero inflation SS.

- **Claim 1**: Log-linearized economy aggregates.

- **Claim 2**:
  - Island economies in log-deviation from aggregates are stationary.
  - Behave like independent small open economies.

- Can write $c_{kt} = c_t + \tilde{c}_{kt}$.

- Study aggregate and local economies separately.
Aggregate v regional NKWPC

- Write the Regional New Keynesian Wage Phillips Curve as:

\[
\tilde{\pi}_w^{kt} = \beta \mathbb{E}_t [\tilde{\pi}_w^{kt+1}] + \kappa_w \nu \tilde{n}_t - \kappa_w \tilde{w}_t + \iota_w (\tilde{\pi}_{kt-1} - \beta \tilde{\pi}_{kt}) + \frac{\kappa_w}{1 - h} (\tilde{c}_{kt} - h \tilde{c}_{kt-1}) + \tilde{\varphi}_{kt}
\]

" ~ " represent island variables in log-deviations from aggregates

- Furthermore, the slope of Regional New Keynesian Phillip's curve is:

\[
\kappa_w \equiv \frac{(1 - \beta \xi_w)(1 - \xi_w)}{\xi_w} \frac{\lambda_w - 1}{\lambda_w (1 + \nu) - 1}
\]

where \(1 - \xi_w\) is the fraction of wages that re-set every period

- The Aggregate New Keynesian Wage Phillips Curve is:

\[
\hat{\pi}_t^w = \beta \mathbb{E}_t [\hat{\pi}_t^{w+1}] + \kappa_w \nu \hat{n}_t - \kappa_w \hat{w}_t + \iota_w (\hat{\pi}_{t-1} - \beta \hat{\pi}_t) + \frac{\kappa_w}{1 - h} (\hat{c}_t - h \hat{c}_{t-1}) + \hat{\varphi}_t
\]

" ^ " represent aggregate variables in log-deviations from BGP.
Aggregate v. Local responses

- Simplified model: no habits, no capital, etc. and perfectly rigid prices
- Derive responses on impact to discount factor shock

\[
\begin{align*}
\frac{d\hat{n}_0}{d\hat{b}_0} &= \frac{\kappa w (1 - \alpha + \nu)}{1 - \beta (1 - a_{ww} - \rho_b) + \kappa w} \\
\frac{d\tilde{n}_k0}{d\tilde{b}_k0} &= \frac{\kappa w}{1 - \beta (1 - a_{ww} - \rho_b) + \kappa w} \\
\frac{d\hat{w}_0}{d\hat{n}_0} &= \frac{\kappa w (1 + \nu)}{1 - \beta (1 - a_{ww} - \rho_b) + \kappa w} \\
\frac{d\tilde{w}_k0}{d\tilde{n}_k0} &= \frac{\kappa w (1 + \nu)}{1 - \beta (1 - a_{ww} - \rho_b) + \kappa w} \\
\end{align*}
\]

- Differences come from:
  - Monetary policy
  - Openness
Part 3: The US Great Recession: From Regions to Aggregate
Estimation

- Iterative procedure with aggregate and regional data.

1. Fix $\beta, \nu, \omega, h$. Estimate $\kappa_w$ from Regional NKWPC using regional data only.
   - Need to instrument for expectations and also all other variables because of $\tilde{\phi}_{kt}$
   - To deal with expectations, we are gonna do GMM. Use lagged variables outside the equation (e.g., unemployment, output)
   - To deal with endogenous regressors, use current and lagged house prices (Mian and Sufi (2014)).

2. Estimate aggregate model with aggregate data, but restricting $\kappa_w$.

3. Obtain new $\beta, \nu, \omega, h$. Iterate until convergence.
### Table: Fit of Aggregate model and Regional NKWPC

<table>
<thead>
<tr>
<th></th>
<th>$\xi_w = 0.24$ ($\vartheta = 0$)</th>
<th>$\xi_w = 0.5$ ($\vartheta = 2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate model log-marginal likelihood</td>
<td>-592</td>
<td>-590</td>
</tr>
<tr>
<td>Mean-squared error of regional NKWPC</td>
<td>0.0002</td>
<td>0.0146</td>
</tr>
</tbody>
</table>

Note: The first line is the aggregate model fit to the aggregate time-series data, as measured by the log-marginal likelihood. The second line is the mean squared error of the regional NKWPC. $\vartheta = 0$ uses regional data only for NKWPC estimation. $\vartheta = 2$ uses aggregate data only.
Figure: Distinguishing between high and low wage stickiness models: the role of demand and labor supply shocks

(A) Short sample N=40, Low $\xi_w = 0.24$

(B) Short sample N=40, High $\xi_w = 0.5$

(C) Long sample N=400, Low $\xi_w = 0.24$

(D) Long sample N=400, High $\xi_w = 0.5$
Table: Predicted $\frac{d \log(w^{agg})}{d \log(n^{agg})}$ during the Great Recession in Response to Various Shocks

<table>
<thead>
<tr>
<th></th>
<th>$b$</th>
<th>$b$ and $\mu$</th>
<th>$b$, $\mu$, and $\varphi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.97</td>
<td>0.83</td>
<td>0.31</td>
</tr>
<tr>
<td>Aggregate data alone</td>
<td>0.39</td>
<td>0.40</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Figure: Employment Response to 2007-2010 Household Demand shocks
Figure: Employment shock decomposition

(a) Benchmark

(b) Aggregate data alone

Employment (deviations from trend, %)


- Aggregate Demand + Policy
- Aggregate Supply
- Labor Supply
Conclusions

- Most of the lit. estimates business cycle models with aggregate data only
  - Ignores regional data that can discipline hard-to-pin-down mechanisms
- A separate literature extrapolates from regional elasticities to aggregates
  - Misses channels/shocks that differ between regional and agg. economies
- Combine both regional and aggregate data to estimate a DSGE model
  - Demand shocks main driver of regional employment in the Great Recession
  - Yet, wage rigidity necessary for demand shocks to explain persistence in aggregate employment after the Great Recession is inconsistent with observed flexibility of wages across regions
  - Instead, aggregate labor supply shocks —which are differenced out when exploiting cross-region variation—are important