Sticky Prices and Wages vs. Sticky Information: Results from an Estimated DSGE Model

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Capsule Summary

• Can we construct a DSGE model with nominal frictions which explains the output, inflation, and interest rate data as well as a VAR model?
   
   Yes.

• Can we construct a DSGE model with nominal frictions whose empirical performance is robust to changes in the economic and policy environment?
   
   Proves difficult.
Background:
The Role of Macro Models in Policymaking

• Policymakers and private analysts want to predict the future path of the economy.
  Reduced-form models are sufficient for that purpose provided that the exogenous shock processes and monetary policy are expected to remain basically unchanged.

• Policy analysts want to explore the effects of alternative policy rules or of continuing to follow the current rule under new circumstances.
  More difficult: Need a structural model in which we have confidence.

• Policymakers hope that estimated DSGE models with nominal frictions will help achieve the second goal.
Strategy of this Paper

• Look for a break in aggregate inflation behavior—a break which might reasonably be expected to change firm price-setting behavior.
  
  Break presumably due to a change in the conduct of monetary policy and/or in the character of the exogenous shocks hitting the economy.

• Use maximum likelihood to estimate DSGE models with 3 different styles of nominal frictions over different inflation regimes:
  
  – *Sticky Prices & Wages with Static Indexation*: Prices and wages that are not reoptimized rise automatically at the steady-state inflation rate.
  
  – *Sticky Prices & Wages with Dynamic Indexation*: Prices and wages that are not reoptimized rise automatically at last period’s inflation rate.
  
  – *Sticky Information*: Price and wage paths are predetermined. Random opportunities exist to re-optimize those paths.
Strategy (continued)

- Use a Bayesian pseudo-odds measure to compare how well the three DSGE models explain the data in each sample. VAR models are also included in that comparison.

- Is there a particular DSGE model which performs well across different inflation regimes and is competitive with VAR models?

- Do the DSGE models generate “reasonable” impulse response functions and variance decompositions?
Main Findings

• There appears to have been a significant shift in the behavior of inflation sometime around the middle of 1981.
  – Inflation is more mean reverting in the late sample.
  – Inflation expectations are lower and less variable in the late sample.

• A sticky price and wage model with dynamic indexation dominates all alternatives in the early sample.

• A sticky price and wage model with static indexation performs best in the late sample, but a sticky information model is competitive.

• Although the best performing structural model is always competitive with the best performing VAR, none of the structural models is entirely successful at producing “reasonable” impulse response functions.
Other Papers

Other papers have generally either limited their analyses to a late sample, failed to consider dynamic indexation, or did not utilize a general equilibrium framework.

- Andre, Lopez-Salido, and Nelson (*JME* 2005) and Laforte (*JMCB* 2007). Examined only a late sample. Their results are similar to ours.

- Dupor, Kitamura, and Tsuruga (*REStat* forthcoming); Korenok (*JM* 2008); and Coibion (*REStat* forthcoming). Partial equilibrium. No dynamic indexation. Late sample results generally consistent with ours.

- Coibion and Gorodnichenko (unpublished 2009). No dynamic indexation. Full sample and late sample. Late sample results consistent with ours.

- Kiley (*JMCB* 2007). Structural price-setting equation plus three reduced-form equations. Full sample and late sample. Sticky price model with dynamic indexation does somewhat better than alternatives even in the late sample.
Our Models

• *Three Models*: Sticky prices and wages with static indexation, sticky prices and wages with dynamic indexation, and sticky information

• *Nominal Frictions*: Price and nominal wage frictions of the same character

• *Real Frictions*: Capital adjustment costs

• *Monetary Policy Rule*: Nominal interest rate target depends on the lagged nominal interest rate, the inflation rate, and the output growth rate

• *Exogenous Shocks*: Monetary policy, technology, and aggregate demand

• *Variations*: Flexible wages and internal habit persistence
Estimating the Models

Estimation Procedure:

• Log-linearize each model around its non-stochastic steady state and find its rational-expectations (RE) solution.
• Put the RE solution into a state-space form and apply the Kalman filter to obtain the optimal linear forecast of $Y_t$ based on $Y_{t-1},...,Y_1$.
• Create the sample log-likelihood function and maximize it with respect to the model’s parameters.

Observed Variables: Detrended real per-capita GDP, GDP price inflation rate, and the effective federal funds rate

Estimated Parameters:

• The monetary policy rule
• Probability that a firm can reoptimize its price
• Serial correlation of the monetary policy, technology, and aggregate demand shocks
• Standard deviations of the innovations to the three shocks
The Behavior of Inflation

Estimate $\pi_t = \alpha_1 \pi^* + (1 - \alpha_1) \pi_{t-h} + \varepsilon_t$

<table>
<thead>
<tr>
<th>Horizon $(h)$</th>
<th>Trim</th>
<th>Most Likely Break</th>
<th>Max F-Statistic</th>
<th>Quandt-Andrews P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25%</td>
<td>1968:Q3</td>
<td>7.184</td>
<td>0.203</td>
</tr>
<tr>
<td>2</td>
<td>25%</td>
<td>1981:Q2</td>
<td>10.575</td>
<td>0.053</td>
</tr>
<tr>
<td>3</td>
<td>25%</td>
<td>1981:Q3</td>
<td>11.351</td>
<td>0.038</td>
</tr>
<tr>
<td>4</td>
<td>25%</td>
<td>1981:Q3</td>
<td>15.529</td>
<td>0.006</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha_1$</td>
<td>1 - $\alpha_1$</td>
</tr>
<tr>
<td>1</td>
<td>0.150</td>
<td>0.850</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>2</td>
<td>0.159</td>
<td>0.841</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.057)</td>
</tr>
<tr>
<td>3</td>
<td>0.187</td>
<td>0.813</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.065)</td>
</tr>
<tr>
<td>4</td>
<td>0.171</td>
<td>0.829</td>
</tr>
<tr>
<td></td>
<td>(0.064)</td>
<td>(0.064)</td>
</tr>
</tbody>
</table>

Suggests that static indexation is more competitive with dynamic indexation in the late sample.
Inflation Expectations Lower and More Stable After 1981:Q2

<table>
<thead>
<tr>
<th></th>
<th>Summary Statistics for SPF Horizon-( h ) Inflation Forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>6.280</td>
</tr>
<tr>
<td>2</td>
<td>5.887</td>
</tr>
<tr>
<td>3</td>
<td>5.625</td>
</tr>
<tr>
<td>4</td>
<td>5.544</td>
</tr>
</tbody>
</table>

*Suggests that the static indexation model is more competitive with the sticky information model in the late sample than in the early sample.*
Performance Comparison

\[ \text{BIC}(i) = \text{Like}(i) - \left[ N_p(i)/2 \right] \times \ln(T) \]

\[ \text{Pseudo-Odds}(i) = \exp[\text{BIC}(i)]/\sum_j \exp[\text{BIC}(j)] \]

### Early-Sample Results: 1954:Q3-1981:Q2

<table>
<thead>
<tr>
<th>Model</th>
<th>BIC</th>
<th>Pseudo-Odds</th>
<th>Pseudo-Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static indexation</td>
<td>1049.31</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Dynamic indexation</td>
<td>1057.99</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sticky information</td>
<td>1053.27</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>VAR, N = 1</td>
<td>1049.13</td>
<td>–</td>
<td>0.02</td>
</tr>
<tr>
<td>Dynamic indexation</td>
<td>1057.99</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sticky information</td>
<td>1053.27</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>VAR, N = 1</td>
<td>1049.13</td>
<td>–</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### Late-Sample Results: 1981:Q3-2006:Q4

<table>
<thead>
<tr>
<th>Model</th>
<th>BIC</th>
<th>Pseudo-Odds</th>
<th>Pseudo-Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static indexation</td>
<td>1151.41</td>
<td>0.61</td>
<td>0.38</td>
</tr>
<tr>
<td>Dynamic indexation</td>
<td>1145.96</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sticky information</td>
<td>1050.98</td>
<td>0.39</td>
<td>0.25</td>
</tr>
<tr>
<td>VAR, N = 3</td>
<td>1151.33</td>
<td>–</td>
<td>0.35</td>
</tr>
<tr>
<td>VAR, N = 2</td>
<td>1147.96</td>
<td>–</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Variance Decompositions

• **Output**
  – Monetary policy shocks are quite important at short-to-medium horizons, especially in the early sample.
  – Technology shocks are important at business-cycle frequencies in the early sample and at medium-to-long horizons in the late sample.
  – Aggregate demand shocks have their greatest influence at longer horizons in the early sample.

• **Inflation**
  – Main drivers are aggregate demand and (especially) technology shocks—*not* monetary policy shocks.
  – The aggregate demand shocks tend to kick in at medium-to-long horizons rather than at short horizons.

• **Nominal Interest Rate**
  – Aggregate demand shocks are the main driver at all horizons.
  – The impact of monetary policy shocks is largely limited to a few quarters.
Impulse Response Functions: Early Sample
Impulse Response Functions: Late Sample

[Graphs showing the response of output, inflation rate, and nominal interest rate to shocks: Monetary Policy Shock, Technology Shock, Aggregate Demand Shock. The graphs display the response in percent for output, inflation rate, and basis points for nominal interest rate.]

Legend:
- Blue line: Sticky Price & Wage (Static)
- Red line: Sticky Price & Wage (Dynamic)
- Green line: Sticky Information
Other Findings

- In all of the models, the innovations for the three exogenous shocks are largest in the early sample.

- The probability that a firm can reoptimize its price is about the same in both samples for the dynamic indexation and sticky information models, but is substantially lower in the early sample for the static indexation model.

- Aggregate demand shocks are more persistent in the early sample.

- Technology shocks are highly persistent in the static indexation and sticky information models, but are nearly white noise in the dynamic indexation model.

- The data does not support a large amount of habit persistence. The best performing model with substantial habit persistence performs much worse than the best performing model with little or no habit persistence.

- The data is uninformative about the degree of wage stickiness.
Summary and Conclusions

• We construct and estimate three DSGE models which explain output, inflation, and interest rates as well as a simple VAR model.

• The relative performance of out three DSGE models is sensitive to the sample period.
  – In the early sample, in which inflation is variable and its fluctuations persist, the sticky price and wage model with dynamic indexation performs best.
  – In the late sample, in which inflation is stable and its fluctuations are fleeting, the sticky price and wage model with static indexation or the sticky information model better fits the data.

• None of our DSGE models are flexible and robust enough for evaluating major changes in the conduct of monetary policy.
Future Research

• What is the incentive for the individual firm to adopt a particular indexation or price-setting scheme given the choices made by others, the Fed’s policy rule, and exogenous shock processes?

• How sensitive are our results to different and/or more general monetary policy rules and shock processes?