Time Variation in U.S. Wage Dynamics

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Motivation

• Two major U.S. macroeconomic phenomena

➤ “Great Inflation”

<table>
<thead>
<tr>
<th></th>
<th>Average inflation</th>
<th>Inflation variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1965</td>
<td>0.40</td>
<td>0.29</td>
</tr>
<tr>
<td>1965 - 1982</td>
<td>1.46</td>
<td>0.60</td>
</tr>
<tr>
<td>&gt; 1982</td>
<td>0.64</td>
<td>0.29</td>
</tr>
</tbody>
</table>

➤ “Great Moderation”

<table>
<thead>
<tr>
<th></th>
<th>Output growth variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1984</td>
<td>1.19</td>
</tr>
<tr>
<td>&gt; 1984</td>
<td>0.54</td>
</tr>
</tbody>
</table>
Motivation

• Clarida et al. (2000); Gali et al. (2003); Lubik and Schorfheide (2004)
  – A shift in systematic monetary policy can explain these phenomena
  – Monetary policy did not stabilize inflation in 1970s, and became more aggressive with respect to inflation when Volcker became Fed chairman
  – “Bad policy – good policy hypothesis”

• Primiceri (2005); Sims and Zha (2006); Canova and Gambetti (2009)
  – Counterfactual simulations with alternate monetary policy rules
  – Shift in systematic component of monetary policy is insufficient or unable to explain the observed volatility break over time
  – Attribute break to changed variance of disturbances affecting the economy: “Bad luck – good luck hypothesis”
• Time variation in wage dynamics has not been studied in this context

  – Surprising given important role of wages in macroeconomic models: inflation is typically driven by real marginal costs, which are directly linked to wages

  – Perception among e.g. policymakers (e.g. Bernanke 2004): second-round effects during “Great Inflation” period

    • Amplification inflationary effects of shocks via mutually reinforcing feedback between wages and prices arising from explicit or implicit wage indexation

    • Wage indexation protects for high inflation (variability), and has vanished with anchoring of inflation expectations in subsequent era of price stability

    • Larger shift in output (variability) is needed for inflation to return to baseline

    • Characteristic of monetary policy regime not captured by parameters of policy rule (reflects Lucas critique)
Motivation

- Institutional evidence supports conjecture that wage indexation has not been constant and could be linked to inflation regime.
Present paper

- Explores patterns and sources of time variation in U.S. wage dynamics and its interlinkage with time variation in macroeconomic dynamics

- Two steps

  1. Estimation of a TVP-BVAR over the period 1957-2008 including nominal wages
     - Analysis of time variation in dynamic effects of supply and demand shock
     - Considerable time variation in wage dynamics

  2. Causes of time variation: estimation of parameters standard DSGE model for specific periods of time by matching impulse responses from TVP-BVAR
Time-varying parameters BVAR with stochastic volatility

- In spirit of Cogley and Sargent (2002); Primiceri (2005); Benati and Mumtaz (2007); Baumeister and Peersman (2008)

\[ y_t = c_t + B_{1,t} y_{t-1} + \ldots + B_{p,t} y_{t-p} + u_t \equiv X_t ' \theta_t + u_t \]

- First difference of logs output, prices (GDP deflator), nominal wages and the level of the interest rate

- Quarterly data: sample period with time-varying parameters covers 1957-2008 (1947-1956 used as a training sample)

- Drifting coefficients to capture time variation in propagation mechanism

\[ \theta_t = \theta_{t-1} + v_t \quad v_t \sim N(0,Q) \]
Time-varying parameters BVAR with stochastic volatility

- Time-varying covariance matrix allows for heteroscedasticity of shocks and time variation in simultaneous relationships between variables

\[ \Omega_t = A_t^{-1} H_t (A_t^{-1})' \]

\[
A_t = \begin{bmatrix}
1 & 0 & 0 & 0 \\
\alpha_{21,t} & 1 & 0 & 0 \\
\alpha_{31,t} & \alpha_{32,t} & 1 & 0 \\
\alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1
\end{bmatrix}
\]

\[
H_t = \begin{bmatrix}
h_{1,t} & 0 & 0 & 0 \\
0 & h_{2,t} & 0 & 0 \\
0 & 0 & h_{3,t} & 0 \\
0 & 0 & 0 & h_{4,t}
\end{bmatrix}
\]

- Error terms of transition equations are independent of each other and of the innovations of the observation equation, and block diagonal structure of \( S \)

- Estimated with Bayesian methods: Primiceri (2005)
Peersman and Straub (2009): set of sign restrictions that are consistent with a large class of DSGE models and robust for parameter uncertainty.

- Technology shock also captures supply-side shocks such as commodity prices or price mark-up shocks.

<table>
<thead>
<tr>
<th>Source</th>
<th>Output</th>
<th>Prices</th>
<th>Interest rate</th>
<th>Nominal wages</th>
<th>Real wages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Labor supply</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Aggregate demand</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monetary policy</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
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</tbody>
</table>

Note: technology shock also captures supply-side shocks such as commodity prices or price mark-up shocks.
Time-varying effects of supply shocks
Time-varying effects of demand shocks
Impact of supply and demand shock over time

**Long-run Impact of Supply shock**

Size of shock could have contributed to time variation but cannot be the only explanation: magnitude and pattern clearly different from nominal wages/prices and cannot explain sign switch.

**Immediate Impact of Demand shock**

Output

Real wages

Size of shock could have contributed to time variation but cannot be the only explanation: magnitude and pattern clearly different from nominal wages/prices and cannot explain sign switch.
Impact of supply shock over time

- Substantial stronger long-run impact on prices between second half 1960s and early 1980s: “Great Inflation”
  - Gali et al. (2003) already detected a much stronger impact on inflation in pre-Volcker period (54Q1-79Q2) relative to Volcker-Greenspan era (82Q3-98Q3)
  - Our evidence indicates that their first period covers two regimes
Impact of supply shock over time

Long-run impact

• Strong negative pass-through to nominal wages during “Great Inflation” is new stylized fact

  – Basu et al. (2006); Liu and Phaneuf (2007) use constant parameters SVARs and conclude that there is only a very weak negative or insignificant impact on nominal wages

  – Misleading since their findings are consequence of considerable time variation cancelling each other out
Impact of supply shock over time

- Sign-switch of long-run nominal wage response striking
  - Before and after 1970s: nominal wages in opposite direction as the price level
  - During “Great Inflation”: nominal wages moved in same direction as prices
  - This is not the case for the contemporaneous impact: has always been positive and of a similar magnitude (see next slide)
Impact of supply shock over time

**Long-run impact**

**Prices**

**Nominal wages**

**Immediate impact**
Also substantial stronger long-run impact of demand shocks on nominal wages and prices during same period
Explaining the time variation in wage dynamics

- Estimation of parameters standard DSGE model for specific periods to examine causes of time variation in a structural way
  - 1960Q1, 1974Q1 and 2000Q1
  - Bayesian impulse response matching procedure (Christiano et al. 2010)
The DSGE model in a nutshell

• Simplified version of Smets and Wouters (2007); Christiano et al. (2005)

• Calvo sticky prices and wages, price and wage indexation, habit formation and a conventional Taylor rule

• Economy subject to (permanent) technology and government spending shock

• Fixed value for some of structural parameters
  – Discount factor, invers labor supply elasticity and degree of monopolistic competition in goods and labor market

• All other parameters estimated with Bayesian matching procedure
• Structural parameters are estimated by minimizing distance between DSGE impulse response functions and those from the VAR for each period

• Impulse response functions that have to be matched are generated with a Bayesian VAR, while shocks are identified with sign restrictions
  
  – There is no point estimate to center minimum distance method

  – We first estimate posterior mode of structural parameters for each impulse response draw from the VAR

  – Distribution posterior modes of structural parameters is calculated in next step
Impulse response matching

1960Q1
Supply shock

Output
Prices
Interest rate
Nominal wages

Output
Prices
Interest rate
Nominal wages

VAR
DSGE model
Impulse response matching

1974Q1
Supply shock

Output
Prices
Interest rate
Nominal wages

Demand shock

Output
Prices
Interest rate
Nominal wages

VAR
DSGE model
Impulse response matching

2000Q1

Supply shock

Output
Prices
Nominal wages

Demand shock

Output
Prices
Nominal wages

VAR
DSGE model
Estimated structural parameters 1

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>1974</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stdv. supply shock</strong></td>
<td>0,60</td>
<td>1,02</td>
<td>0,31</td>
</tr>
<tr>
<td></td>
<td>[0.46 – 0.85]</td>
<td>[0.71 – 1.69]</td>
<td>[0.25 – 0.42]</td>
</tr>
<tr>
<td><strong>Stdv. demand shock</strong></td>
<td>4,75</td>
<td>4,73</td>
<td>3,25</td>
</tr>
<tr>
<td></td>
<td>[3.41 – 7.92]</td>
<td>[3.94 – 5.95]</td>
<td>[2.30 – 6.22]</td>
</tr>
<tr>
<td><strong>Autocorr. demand shock</strong></td>
<td>0,87</td>
<td>0,89</td>
<td>0,91</td>
</tr>
<tr>
<td></td>
<td>[0.83 – 0.92]</td>
<td>[0.86 – 0.93]</td>
<td>[0.87 – 0.95]</td>
</tr>
<tr>
<td><strong>Price stickiness</strong></td>
<td>0,81</td>
<td>0,84</td>
<td>0,78</td>
</tr>
<tr>
<td></td>
<td>[0.76 – 0.85]</td>
<td>[0.81 – 0.87]</td>
<td>[0.70 – 0.84]</td>
</tr>
<tr>
<td><strong>Wage stickiness</strong></td>
<td>0,60</td>
<td>0,64</td>
<td>0,54</td>
</tr>
<tr>
<td></td>
<td>[0.46 – 0.85]</td>
<td>[0.54 – 0.73]</td>
<td>[0.43 – 0.69]</td>
</tr>
<tr>
<td><strong>Consumption habit</strong></td>
<td>0,33</td>
<td>0,71</td>
<td>0,37</td>
</tr>
<tr>
<td></td>
<td>[0.21 – 0.40]</td>
<td>[0.51 – 0.96]</td>
<td>[0.18 – 0.57]</td>
</tr>
</tbody>
</table>

- Size of shocks has changed over time (good luck hypothesis)
- There is also a change in habit persistence over time
Pattern of parameters of monetary policy rule consistent with literature on evolution of Fed monetary policy conduct (bad monetary policy in 1970s)

Less aggressive policy response to inflation in 1970s and stronger focus on output stabilization

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<tr>
<th></th>
<th>1960</th>
<th>1974</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor rule inflation</td>
<td>1,55</td>
<td>1,11</td>
<td>1,35</td>
</tr>
<tr>
<td></td>
<td>[1,34 – 1,74]</td>
<td>[1,07 – 1,18]</td>
<td>[1,24 – 1,49]</td>
</tr>
<tr>
<td>Taylor rule Δoutput</td>
<td>0,30</td>
<td>0,50</td>
<td>0,39</td>
</tr>
<tr>
<td></td>
<td>[0,21 – 0,40]</td>
<td>[0,27 – 0,84]</td>
<td>[0,27 – 0,59]</td>
</tr>
<tr>
<td>Taylor rule output</td>
<td>0,10</td>
<td>0,11</td>
<td>0,10</td>
</tr>
<tr>
<td></td>
<td>[0,07 – 0,16]</td>
<td>[0,06 – 0,29]</td>
<td>[0,07 – 0,15]</td>
</tr>
<tr>
<td>Taylor rule smoothing</td>
<td>0,76</td>
<td>0,69</td>
<td>0,78</td>
</tr>
<tr>
<td></td>
<td>[0,68 – 0,82]</td>
<td>[0,58 – 0,87]</td>
<td>[0,70 – 0,88]</td>
</tr>
</tbody>
</table>
Price indexation was higher in “Great Inflation” period

- In line with studies documenting a rise of inflation persistence in 1970s

- Time variation in wage indexation parameter: much higher in “Great Inflation” compared to preceding and subsequent periods

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<tr>
<th></th>
<th>1960</th>
<th>1974</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price indexation</td>
<td>0.15</td>
<td>0.80</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>[0.11 – 0.19]</td>
<td>[0.58 – 0.93]</td>
<td>[0.12 – 0.21]</td>
</tr>
<tr>
<td>Wage indexation</td>
<td>0.30</td>
<td>0.91</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>[0.21 – 0.67]</td>
<td>[0.74 – 0.96]</td>
<td>[0.11 – 0.25]</td>
</tr>
</tbody>
</table>
Relevance for macroeconomic dynamics

• Relevance of wage indexation for macro dynamics is considerable

• Simulation of DSGE model for 1974 and replacing wage indexation parameter by its 2000 posterior median value
  
  – Impact of supply and demand shock on prices respectively 44% and 39% lower

  – Note 1: for policy rule parameters, this is respectively 31% and 37%

  – Note 2: for price indexation, this is respectively 23% and 19%
Dynamic effects of 1% decline in productivity

Output

- low wage indexation
- high wage indexation

Inflation

- low wage indexation
- high wage indexation

Interest rate

- low wage indexation
- high wage indexation

Prices and nominal wages

- prices (low)
- prices (high)
- wages (low)
- wages (high)
Conclusions and consequences

- Considerable time variation in U.S. wage dynamics within TVP-BVAR
  - Much stronger long-run effects of supply and demand shocks on nominal wages and prices during “Great Inflation” than in preceding and subsequent periods
  - For supply shocks, there is even a sign switch in nominal wage response
    - Move in same direction as real wages and opposite direction of price level before and after “Great Inflation”
    - Nominal wages and prices move in same direction at longer horizons after the shock in 1970s (not on impact)

- Estimation of DSGE model: results reflect changes in conduct of monetary policy and, especially, changes in degree of wage indexation over time
  - Indexation very high in “Great Inflation”, but low before and after this period
  - Wage-price spirals amplified effects of inflationary shocks in “Great Inflation”
Conclusions and consequences

- Parameters of policy rule and degree of wage (price) indexation are two sides of same coin, i.e. monetary policy regime
  - Simultaneous switch of response to inflation and degree of indexation in data
  - Weakly inflation stabilizing policy rule is conducive to high and volatile inflation, which fosters use of indexation clauses as protection against inflation uncertainty
    - Indexation in turn contributes to inflation uncertainty by amplifying the effects of inflationary shocks
    - Regime of price stability with strong inflation stabilizing policy rule reduces the need for protection against inflation uncertainty, mitigating indexation
  - Reasoning reflects Lucas critique: change in policy regime could have wider effects on empirical macroeconomic regularities
Conclusions and consequences

- Hard-wiring certain degree of wage indexation in macro models potentially misleading when changes in monetary policy regime are analyzed
  - Wage (and price) indexation should be treated as endogenous

- Counterfactual experiments in context of “Great Inflation” and “Great Moderation” by altering solely the monetary policy rule do not capture the wider consequences of a change in the policy regime