Monetary Policy and Unemployment: A New Keynesian Perspective

Jordi Galí

CREI, UPF and Barcelona GSE

April 2015
Introducing unemployment in the Standard NK model

- New approach developed in my Zeuthen lectures [1]
  - reformulation of the *standard* NK model $\Rightarrow$ unemployment

- Alternative to recent literature: labor market frictions + nominal rigidities

Walsh, Trigari, Blanchard-Galí, Thomas, Gertler-Sala-Trigari, Faia, Ravenna-Walsh,…

- Applications:
  - An empirical model of wage inflation and unemployment dynamics [2]
  - Unemployment and the measurement of the output gap (ch. 2 in [1])
  - Unemployment and the design of monetary policy (ch.3 in [1])
  - Revisiting the sources of fluctuations in the Smets-Wouters model [3]
  - A structural interpretation of slow recoveries [4]
References

A Model of Unemployment and Inflation Fluctuations

Households

- Representative household with a continuum of members, indexed by \((j, s) \in [0, 1] \times [0, 1]\)
- Continuum of differentiated labor services, indexed by \(j \in [0, 1]\)
- Disutility from (indivisible) labor: \(\chi s^\varphi\), for \(s \in [0, 1]\), where \(\varphi \geq 0\)
- Full consumption risk sharing within the household
- Household utility: 
  \[
  E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, \{N_t(j)\}; Z_t)
  \]

\[
U(C_t, \{N_t(j)\}; Z_t) \equiv \left( \frac{C_t^{1-\sigma} - 1}{1 - \sigma} - \chi \int_0^1 \int_0^1 s^\varphi dsdj \right) Z_t
\]

\[
= \left( \frac{C_t^{1-\sigma} - 1}{1 - \sigma} - \chi \int_0^1 \frac{N_t(j)^{1+\varphi}}{1 + \varphi} dj \right) Z_t
\]

where \(C_t \equiv \left( \int_0^1 C_t(i)^{1-\frac{1}{\epsilon_p}} di \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}\)
• Budget constraint

\[ \int_0^1 P_t(i) C_t(i) \, di + Q_t B_t \leq B_{t-1} + \int_0^1 W_t(j) N_t(j) \, dj + D_t \]

• Two optimality conditions

\[ C_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\epsilon_p} C_t \]

where \( P_t \equiv \left( \int_0^1 P_t(i)^{1-\epsilon_p} \, di \right)^{\frac{1}{1-\epsilon_p}} \), implying \( \int_0^1 P_t(i) C_t(i) \, di = P_t C_t \).

\[ Q_t = \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \left( \frac{Z_{t+1}}{Z_t} \right) \left( \frac{P_t}{P_{t+1}} \right) \right\} \]
Wage Setting

- Nominal wage for each labor type reset with probability $1 - \theta_w$ each period.

- Average wage dynamics

$$w_t = \theta_w w_{t-1} + (1 - \theta_w) w_t^*$$

- Optimal wage setting rule

$$w_t^* = \mu^w + (1 - \beta \theta_w) \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \{ mrs_{t+k|t} + p_{t+k} \}$$

where $\mu^w \equiv \log \frac{\epsilon_w}{\epsilon_w - 1}$ and $mrs_{t+k|t} \equiv \sigma c_{t+k} + \varphi n_{t+k|t} + \zeta$

- Wage inflation equation

$$\pi_t^w = \beta E_t \{ \pi_{t+1}^w \} - \lambda_w (\mu_t^w - \mu^w)$$

where $\pi_t^w \equiv w_t - w_{t-1}$, $\mu_t^w \equiv w_t - p_t - mrs_t$, and $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta \theta_w)}{\theta_w (1+\epsilon_w \varphi)}$. 
Introducing Unemployment

- Participation condition for an individual \((j, s)\):
  \[
  \frac{W_t(j)}{P_t} \geq \chi C_t \sigma s^\varphi
  \]

- Marginal participant, \(L_t(j)\), given by:
  \[
  \frac{W_t(j)}{P_t} = \chi C_t \sigma L_t(j)^\varphi
  \]

- Taking logs and integrating over \(i\),
  \[
  w_t - p_t = \sigma c_t + \varphi l_t + \xi
  \]

where \(w_t \sim \int_0^1 w_t(j) dj\) and \(l_t \equiv \int_0^1 l_t(j) dj\) is the model’s implied (log) aggregate labor force.
Introducing Unemployment

- Unemployment rate
  \[ u_t \equiv l_t - n_t \]

- Average wage markup and unemployment
  \[
  \mu^w_t = (w_t - p_t) - (\sigma c_t + \varphi n_t + \xi) \\
  = \varphi u_t
  \]

- Under flexible wages:
  \[
  \mu^w = \varphi u^n
  \]
  \[ \Rightarrow u^n: \text{natural rate of unemployment} \]

- The nature of unemployment and its fluctuations

- A New Keynesian Wage Phillips Curve
  \[
  \pi^w_t = \beta E_t \{ \pi^w_{t+1} \} - \lambda_w \varphi (u_t - u^n)
  \]
Figure 7.1  The Wage Markup and the Unemployment Rate

\[ w_t - p_t \]

\[ \mu_t^w \]

\[ u_t \]

\[ n_t \]

\[ l_t \]
Firms and Price Setting

- Continuum of firms, $i \in [0, 1]$, each producing a differentiated good.
- Technology
  \[
  Y_t(i) = A_t N_t(i)^{1-\alpha}
  \]
  where $N_t(i) \equiv \left( \int_0^1 N_t(i, j)^{1-\frac{1}{\epsilon_w}} \, di \right)^{\frac{\epsilon_w}{\epsilon_w-1}}$
- The price of each good reset with a probability $1 - \theta_p$ each period
- Average price dynamics
  \[
  p_t = \theta_p p_{t-1} + (1 - \theta_p) p_t^*
  \]
- Optimal price setting rule
  \[
  p_t^* = \mu^p + (1 - \beta \theta_p) \sum_{k=0}^{\infty} (\beta \theta_p)^k E_t \{ \psi_{t+k} \mid t \} 
  \]
Firms and Price Setting

- Implied price inflation equation

\[ \pi^p_t = \beta E_t \{ \pi^p_{t+1} \} - \lambda_p (\mu^p_t - \mu^p) \]

where

\[ \mu^p_t \equiv p_t - \psi_t \]

\[ \psi_t \equiv w_t - (a_t - \alpha n_t + \log(1 - \alpha)) \]

and

\[ \lambda_p \equiv (1 - \theta_p)(1 - \beta \theta_p) \]

\[ \frac{1 - \alpha}{\theta_p} \]

\[ \frac{1 - \alpha + \alpha \epsilon_p}{1 - \alpha + \alpha \epsilon_p}. \]
Equilibrium

- Non-Policy block

\[ \tilde{y}_t = -\frac{1}{\sigma}(i_t - E_t\{\pi^p_{t+1}\} - r^n_t) + E_t\{\tilde{y}_{t+1}\} \]

\[ \pi^p_t = \beta E_t\{\pi^p_{t+1}\} + \nu_p \tilde{y}_t + \lambda_p \tilde{\omega}_t \]

\[ \pi^w_t = \beta E_t\{\pi^w_{t+1}\} - \lambda_w \varphi \hat{u}_t \]

\[ \tilde{\omega}_t \equiv \tilde{\omega}_{t-1} + \pi^w_t - \pi^p_t - \Delta \omega^\prime_t \]

\[ \varphi \hat{u}_t = \hat{\mu}^w_t \]

\[ = \tilde{\omega}_t - (\sigma \tilde{c}_t + \varphi \tilde{n}_t) \]

\[ = \tilde{\omega}_t - \left(\sigma + \frac{\varphi}{1 - \alpha}\right) \tilde{y}_t \]
Example:

\[ i_t = \rho + \phi_p \pi_t^p + \phi_y \hat{y}_t + \nu_t \]

Natural equilibrium

\[ \hat{y}_t^n = \psi_{ya} a_t \]
\[ r_t^n = \rho - \sigma(1 - \rho_a)\psi_{ya} a_t + (1 - \rho_z)z_t \]
\[ \hat{\omega}_t^n = \psi_{wa} a_t \]

with \( \psi_{ya} \equiv \frac{1+\varphi}{\sigma(1-\alpha)+\varphi+\alpha} \) and \( \psi_{wa} \equiv \frac{1-\alpha \psi_{ya}}{1-\alpha} > 0 \).

Exogenous AR(1) processes for \( \{a_t\} \), \( \{z_t\} \), and \( \{\nu_t\} \)
### Baseline calibration

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>ϕ  Curvature of labor disutility</td>
<td>5</td>
<td>Frisch elasticity 0.2</td>
</tr>
<tr>
<td>α  Index of decreasing returns to labor</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>ϵ&lt;sub&gt;w&lt;/sub&gt; Elasticity of substitution (labor)</td>
<td>4.52</td>
<td></td>
</tr>
<tr>
<td>ϵ&lt;sub&gt;p&lt;/sub&gt; Elasticity of substitution (goods)</td>
<td>9</td>
<td>u&lt;sup&gt;n&lt;/sup&gt; = 0.05</td>
</tr>
<tr>
<td>θ&lt;sub&gt;p&lt;/sub&gt; Calvo index of price rigidities</td>
<td>3/4</td>
<td>S = 1 - α / (ϵ&lt;sub&gt;p&lt;/sub&gt; - 1) = 2/3</td>
</tr>
<tr>
<td>θ&lt;sub&gt;W&lt;/sub&gt; Calvo index of wage rigidities</td>
<td>3/4</td>
<td>avg. duration = 4</td>
</tr>
<tr>
<td>φ&lt;sub&gt;p&lt;/sub&gt; Inflation coefficient in policy rule</td>
<td>1.5</td>
<td>avg. duration = 4</td>
</tr>
<tr>
<td>φ&lt;sub&gt;y&lt;/sub&gt; Output coefficient in policy rule</td>
<td>0.125</td>
<td>Taylor (1993)</td>
</tr>
<tr>
<td>β  Discount factor</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td>ρ&lt;sub&gt;a&lt;/sub&gt; Persistence: technology shocks</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>ρ&lt;sub&gt;z&lt;/sub&gt; Persistence: demand shocks</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>ρ&lt;sub&gt;v&lt;/sub&gt; Persistence: monetary shocks</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>
Dynamic Effects of Monetary Policy Shocks on Labor Markets

- Impulse responses
- Wage rigidities and the volatility and persistence of unemployment
Figure 7.2  Response of Labor Market Variables to a Monetary Policy Shock

- Unemployment rate
- Employment
- Labor force
- Real wage
<table>
<thead>
<tr>
<th></th>
<th>Volatility</th>
<th>Persistence</th>
<th>Cyclicality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\theta_w$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_v = 0.0$</td>
<td>0.1</td>
<td>0.32</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.14</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.99</td>
<td>-0.99</td>
</tr>
<tr>
<td>$\rho_v = 0.5$</td>
<td>0.36</td>
<td>0.60</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.24</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.96</td>
<td>-0.99</td>
</tr>
<tr>
<td>$\rho_v = 0.9$</td>
<td>0.31</td>
<td>1.24</td>
<td>2.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.51</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.77</td>
<td>-0.98</td>
</tr>
</tbody>
</table>

Source: Galí (2015, ch. 7)
Optimal Monetary Policy Problem

\[
\min \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left( \left( \frac{\sigma + \varphi + \alpha}{1 - \alpha} \right) \tilde{y}_t^2 + \frac{\epsilon_p}{\lambda_p} (\pi_t^p)^2 + \frac{\epsilon_w (1 - \alpha)}{\lambda_w} (\pi_t^w)^2 \right)
\]

subject to:

\[
\pi_t^p = \beta E_t \{ \pi_{t+1}^p \} + \kappa_p \tilde{y}_t + \lambda_p \tilde{\omega}_t
\]

\[
\pi_t^w = \beta E_t \{ \pi_{t+1}^w \} + \kappa_w \tilde{y}_t - \lambda_w \tilde{\omega}_t
\]

\[
\tilde{\omega}_t \equiv \tilde{\omega}_{t-1} + \pi_t^w - \pi_t^p - \Delta \omega_t^n
\]
- Optimality conditions

\[
\left( \sigma + \frac{\varphi + \alpha}{1 - \alpha} \right) \tilde{y}_t + \kappa_p \zeta_{1,t} + \kappa_w \zeta_{2,t} = 0 \quad (1)
\]

\[
\frac{\epsilon_p}{\lambda_p} \pi_t^p - \Delta \zeta_{1,t} + \zeta_{3,t} = 0 \quad (2)
\]

\[
\frac{\epsilon_w (1 - \alpha)}{\lambda_w} \pi_t^w - \Delta \zeta_{2,t} - \zeta_{3,t} = 0 \quad (3)
\]

\[
\lambda_p \zeta_{1,t} - \lambda_w \zeta_{2,t} + \zeta_{3,t} - \beta E_t \{ \zeta_{3,t+1} \} = 0 \quad (4)
\]

- Impulse responses: Optimal vs. Taylor

- A simple rule with unemployment (vs. optimal policy)

\[
i_t = 0.01 + 1.5 \pi_t^p - 0.5 \hat{u}_t \quad (5)
\]
Figure 7.3 Optimal Policy vs. Taylor Rule: Technology Shocks

- Output
- Unemployment
- Employment
- Labor force
- Real wage
- Price inflation
Figure 7.4 Optimal Policy vs. Taylor Rule: Demand Shocks

- Output:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state

- Unemployment:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state

- Employment:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state

- Labor Force:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state

- Real Wage:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state

- Price Inflation:
  - Taylor Rule: Decreasing trend
  - Optimal: Steady state
Figure 7.5  Optimal Policy vs. Simple Rule: Technology Shocks

- Output
- Unemployment
- Employment
- Labor force
- Real wage
- Price inflation
Figure 7.6 Optimal Policy vs. Simple Rule: Demand Shocks

- Output
- Unemployment
- Employment
- Labor force
- Real wage
- Price inflation