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Plenary Lectures

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Content

Lecture 1: Nominal Rigidity, Exchange Rates, and Unemployment

Lecture 2: The Neo-Fisher Effect

Lecture 3: The Commodity Price Super Cycle
Lecture 1

Nominal Rigidity, Exchange Rates, and Unemployment*

Boom-Bust Cycle in Peripheral Europe: 2000-2011

Data Source: Eurostat. Labor Cost Index, Nominal, is the nominal hourly wage rate in manufacturing, construction and services (including the public sector, but for Spain.)

Data represents arithmetic mean of Bulgaria, Cyprus, Estonia, Greece, Ireland, Lithuania, Latvia, Portugal, Spain, Slovenia, and Slovakia.
The Disaggregated Story: Boom-Bust Cycles in Cyprus, Greece, Ireland, Portugal, and Spain.
An Open Economy with Downward Nominal Wage Rigidity
(The DNWR Model)
Households

\[
\max_{\{c_t^T, c_t^N, d_{t+1}\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(c_t)
\]

subject to

\[
c_t = A(c_t^T, c_t^N)
\]

\[
c_t^T + p_t c_t^N + d_t = y_t^T + w_t h_t + \frac{d_{t+1}}{1 + r_t} + \phi_t
\]

\[
h_t \leq \bar{h}
\]

where \(c_t = \) consumption; \(c_t^T, c_t^N = \) consumption of tradables/nontradables; \(h_t = \) hours worked; \(p_t = \) relative price of nontradables in terms of tradables; \(w_t = \) real wage; \(d_t = \) dollar-denominated debt assumed in \(t-1\) and due in \(t\); \(r_t = \) real interest rate; \(y_t^T = \) endowment of tradables; and \(\phi_t = \) profits.
Optimality Conditions Associated with the Household Problem

\[ p_t = \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} \]

\[ \lambda_t = U'\left(A(c_t^T, c_t^N)\right)A_1(c_t^T, c_t^N) \]

\[ \lambda_t = \beta(1 + r_t)E_t\lambda_{t+1} \]

\[ c_t^T + p_t c_t^N + d_t = y_t^T + w_t h_t + \frac{d_{t+1}}{1 + r_t} + \phi_t \]

\[ h_t \leq \bar{h} \]
The Demand For Nontradables

\[ \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} = p_t. \]
The Demand For Nontradables

\begin{align*}
A_1(c_T^1, c^N) \\
A_2(c_T^2, c^N)
\end{align*}

\begin{align*}
A_1(c_T^1, c^N) \\
A_2(c_T^2, c^N)
\end{align*}

Price, $p$

Quantity, $c^N$
Firms
Nontraded output, $y_t^N$, is produced by perfectly competitive firms using labor as the sole input.
Real profits, expressed in units of tradable goods and denoted $\phi_t$, are given by

$$p_t F'(h_t) - \frac{W_t}{\mathcal{E}_t} h_t$$

where $\mathcal{E}_t$ = nominal exchange rate (=domestic-currency price of foreign currency).

Two assumptions are implicit in this expression: (1) the LOOP holds for tradables, $P_t^T = \mathcal{E}_t P_t^{T*}$, where $P_t^T$ = domestic price of the tradable good and (in domestic currency) $P_t^{T*}$ = foreign price of tradable (in in foreign currency). (2) $P_t^{T*} = 1$. Then $P_t^T = \mathcal{E}_t$.

The Firm’s Optimality Condition (price=marginal cost):

$$p_t = \frac{W_t / \mathcal{E}_t}{F'(h_t)}$$
The Supply Of Nontradables

\[ \frac{W_1/E_0}{F'(F^{-1}(y^N))} \]

\[ \frac{W_0/E_0}{F'(F^{-1}(y^N))} \]

Price, \( p \) vs. Quantity, \( y^N \)
Downward Nominal Wage Rigidity and the Labor Market

\[ W_t \geq \gamma W_{t-1} \]
\[ h_t \leq \bar{h} \]
\[ (\bar{h} - h_t) (W_t - \gamma W_{t-1}) = 0 \]

Think of \( \gamma \) as being close to 1. Letting \( w_t \equiv W_t/E_t \) be the real wage in terms of tradables and \( \epsilon_t \equiv E_t/E_{t-1} \) the gross devaluation rate, we can rewrite these 3 expressions as

\[ w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t}; \quad h_t \leq \bar{h}; \quad (\bar{h} - h_t) \left( w_t - \gamma \frac{w_{t-1}}{\epsilon_t} \right) = 0 \]
Market Clearing in the Nontraded Sector

\[ c_t^N = F(h_t) \]
Currency Pegs

\[ E_t = E_0; \quad \forall t \geq 0. \]
Adjustment to a Boom-Bust Cycle under a Currency Peg

\[
\frac{A_2 (c^T, F(h))}{A_1 (c^T, F(h))} = \frac{W_1/\varepsilon_0}{F'(h)} = \frac{W_0/\varepsilon_0}{F'(h)} = \frac{W_1/\varepsilon_1}{F'(h)}
\]

\[
c^{T_1} > c^{T_0}
\]
Competitive Equilibrium: Stochastic processes \( \{c^T_t, h_t, w_t, d_{t+1}, p_t, \lambda_t\}_{t=0}^{\infty} \) satisfying

\[
c^T_t + d_t = y^T_t + \frac{d_{t+1}}{1 + r_t}
\]

\[
\lambda_t = U'(A(c^T_t, F(h_t)))A_1(c^T_t, F(h_t))
\]

\[
\frac{\lambda_t}{1 + r_t} = \beta E_t \lambda_{t+1}
\]

\[
p_t = \frac{A_2(c^T_t, F(h_t))}{A_1(c^T_t, F(h_t))}
\]

\[
p_t = \frac{w_t}{F'(h_t)}
\]

\[
w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t}; \quad h_t \leq \bar{h}; \quad (\bar{h} - h_t) \left( w_t - \gamma \frac{w_{t-1}}{\epsilon_t} \right) = 0
\]

given an exchange rate policy.
Special Case: **Equal Intra- and Itertemporal Elasticities**

\[ U(c) = \frac{c^{1-\sigma}}{1-\sigma} \]

\[ A(c^T, c^N) = \left[ ac^T^{1-\frac{1}{\xi}} + (1-a)c^N^{1-\frac{1}{\xi}} \right] \]

Suppose that \( \xi = 1/\sigma \). (The case \( \sigma = 1/\xi = 2 \) is of much empirical relevance.) Then

\[ U(A(c^T, c^N)) = ac^T^{1-\sigma} + (1-a)c^N^{1-\sigma} \]

is separable. Then \( c^T_t \) is the solution to the block

\[ c_t^{T-\sigma} = \beta(1 + r_t)E_t c_{t+1}^{T-\sigma} \]

\[ c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1 + r_t} \]

This is a relatively simple dynamic programming problem to solve. The other equations of the model are static and easy to solve.
Adjustment to a Temporary Fall in the Interest Rate

To illustrate the source of the peg-induced externality, consider the following analytical example.

$$U(A(c^T_t, c^N_t)) = \ln c^T_t + \ln c^N_t$$

$$F(h_t) = h^\alpha_t; \quad 0 < \alpha < 1$$

$$\bar{h} = 1; \quad y^T_t = y^T > 0; \quad \gamma = 1; \quad \beta(1+r) = 1; \quad d_0 = 0; \quad w_{-1} = \alpha y^T$$

$$r_t = \begin{cases} 
  r & t > 0 \\
  \bar{r} < r & t = 0 
\end{cases}$$
A Temporary Decline in the Country Interest Rate

- Country Interest Rate, $r_t$
- Consumption of Tradables, $c^T_t$
- Debt, $d_t$
- Unemployment, $(\bar{h} - h)/\bar{h}$
- Real Wage, $w_t$
- Real Exchange Rate, $P^N_t/P^T_t$

---
currency peg flexible wage economy or optimal exchange rate economy
Optimal Exchange Rate Policy
Motivation

• We have just seen that under an exchange rate peg a negative external shock may lead to involuntary unemployment. How would optimal exchange rate policy look like?

• In this section we show that under optimal policy there is (1) full employment and (2) negative external shocks call for devaluations.

• We begin with a graphical explanation.
Optimal Exchange-Rate Policy
(again, assume $\gamma = 1$)

$c_1^T < c_0^T$ (negative shock, possibly $r_t \uparrow$)
$\varepsilon_1 > \varepsilon_0$ (optimal devaluation)
The Ramsey Optimal Exchange-Rate Policy

Pick a process $\epsilon_t$ to

$$\max E_0 \sum_{t=0}^\infty \beta^t U(A(c^T_t, F(h_t))) \quad \text{subject to}$$

$$c^T_t + d_t = y^T_t + \frac{d_{t+1}}{1+r_t}$$

$$\lambda_t = U'(A(c^T_t, F(h_t))) A_1(c^T_t, F(h_t))$$

$$\frac{\lambda_t}{1 + r_t} = \beta E_t \lambda_{t+1}$$

$$p_t = \frac{A_2(c^T_t, F(h_t))}{A_1(c^T_t, F(h_t))}$$

$$p_t = \frac{w_t}{F'(h_t)}$$

$$w_t \geq \gamma \frac{w_{t-1}}{\epsilon_t}; \quad h_t \leq \bar{h}; \quad (\bar{h} - h_t) \left( w_t - \gamma \frac{w_{t-1}}{\epsilon_t} \right) = 0$$
The Optimal Depreciation Rate

The Ramsey optimal real wage rate, denoted \( \omega(c^T_t) \), is

\[
\omega(c^T_t) = \frac{A_2(c^T_t, F(\bar{h}))}{A_1(c^T_t, F(\bar{h}))} F'(\bar{h}); \quad \omega'(c^T_t) > 0
\]

Then, the optimal depreciation rate is any process satisfying

\[
\epsilon_t \geq \frac{\gamma W_{t-1}/\mathcal{E}_{t-1}}{\omega(c^T_t)}
\]

Note: There is a whole family of optimal exchange-rate policies. Under any member of this policy, \( h_t = \bar{h} \) and \( w_t = \omega(c^T_t) \) for all \( t \).
When is it inevitable to devalue?

Optimal exchange rate policy is:

$$
\epsilon_t \geq \frac{\gamma W_{t-1}/c_{t-1}}{\omega(c_{t}^{T})}
$$

Because $\omega'(c_{t}^{T}) > 0$, optimal devaluations occur in periods of contraction of aggregate demand. It follows that contractions are devaluatory as opposed to devaluations being contractionary.
Empirical Evidence On

Downward Nominal Wage Rigidity
A.) Evidence From Micro Data from Developed Countries
## A1.) United States, 1986-1993, SIPP panel data

### Probability of Decline, Increase, or No Change in Wages

<table>
<thead>
<tr>
<th></th>
<th>Interviews</th>
<th>One Year apart</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Decline</td>
<td>5.1%</td>
<td>4.3%</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>53.7%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Increase</td>
<td>41.2%</td>
<td>46.5%</td>
</tr>
</tbody>
</table>

Source: Gottschalk (2005). Note: Male and female hourly workers not in school, 18 to 55 at some point during the panel. All nominal-wage changes are within-job wage changes, defined as changes while working for the same employer. SIPP panel data.

- Large mass at ‘Constant’ suggests nominal wage rigidity.
- Small mass at 'Decline’ suggests downward nominal wage rigidity.
A2.) United States 1996-1999, SIPP panel data

Distribution of Non-Zero Nominal Wage Changes

Source: Barattieri, Basu, and Gottschalk (2012). SIPP panel data.
A3.) United States, 1997-2016, CPS panel data

B.) Evidence From Informal Labor Markets

• Kaur (2012) examines the behavior of nominal wages, employment, and rainfall in casual daily agricultural labor markets in rural India (500 districts from 1956 to 2008).

• Finds asymmetric nominal wage adjustment:

  — $W_t$ increases in response to positive rainfall shocks

  — $W_t$ fails to fall, labor rationing, and unemployment are observed in response to negative rain shocks.

• Inflation (uncorrelated with local rain shocks) tends to moderate rationing and unemployment during negative rain shocks, suggesting downward rigidity in nominal rather than real wages.
C.) Evidence From the Great Depression in the U.S.
Nominal Wage Rate and Consumer Prices, United States 1923:1-1935:7

### D.) Evidence From Peripheral Europe (2008-2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Unemployment Rate</th>
<th>Wage Growth</th>
<th>Implied Value of $\gamma$ in $W_t \geq \gamma W_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008Q1 (in percent)</td>
<td>2011Q2 (in percent)</td>
<td>$\frac{W_{2011Q2}}{W_{2008Q1}}$</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>6.1</td>
<td>11.3</td>
<td>43.3</td>
</tr>
<tr>
<td>Cyprus</td>
<td>3.8</td>
<td>6.9</td>
<td>10.7</td>
</tr>
<tr>
<td>Estonia</td>
<td>4.1</td>
<td>12.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Greece</td>
<td>7.8</td>
<td>16.7</td>
<td>-2.3</td>
</tr>
<tr>
<td>Ireland</td>
<td>4.9</td>
<td>14.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Italy</td>
<td>6.4</td>
<td>8.2</td>
<td>10.0</td>
</tr>
<tr>
<td>Lithuania</td>
<td>4.1</td>
<td>15.6</td>
<td>-5.1</td>
</tr>
<tr>
<td>Latvia</td>
<td>6.1</td>
<td>16.2</td>
<td>-0.6</td>
</tr>
<tr>
<td>Portugal</td>
<td>8.3</td>
<td>12.5</td>
<td>1.91</td>
</tr>
<tr>
<td>Spain</td>
<td>9.2</td>
<td>20.8</td>
<td>8.0</td>
</tr>
<tr>
<td>Slovenia</td>
<td>4.7</td>
<td>7.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Slovakia</td>
<td>10.2</td>
<td>13.3</td>
<td>13.4</td>
</tr>
</tbody>
</table>

Note. $W$ is an index of nominal average hourly labor cost in manufacturing, construction, and services, including the public sector (except for Spain). Source: Schmitt-Grohé and Uribe (2016)
How To Infer $\gamma$ From European Data

The slackness condition of the model, $(W_t - \gamma W_{t-1})(\bar{h} - h_t)$, implies that if unemployment increases form one period to the next, then nominal wages must be growing at the rate $\gamma$: $\frac{W_t}{W_{t-1}} = \gamma$.

How to calculate $\gamma$ from the wage and unemployment data of the previous table:

$$\gamma = \left( \frac{W_{2011:Q2}}{W_{2008:Q1}} \right)^{\frac{1}{13}}$$

Subtract 0.6% per quarter to adjust for foreign inflation and long-run growth (because they are not explicitly incorporated in the model) to obtain the estimate:

$$\gamma \in [0.99, 1.022]$$
Quantitative Analysis

Replication files:  usg_dnwr.zip  available online with the materials for this chapter.
Functional Forms

Assume a CRRA form for preferences, a CES form for the aggregator of tradables and nontradables, and an isoelastic form for the production function of nontradables:

\[ U(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \]

\[ A(c^T, c^N) = \left[ a(c^T)^{1-\frac{1}{\xi}} + (1 - a)(c^N)^{1-\frac{1}{\xi}} \right]^{\frac{1}{1-\frac{1}{\xi}}} \]

\[ F(h) = h^\alpha, \]

with \( \sigma, \xi, a, \alpha > 0. \)
The Driving Process:

**Data:** Argentine data over the period 1983:Q1—2001:Q3. Exclude the period 2001:Q4 to present, because of the default episode in 2002 (no default in the model).

**Empirical Measure of** $y_t^T$: sum of GDP in agriculture, manufacturing, fishing, forestry, and mining. Quadratically detrended.

**Empirical Measure of** $r_t$: Sum of Argentine EMBI+ plus 90-day Treasury-Bill rate minus a measure of U.S. expected inflation.

The following slide displays the two time series.
Tradable Output and Country Interest Rate
Argentina 1983:Q1 to 2001:Q3
Estimate the AR(1) system

\[
\begin{bmatrix}
\ln y_t^T \\
\ln \frac{1+r_t}{1+r}
\end{bmatrix} = A \begin{bmatrix}
\ln y_{t-1}^T \\
\ln \frac{1+r_{t-1}}{1+r}
\end{bmatrix} + \epsilon_t,
\]

**OLS Estimate of the Driving Process**

\[A = \begin{bmatrix}
0.79 & -1.36 \\
-0.01 & 0.86
\end{bmatrix}; \quad \Sigma\epsilon = \begin{bmatrix}
0.00123 & -0.00008 \\
-0.00008 & 0.00004
\end{bmatrix};\]

\[r = 0.0316 \text{ (3.16\% per quarter).}\]
### Some Unconditional Summary Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>$y^T_t$</th>
<th>$r_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. Dev.</td>
<td>12%</td>
<td>6%</td>
</tr>
<tr>
<td>Serial Corr.</td>
<td>0.95</td>
<td>0.93</td>
</tr>
<tr>
<td>Corr($y^T_t, r_t$)</td>
<td>-0.86</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1</td>
<td>12%yr</td>
</tr>
</tbody>
</table>

Observations:
1. High volatility of both $y^T_t$ and $r_t$;
2. Negative correlation between $y^T_t$ and $r_t$ (when it rains it pours);
3. High mean country interest rate.
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>γ</td>
<td>0.99</td>
<td>Degree of downward nominal wage rigidity</td>
</tr>
<tr>
<td>σ</td>
<td>2</td>
<td>Inverse Intertemp. elast. of subst.</td>
</tr>
<tr>
<td>$y^T$</td>
<td>1</td>
<td>Steady-state tradable output</td>
</tr>
<tr>
<td>$\bar{h}$</td>
<td>1</td>
<td>Labor endowment</td>
</tr>
<tr>
<td>$a$</td>
<td>0.26</td>
<td>Share of tradables</td>
</tr>
<tr>
<td>$\xi$</td>
<td>0.5</td>
<td>Intratemp. elast. of subst.</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.75</td>
<td>Labor share in nontraded sector</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.9635</td>
<td>Quarterly subjective discount factor</td>
</tr>
</tbody>
</table>

Note: $\sigma = 2$ is widely used in business cycle analysis, and $\xi = 0.5$ is within the range of values estimated for emerging countries (see the survey by Akinci, 2011). Consequently, the restriction $\xi = 1/\sigma$ is quite compelling on empirical and computational grounds.
Approximating Equilibrium Dynamics

When $\xi = 1/\sigma$, the dynamics in the traded sector are independent of the exchange-rate regime. The equilibrium processes $\{c_t^T, d_{t+1}\}$ solve the Bellman equation problem

$$v(y_t^T, r_t, d_t) = \max_{\{d_{t+1}, c_t^T\}} \left\{ U(A(c_t^T, F(\bar{h}))) + \beta E_t v(y_{t+1}^T, r_{t+1}, d_{t+1}) \right\}$$

subject to $c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1 + r_t}$ and $d_{t+1} \leq \bar{d}$.

Solve by value function iteration over a discretized state space $(y_t^T, r_t, d_t)$. Use 21 values for $y_t^T$ and 11 for $r_t$ (the estimated joint process $(y_t^T, r_t)$ is the one given above). Use 501 equally spaced points for $d_t$ between 1 and 8.34. The solution are policy functions $c_t^T = C^T(y_t^T, r_t, d_t)$ and $d_{t+1} = D(y_t^T, r_t, d_t)$.

The other variables of the model do depend on the exchange-rate regime.
Approximating Equilibrium Under the Optimal Exchange-Rate Policy

We know that $h_t = \bar{h}$. Then, given the solution for $c_t^T$, we have

$$p_t = \frac{A_2(c_t^T, F(\bar{h}))}{A_1(c_t^T, F(\bar{h}))},$$

$$w_t = p_t F'(\bar{h}),$$

From the family of optimal devaluation policies, we pick

$$\epsilon_t = \frac{w_{t-1}}{w_t}.$$

Properties: (1) It fully stabilizes $W_t$ and $P_t^N$; (2) Zero average inflation and devaluation.
Approximating Equilibrium Under a Currency Peg

The solution is in two steps:

(1) Given the process $c^T_t$, try the guess $h_t = \bar{h}$. Then, $p_t$ and $w_t$ are given by

$$p_t = \frac{A_2(c^T_t, F(\bar{h}))}{A_1(c^T_t, F(\bar{h}))} \quad \text{and} \quad p_t = \frac{w_t}{F'(\bar{h})}.$$ 

If $w_t \geq \gamma w_{t-1}$, then the equilibrium values of $w_t$ and $p_t$ have been found.

(2) If $w_t < \gamma w_{t-1}$, then in equilibrium $w_t = \gamma w_{t-1}$, and the equilibrium values of $p_t$ and $h_t$ are the solution to

$$p_t = \frac{A_2(c^T_t, F(h_t))}{A_1(c^T_t, F(h_t))} \quad \text{and} \quad p_t = \frac{w_t}{F'(h_t)}.$$
Crisis Dynamics Under A Currency Peg and Under Optimal Exchange-Rate Policy

We are interested in characterizing quantitatively the response of the model economy to large contractions like the ones observed in Argentina in 2001 and in the periphery of Europe in 2008. In Argentina, for instance, traded output fell by 2 standard deviations in a period of two and a half years (10 quarters). Accordingly, we use the following operational definition of an external crisis.

Definition of an External Crisis. A crisis is a situation in which in period $t$ tradable output, $y_t^T$, is at or above average, and 10 quarters later, in period $t + 10$, it is at least two standard deviations below trend.

The Typical External Crisis: Simulate the model for 20 million periods. Extract all windows of time in which $y_t^T$ conforms to the definition of a crisis. For each variable of interest, average all windows and subtract its unconditional mean (i.e., the mean taken over the 20 million observations).
Sources of an External Crisis

Note. Replication file plot_ir.m in usg_dnwr.zip.

Comments: (1) Because $y^T_t$ and $r_t$ are negatively correlated, the collapse in $y^T_t$ coincides with a sharp increase in the country interest rate. (2) The response of $y^T_t$ and $r_t$ are exogenous to the model, so this plot is independent of the exchange-rate policy. The next slide displays the response of the endogenous variables.
Pegs Amplify Negative External Shocks

Note. Replication file plot_ir.m in usg_dnwr.zip.
Devaluations and Revaluations in Reality: Latin America: 2006-2011

Observation. During the global financial crisis, all countries devalued significantly. However, during the recovery, all countries but Argentina revalued their currencies. The countries that revalued experienced lower inflation than Argentina.
Are devaluations expansionary as predicted by the DNWR model?

To address this issue, let’s take a look at two episodes of exiting a currency peg:

- Ending Convertibility: Argentina 1996-2006
- Exiting the Gold Standard: Europe 1929-1935
The End of the Argentine Convertibility: 1996-2006

Memo: Average annual CPI inflation 1998-2001: -0.86%.
Exiting the Gold Standard: Europe 1929 to 1935

• Friedman and Schwartz (1963) observe that countries that left gold early (the sterling bloc) enjoyed more rapid recoveries than countries that stayed on gold longer (the gold bloc).

• Sterling bloc: United Kingdom, Sweden, Finland, Norway, Denmark.

• Gold bloc: France, Belgium, the Netherlands, and Italy.

• Eichengreen and Sachs (1986) observe that real wages behaved differently in countries that left gold early (ie devalued) and in countries that stayed on gold longer (ie stayed on the peg). Take a look at the next figure, which is redrawn from Eichengreen and Sachs.
Changes In Real Wages and Industrial Production
Europe, 1929 to 1935

The graph shows the relationship between real wages and industrial production for various countries in Europe from 1929 to 1935. The x-axis represents the real wage, 1935, normalized to 1929=100, while the y-axis represents industrial production, 1935, normalized to 1929=100.
Default, Devaluation, and Unemployment:

Note. Vertical line indicates the year of default. Own calculations based on data from INDEC (Argentina), EuroStat, and the Central Bank of Iceland.
The Welfare Costs of Currency Pegs

Find the compensation, measured as percent increase in the stream of consumption in the peg economy, denoted $\Lambda(s_t)$, that makes agents indifferent between living under a peg or under the optimal exchange-rate policy, given the current state $s_t = (y^T_t, r_t, d_t, w_{t-1})$. This compensation is implicitly given by

$$E \left \{ \sum_{j=0}^{\infty} \beta^j U \left( c_{t+j}^{\text{PEG}} \frac{1 + \Lambda(s_t)}{100} \right) \bigg| s_t \right \} = E \left \{ \sum_{j=0}^{\infty} \beta^j U \left( c_{t+j}^{\text{OPT}} \right) \bigg| s_t \right \},$$

Solve for $\Lambda(s_t)$ to obtain

$$\Lambda(s_t) = 100 \left \{ \left[ \frac{v^{\text{OPT}}(y^T_t, r_t, d_t)(1 - \sigma) + (1 - \beta)^{-1}}{v^{\text{PEG}}(y^T_t, r_t, d_t, w_{t-1})(1 - \sigma) + (1 - \beta)^{-1}} \right]^{1/(1-\sigma)} - 1 \right \},$$

where $v^{\text{OPT}}(y^T_t, r_t, d_t) \equiv E \left \{ \sum_{j=0}^{\infty} \beta^j U \left( c_{t+j}^{\text{OPT}} \right) \bigg| s_t \right \}$ and $v^{\text{PEG}}(y^T_t, r_t, d_t, w_{t-1}) \equiv E \left \{ \sum_{j=0}^{\infty} \beta^j U \left( c_{t+j}^{\text{PEG}} \right) \bigg| s_t \right \}$, with the expectation taken over the distribution of $s_t$ in the peg economy. The welfare cost of a peg, $\Lambda(s_t)$, is a random variable as it is a function of the state in period $t$, $s_t$. 
The Welfare Costs of Currency Pegs

<table>
<thead>
<tr>
<th>Model</th>
<th>Welfare Cost</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (γ = 0.99)</td>
<td>7.8</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>Mean Median</td>
<td>Mean Rate</td>
</tr>
</tbody>
</table>

Note. The welfare cost of a currency peg is expressed in percent of consumption. Welfare costs are computed over the distribution of the state \((y_t^T, r_t, d_t, w_{t-1})\) induced by the peg economy. Replication files: simu_welf.m (welfare cost) and simu.m (unemployment) in usg_dnwr.zip.

Observation: Large welfare costs of currency pegs. All of the cost is explained by lost consumption of nontradables due to unemployment in that sector.
Observation: The distribution of welfare costs of pegs is highly skewed to the right, suggesting the existence of initial states, \((y^T_t, r_t, d_t, w_{t-1})\), in which pegs are highly costly in terms of unemployment. The next slide identifies such states.
Welfare Cost of Currency Pegs and the Initial State

Note. In each plot, all states except the one shown on the horizontal axis are fixed at their unconditional mean values. The dashed vertical lines indicate the unconditional mean of the state displayed on the horizontal axis (under a currency peg if the state is endogenous). Replication file plot_welf.m in usg_dnwr.zip.

**Observation:** Currency pegs are more costly the higher the initial past wage, the higher the initial stock of external debt, the lower the initial endowment of tradables, and the higher the initial country interest rate.
Alternative Parameterizations and Model Specifications

- Varying the Degree of Wage Rigidity
- Symmetric Wage Rigidity
- Endogenous Labor Supply item Production in the Traded Sector
- Product Price Rigidity
### Varying the Degree of Downward Wage Rigidity

<table>
<thead>
<tr>
<th>Model</th>
<th>Welfare Cost</th>
<th></th>
<th>Unempl. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td></td>
</tr>
<tr>
<td>Baseline ($\gamma = 0.99$)</td>
<td>7.8</td>
<td>7.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Lower Downward Wage Rigidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma = 0.98$</td>
<td>5.7</td>
<td>5.3</td>
<td>8.9</td>
</tr>
<tr>
<td>$\gamma = 0.97$</td>
<td>3.5</td>
<td>3.3</td>
<td>5.6</td>
</tr>
<tr>
<td>$\gamma = 0.96$</td>
<td>2.8</td>
<td>2.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Higher Downward Wage Rigidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma = 0.995$</td>
<td>14.3</td>
<td>13.0</td>
<td>19.5</td>
</tr>
</tbody>
</table>

**Observation:** Sizable welfare costs and unemployment even for highly flexible wages, e.g., $\gamma = 0.96$. Recall, $\gamma = 0.96$ means that wages can fall frictionlessly by 16% per year.
Symmetric Wage Rigidity

Is more wage flexibility always welfare increasing?

Not always. We have just seen that the welfare costs of a currency peg increase as the degree of downward wage rigidity, $\gamma$, increases. So the answer here is Yes.

We now consider a different way of increasing wage rigidity, namely, bi-directional wage rigidity:

$$\frac{1}{\gamma} \geq \frac{W_t}{W_{t-1}} \geq \gamma$$

We will see that this increase in wage rigidity is welfare enhancing.
The Welfare Costs of Pegs: Symmetric Wage Rigidity

\((\gamma = 0.99)\)

<table>
<thead>
<tr>
<th>Welfare Cost Mean</th>
<th>Unempl. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downward only: (\frac{W_t}{W_{t-1}} \geq \gamma)</td>
<td>7.8</td>
</tr>
<tr>
<td>Upward and downward: (\frac{1}{\gamma} \geq \frac{W_t}{W_{t-1}} \geq \gamma)</td>
<td>3.3</td>
</tr>
</tbody>
</table>

- Welfare costs under symmetric rigidity, while still large, are half that under downward wage rigidity. Thus greater wage flexibility is welfare decreasing. Why? Symmetric wage rigidity alleviates the peg-induced externality (we saw this theoretically).

- To the extent that downward wage rigidity is the case of greatest empirical relevance, this result suggests that models with upward and downward wage rigidity underestimate the welfare costs of currency pegs.