The Great Depression and the Friedman-Schwartz Hypothesis
Lawrence J. Christiano, Roberto Motto and Massimo Rostagno
Background

- Want to Construct a Dynamic Economic Model Useful for the Analysis of Monetary and Fiscal Policy in a Large Economy Such as the Euro Area or U.S.
- Would Like a Model That Can be Used to:
  - Identify the Fundamental Shocks Driving Historical Data
  - Identify the Mechanisms Responsible for Propagating the Shocks
  - Serve as a Laboratory For Evaluating Alternative Strategies for Responding to Shocks.
- We Expand a Standard Monetary Business Cycle Model to Incorporate Multiple Shocks, Financial Frictions and a Banking Sector.
- We Use our Model to Address one of the Biggest Policy Questions:
  - What Shocks Caused the US Great Depression?
  - What Mechanisms Propagated the Shocks?
  - Could the Monetary Authorities have Mitigated the Severity of the Great Depression By Reacting in a Different Way to the Shocks?
- Great Depression is a Perfect Testing Ground for Our Model
  – It Was a Big Deal!
• Great Depression is a Perfect Testing Ground for Our Model
  – Big Question: What Shocks?
    ∗ Exogenous Monetary Contraction in 1920s (Bernanke, Hamilton)
    ∗ Increased Money Demand in Late 1920s (Alexander Field).
    ∗ Deposit Withdrawals (Fear of Bank Closures and Dollar Devaluation).
    ∗ Stock Market Collapse.
    ∗ Institutional Changes, Especially New Deal (Cole and Ohanian).
  – What Propagation Mechanisms?
    ∗ Stock Market Collapse (Mishkin, Romer).
    ∗ Nominal Wage and Debt Rigidities (Irving Fisher, Bordo et al).
    ∗ Banking System (Friedman and Schwartz).
    ∗ Policy Mistakes at Fed (Friedman and Schwartz, Cecchetti).
What We Do, and What We Find

• Incorporate Various Shocks and Propagation Mechanisms into a Single Dynamic General Equilibrium Model.
• Combine the Model with Data from 1920s and 1930s.
• Determine Which Shocks and Propagation Mechanisms Were Crucial.

• Results:
  – A Liquidity Preference Shock is Important in Contraction Phase (Surprise, consistent with Alex Field?)
  – Financial Frictions
    * Somewhat Important for Investment
    * Not Important Enough to Have a Major Impact on Aggregate Output and Employment (Surprising!)
  – Increased Market Power of Workers Responsible for Duration of Great Depression.

• A More Responsive Monetary Policy Could Have Substantially Reduced the Severity of the Great Depression.
The Great Depression and the Zero Lower Bound on the Interest Rate

- In Recent Years: Interest In Understanding Monetary Policy in a Low Interest Rate Environment:
  - Can Monetary Policy Resist Deflation and Output Collapse?
  - What Sort of Monetary Policy Can do This?

- Interest Rates Near Zero In Most of the 1930s
  - Analysis of Monetary Policy in 1930s Must Confront Zero Lower Bound Constraint
  - Policy We Consider AVOIDS ZERO LOWER BOUND By Committing to Temporarily High Future Money Growth.
  - Credibility Issues (Eggertsson-Woodford, Krugman).
Previous Quantitative Analyses of Great Depression

• McCallum ‘Could a Monetary Base Rule Have Prevented the Great Depression?’, JME, 1990.
Outline

• A Quick Look at the Data.
• The Model.
• Model Estimation
  – Calibration of Some Model Parameters
  – Maximum Likelihood Estimation of Other Parameters
  – Model Fit.
• Evaluating Alternative Monetary Policies.
Modern Spending Transmission Mechanism

- Real Wage
- Labor Demand Curve (Markup, Capacity utilization, ...)
- No Change in Real Wage
- Drop in Employment
- Employment

The diagram illustrates the relationship between real wage and employment under the modern spending transmission mechanism. The labor demand curve reflects changes in employment in response to changes in real wage.
The Data

• GNP Falls Over 30%, 1929 to 1933
• Investment:
  – Falls 80%
  – $I/Y$ Goes From 0.25 (P) to 0.06 (T)
• Consumption:
  – Falls 25%
  – $C/Y$ initially rises from 0.68 in 1929IV to 0.77 in 1931IV and then falls back to 0.68 in 1933IV
• Employment: Drops Less than GNP (i.e., Productivity Falls) and Never Fully Recovers
• Price Deflator: Drops and Never Fully Recovers
The Data, cont’d

• What Started It?
  – Was it the Fed?
  – Probably Not (Note: $\frac{M1}{P}$ Roughly Constant, $R$ Drops)
  – Whatever it Was, it was Something that Hit Investment Hard

• Stock Prices Collapsed: Was that What Hurt Investment?

• ‘Flight to Quality’: Banks Accumulate Reserves, Households Accumulate Currency


• Real Wage Rose Continually: A Reason for the Long Duration of the Depression?
Model Features Suggested by Examination of Data

• Need a Good Model of:
  – Investment,
  – Employment,

• Need a Model that Allows for Interaction Between Financial Factors and Real Activity.

• Need Model That Can Come to Terms with Bank Reserves, Currency, Bank Deposits, etc.

• Model is a Marriage of Three:
  – Christiano, Eichenbaum and Evans, ‘Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy’, forthcoming, JPE.
Private Agents in the Model

- Goods-Producing Firms
  - Intermediate Goods, Final Goods and Capital Goods
- Entrepreneurs: Own and Rent Out Capital
- Banks
- Households
- Monetary and Fiscal Authorities.
Private Agents in the Model

- Final Goods-Producing Firms:

\[ Y_t = \left[ \int_0^1 Y_{jt} \frac{1}{\lambda_{f,t}} dj \right]^{\lambda_{f,t}} \]
Private Agents in the Model

• Final Goods-Producing Firms:

\[ Y_t = \left[ \int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj \right]^{\lambda_{f,t}} \]

• Intermediate Goods-Producing Firms:

\[ Y_{jt} = \begin{cases} \epsilon_t K_{jt}^\alpha (z_{jt} l_{jt})^{1-\alpha} - \Phi z_t & \text{if } \epsilon_t K_{jt}^\alpha (z_{jt} l_{jt})^{1-\alpha} > \Phi z_t, \\ 0, & \text{otherwise} \end{cases} \]

\[ z_t = \mu z_{t-1}. \]

– Profits:

\[ P_{jt} Y_{jt} - P r_t K_{jt} - (1 + R_t) W_t l_{jt}. \]

– Price-setting:

with probability \( 1 - \xi_p \) : \( P_{jt} \) chosen optimally

with probability \( \xi_p \) : \( P_{jt} = \pi_{t-1} P_{j,t-1}. \)
Private Agents in the Model, cont’d

• Producers of Physical Capital
  – Buy Investment Goods and ‘Old’ Capital and Make $\bar{K}_{t+1}$:
    \[
    \bar{K}_{t+1} = (1 - \delta)\bar{K}_t + F(I_t, I_{t-1}).
    \]
Private Agents in the Model, cont’d

- Entrepreneurs
  - Buy $\bar{K}_{t+1}$ at end of $t$ and Rent it out in $t + 1$
  - Borrowing:
    \[ B_{t+1} = Q_{K',t} \bar{K}_{t+1} - N_{t+1} \geq 0. \]
  - Capital Services:
    \[ K_{t+1} = u_{t+1} \bar{K}_{t+1}, \]
  - Capital Utilization costs:
    \[ a(u_{t+1}) \bar{K}_{t+1}, a', a'' > 0, \]

- Net worth
  - $N_{t+1} =$ past net worth + earnings from renting capital + market value of physical capital - repayments of past debt to bank.

- total net worth is kept low because random fraction of entrepreneurial wealth is destroyed

- entrepreneurs receive a ‘costly state verification’ contract from the bank
Private Agents in the Model, cont’d

• Banks:
  – Issue Liabilities (Time Deposits) Used to Finance Entrepreneurs
  – Issue Liabilities (Demand Deposits) Used to Finance Working Capital Loans to Firms

• Households: Supply Labor, Consume, Hold Demand and Time Deposits

\[
E_t^j \sum_{l=0}^{\infty} \beta^{l-t} \left\{ u(C_{t+l} - bC_{t+l-1}) - z(h_{j,t+l}) \right. \\
\left. - \nu_{t+l} \left[ \left( \frac{P_{t+l}C_{t+l}}{M_{t+l}} \right)^{\theta_{t+l}} \left( \frac{P_{t+l}C_{t+l}}{D_{t+l}^h} \right)^{1-\theta_{t+l}} \right]^{1-\sigma_q} \right\} \\
l = \left[ \int_0^1 (h_j)^{\lambda_{w,t}} \, dj \right]^{\lambda_{w,t}}, \ 1 \leq \lambda_{w,t} < \infty.
\]
Private Agents in the Model, cont’d

• Monetary and Fiscal Authorities
  – Taxes.
  – Monetary Policy: Money Base Growth Feeds Back on Shocks:
    \[
    \log \left( \frac{M^b_{t+1}}{M^b_t} \right) = \mu \sum_i (\mu_{i,t} + 1)
    \]
  – Agnostic About Nature of Monetary Policy
    * Could Be Taylor Rule, McCallum Rule, Something Else.....
Private Agents in the Model

- Goods-Producing Firms
  - Intermediate Goods, Final Goods and Capital Goods
- Entrepreneurs: Own and Rent Out Capital
- Banks
- Households
- Monetary and Fiscal Authorities.
Steps in the Analysis

- Select Parameter Values for the Model:
  - Parameters that Control Nonstochastic Part of the Model
  - Parameters Governing Exogenous Shocks and Monetary Response.
- Evaluate Model Empirically.
- Counterfactual Policy Analysis.
Selection of Model Parameters

- ‘Nonstochastic’ Parameters
  - Match Various Long-Run Averages
- Use Evidence on the Shocks in the 1920s and 1930s to Parameterize Exogenous Shocks.
<table>
<thead>
<tr>
<th>Panel</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Household Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta )</td>
<td>Discount rate</td>
<td>1.03^{−0.25}</td>
</tr>
<tr>
<td>( b )</td>
<td>Habit persistence parameter</td>
<td>0.63</td>
</tr>
<tr>
<td>( \xi_w )</td>
<td>Probability of Not Reoptimizing Wage in Given Quarter</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Panel B: Goods Producing Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \mu_z )</td>
<td>Growth Rate of Technology (APR)</td>
<td>1.50</td>
</tr>
<tr>
<td>( \xi_p )</td>
<td>Probability of Not Reoptimizing Price Within Quarter</td>
<td>0.50</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Depreciation rate on capital.</td>
<td>0.02</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Power on capital in production function</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>Panel C: Entrepreneurs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \gamma )</td>
<td>Quarterly Entrepreneurial Survival Probability</td>
<td>97.00</td>
</tr>
<tr>
<td>( \mu )</td>
<td>Fraction of Realized Profits Lost in Bankruptcy</td>
<td>0.120</td>
</tr>
<tr>
<td>( F(\bar{\omega}) )</td>
<td>Percent of Businesses that go into Bankruptcy in a Quarter</td>
<td>0.80</td>
</tr>
<tr>
<td>( \text{Var}(\log(\omega)) )</td>
<td>Variance of log of idiosyncratic productivity parameter</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Panel E: Policy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau )</td>
<td>Bank Reserve Requirement</td>
<td>0.100</td>
</tr>
<tr>
<td>( \tau^l )</td>
<td>Tax Rate on Labor Income</td>
<td>0.04</td>
</tr>
<tr>
<td>( x )</td>
<td>Growth Rate of Monetary Base (APR)</td>
<td>1.610</td>
</tr>
<tr>
<td>Variable</td>
<td>Model</td>
<td>US, 1921-29</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>$k/y$</td>
<td>8.35</td>
<td>10.8&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>$i/y$</td>
<td>0.20</td>
<td>0.24</td>
</tr>
<tr>
<td>$c/y$</td>
<td>0.73</td>
<td>0.67</td>
</tr>
<tr>
<td>$g/y$</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>$N/K-N$ ('Equity to Debt')</td>
<td>0.999</td>
<td>1-1.25&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Percent of Goods Output Lost to Bankruptcy</td>
<td>0.371%</td>
<td></td>
</tr>
<tr>
<td>Percent of Aggregate Labor and Capital in Banking</td>
<td>1.00%</td>
<td>1%&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inflation (APR)</td>
<td>0.11%</td>
<td>-0.6%&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Money</td>
<td>Variable</td>
<td>Model</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Monetary Base Velocity</td>
<td>9.77</td>
<td>12</td>
</tr>
<tr>
<td>M1 Velocity</td>
<td>3.92</td>
<td>3.5</td>
</tr>
<tr>
<td>Currency / Demand Deposits</td>
<td>0.28</td>
<td>0.2</td>
</tr>
<tr>
<td>Currency / Monetary Base</td>
<td>0.70</td>
<td>0.55</td>
</tr>
<tr>
<td>Curr. / Household D. Deposit</td>
<td>2.30</td>
<td></td>
</tr>
</tbody>
</table>
Shocks Incorporated Into Model

- Eight Shocks:
  - Monopoly Power of Firms
  - Monopoly Power of Households
  - Demand for Reserves By Banks
  - Two Household Money Demand Shocks
  - Shock to Riskiness of Entrepreneurs
  - Aggregate Technology Shock
  - Shock to Rate of Destruction of Entrepreneurial Wealth
Parameterization of Shocks

- Each Shock, Say $x_t$, Has 4 Parameters
- Representation:
  \[ x_t = \rho x_{t-1} + \varepsilon_{x,t}, \sigma_{\varepsilon_x} \]
- Monetary Policy Response:
  \[ \mu_{xt} = \rho \mu_{x,t-1} + \phi \varepsilon_{x,t} \]
- There are $8 \times 4 = 32$ Parameters to be Estimated
- Monetary Policy
  \[ \log \left( \frac{M_t^{b+1}}{M_t^b} \right) = \mu \sum_i (\mu_{i,t} + 1) \]
Solution to Model

- Matrices, $A, B$

$$\tilde{z}_t = A\tilde{z}_{t-1} + B\Psi_t.$$ 

$\tilde{z}_t \sim$ Core set of 23 Endogenous Variables

$\Psi_t \sim$ Exogenous Variables, Stacked
Estimation of Parameters of Exogenous Shock Processes

- Data Used in Estimation:
  - Net Worth (Measured by Value of the DOW)
  - Inflation
  - log, hours
  - Short Term Interest Rate
  - Output
  - Real Wage
  - Investment
  - Velocity of $M_1$
  - Consumption
  - Risk Premium (Baa - Aaa Bond Returns)
  - Currency to Deposit Ratio
  - Bank Reserves to Deposit Ratio
Stochastic Model

• Data:
\[ X_t = \left( \log \left( \frac{N_{t+1}}{P_t Y_t} \right), \log(\pi_t), \log(l_t), R^b_t, \Delta \log(Y_t) \right. \]
\[ \log \left( \frac{W_t}{P_t Y_t} \right), \log\left( \frac{I_t}{Y_t} \right), \log(V^1_t), \log\left( \frac{C_t}{Y_t} \right), P^e_t, \log(d^c_t), \log(d^r_t) \left. \right) \]’

• Here,

\[ N_{t+1} \sim \text{Net Worth}, \]
\[ R^b_t \sim \text{Short Term Interest Rate} \]
\[ V^1_t \sim \text{Velocity of } M_1 \]
\[ P^e \sim \text{Premium} \]
\[ d^c \sim \text{Currency to Deposit Ratio} \]
\[ d^r \sim \text{Reserves to Deposit Ratio} \]

• Representation of \( X_t \):
\[ X_t = \alpha + \tau z_t + \tau^s \Psi_t + \bar{\tau} z_{t-1} + \bar{\tau}^s \Psi_{t-1}. \]
State-Observer System

- State, $\xi_t$

$$\xi_t = \begin{pmatrix} \tilde{z}_t \\ \tilde{z}_{t-1} \\ \Psi_t \\ \Psi_{t-1} \end{pmatrix}.$$ 

- Law of Motion of State:

$$\begin{pmatrix} \tilde{z}_{t+1} \\ \tilde{z}_t \\ \Psi_{t+1} \\ \Psi_t \end{pmatrix} = \begin{bmatrix} A & 0 & B \rho & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & \rho & 0 \\ 0 & 0 & I & 0 \end{bmatrix} \begin{pmatrix} \tilde{z}_t \\ \tilde{z}_{t-1} \\ \Psi_t \\ \Psi_{t-1} \end{pmatrix} + \begin{pmatrix} BD \\ 0 \\ D \\ 0 \end{pmatrix} \hat{\varphi}_{t+1},$$

$$\xi_{t+1} = F\xi_t + \nu_{t+1}.$$
• Observer Equation

\[ y_t = H \xi_t + w_t, \]

where

\[ H = \begin{bmatrix} \tau & \bar{\tau} & \hat{\tau}_s & \hat{\tau}^s \end{bmatrix}. \]

• Estimate by Maximum Likelihood, Given Parameters of Nonstochastic Part.
Results of Model Fit

- Overall, Model Fit Seems ‘Reasonable’
- Places Where Model ‘Misses’
  - Understates Fall in Labor Productivity
  - Overstates Rise in Real Wage
  - Understates Fall in Consumption.
- Shocks Seem ‘Reasonable’
Figure 5: Actual and Fitted Data, Converted to Levels

Notes:
(i) Dotted, Solid Line - Model, Actual Data.
(ii) Results Obtained by First Adding Actual Data Sample Mean to Results Displayed in Figure 4 and then Aggregating to Levels.
(iii) Currency-Deposit, Reserves-Deposit Ratio, Premium Reproduced from Figure 4.
Figure 7: Estimated Economic Shocks

- **Firm Markup**, $\lambda_{t,t}$
- **Banking Money Demand Shock**, $\xi_t$
- **Money Demand**, $\theta_t$
- **Labor Market Power**, $\zeta_t$
- **Liquidity Demand**, $\upsilon_t$
- **Financial Wealth Shock**, $\gamma_t$
- **Technology Shock**, $\epsilon_t$
- **Riskiness of Entrepreneurs**, $\sigma_t$
Liquidity Preference Shock

- **Demand Deposits Drop**: Leads to **Working Capital Loans Drop**
- **Consumption Drops**: Leads to **Entrepreneur Loans Fall**
- **Entrepreneur Loans Fall**: Leads to **Investment Falls**
- **Investment Falls**: Leads to **Output Drops**
- **Net Worth Falls**: Leads to **Debt Deflation**
- **Debt Deflation**: Leads to **Price Level Drops**
- **Price Level Drops**: Leads to **Rental Rate Of Capital Falls**
- **Rental Rate Of Capital Falls**: Leads to **Asset Price Falls**
- **Asset Price Falls**: Leads to **Financial Accelerator**
- **Financial Accelerator**: Leads to **Output Drops**

**Liquidity Shock**

- **Time Deposits Fall**: Leads to **Demand Deposits Drop**
- **Demand Deposits Drop**: Leads to **Working Capital Loans Drop**
Response to One-Standard Deviation Innovation to Liquidity Preference, $\nu_t$

- Household Currency Relative to SS
- Household Deposits Relative to SS
- Household Time Deposits Relative to SS
- Interbank Loan Rate
- Consumption
- Investment
- Output

Graphs show the response of various economic indicators to a one-standard deviation innovation in liquidity preference, $\nu_t$. The graphs display different ratios and percentages over time, with axes labeled in units of quarters.
Figure 9: Model Response with Only $\nu_t$ Shocks, and Data

Notes:
Results Correspond to Those in Figure 5, Except Model Simulation Only Includes Estimated $\nu_t$ Shocks
Dynamic Response to a \( v \) Shock - benchmark (*)\; no entrepreneur (o)

- **Consumption**
  - Percent deviation from unshocked path vs. quarters

- **Investment**
  - Percent deviation from unshocked path vs. quarters

- **Output**
  - Percent deviation from unshocked path vs. quarters

- **Price of installed capital, in units of \( C \)**
  - Percent deviation from unshocked path vs. quarters
Counterfactual Experiment

- Identify Alternative Monetary Policy Within a Particular Class

\[
\log \left( \frac{M_{t+1}^b}{M_t^b} \right) = \mu \sum_{i} (\mu_{i,t} + 1)
\]

\[
\mu_{i,t} = \theta^0 \varepsilon_{i,t} + \theta^1 \varepsilon_{i,t-1} + \theta^2 \mu_{i,t-1}
\]

- Trade-off:
  - Immediate Monetary Response
  - Delayed Monetary Response

<table>
<thead>
<tr>
<th>Selected Quantities in Baseline and Counterfactual, 1929IV - 1939IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Growth, APR</strong></td>
</tr>
<tr>
<td>Real Output</td>
</tr>
<tr>
<td>Inflation</td>
</tr>
<tr>
<td>Monetary Base</td>
</tr>
<tr>
<td>M1</td>
</tr>
<tr>
<td>(400(\max R - \min R))</td>
</tr>
</tbody>
</table>
Figure 12: Baseline Estimated Policy (Solid Line) and Counterfactual Policy (Dotted Line)
Concluding Remarks

• Fit a Model to 1920s and 1930s data
  – Liquidity Preference Shock Important in Contraction
  – Increased Worker Bargaining Power Important in Delaying Recovery
  – Financial Frictions:
    * Exacerbate Fall in Investment
    * But, Not Enough to Have a Major Impact on Aggregate Output and Employment

• Question:
  – Could the Great Depression Have Been Substantially Mitigated Under an Alternative Monetary Policy?
  – Answer: Yes.