Real-Time Macroeconomic Monitoring

Francis X. Diebold
University of Pennsylvania

30th CIRET Conference, New York

October 8, 2010

Several Authors/Papers/Teams...

Aruoba, Diebold and Scotti (2009)
"Real-Time Measurement of Business Conditions"
Journal of Business and Economic Statistics

Aruoba, Diebold, Price, Sill, Stark (2009-present)
ADS Index (Web)
FRB Philadelphia, Real-Time Data Research Center

Aruoba and Diebold (2010)
"Real-Time Macroeconomic Monitoring:
Real Activity, Inflation, and Interactions"
American Economic Review

Aruoba, Diebold, Kose and Terrones (2010)
"Globalization, the Business Cycle, and Macro Monitoring"
NBER Working Paper No. 16264.

Our Approach

- Guide real people, making real decisions, in real time
- Nowcasting, updated in real-time
- Dynamic factor model with missing data

Close Cousins:
Stock and Watson (1989) (small data)
Mariano and Murasawa (2003) (mixed frequency)

Penn
University of Pennsylvania

Interest is Percolating

- Conferences
- Centers
- Handbook chapters
- Policy
- Even Google!

Penn
University of Pennsylvania

"Economic Decision Making Over the Cycle"

- Merger activity over the cycle
- Pricing and other competitive issues over the cycle
- Accounting behavior over the cycle
- Distress and bankruptcy over the cycle
- Labor/personnel decisions over the cycle
- Portfolio allocation over the cycle
- Risk management over the cycle
- Asset pricing over the cycle

We want:

- Real-time information
- Based on many indicators
- Quantitative (cardinal), not 0-1 (ordinal)

Penn
University of Pennsylvania

Underlying High-Frequency Dynamic Factor Structure

Economic activity factor:

$$x_t = \phi x_{t-1} + \eta_t$$

i^{th} indicator:

$$y_t^i = c^i + \beta^i x_t + \varepsilon_t^i$$

Methodological Econometric Issues

- High-frequency, mixed-frequency, missing data
- Potentially time-varying system matrices
- Likelihood evaluation and model estimation
- Optimal extraction of latent macroeconomic activity

Penn
University of Pennsylvania

State Space Representation

$$y_t = Z\alpha_t + \Gamma w_t + \varepsilon_t$$

$$\alpha_{t+1} = T\alpha_t + R\eta_t$$

$$\varepsilon_t \sim (0, H), \quad \eta_t \sim (0, Q)$$

Kalman Filter Extraction of Latent Economic Activity

$$
\begin{aligned}
a_{t|t} &= a_t + P_t Z' F_t^{-1} v_t \\
P_{t|t} &= P_t - P_t Z' F_t^{-1} Z P_t' \\
a_{t+1} &= T a_{t|t} \\
P_{t+1} &= T P_{t|t} T' + RQR',
\end{aligned}
$$

where

$$
\begin{aligned}
v_t &= y_t - Z a_t - \Gamma w_t \\
F_t &= Z P_t Z' + H
\end{aligned}
$$

$$
a_{t|t} \equiv E\left(\alpha_t | \mathcal{Y}_t\right),\ P_{t|t} = var\left(\alpha_t | \mathcal{Y}_t\right),\ a_t \equiv E\left(\alpha_t | \mathcal{Y}_{t-1}\right),
$$
$$
P_t = var\left(\alpha_t | \mathcal{Y}_{t-1}\right),\ \mathcal{Y}_t \equiv \{y_1, ..., y_t\}
$$

Filtering with Missing Data

All of y_t missing (skip updating):

$$\begin{aligned} a_{t+1} &= Ta_t \\ P_{t+1} &= TP_tT' + RQR \end{aligned}$$

Some of y_t missing (update w/ modified measurement eqn.):

$$\begin{aligned} y_t^* &= Z^*\alpha_t + \Gamma^* w_t + \varepsilon_t^* \\ \varepsilon_t^* &\sim N(0, H^*) \end{aligned}$$

$y_t^* = W_t y_t$, $Z^* = W_t Z$, $\Gamma^* = W_t \Gamma$, $\varepsilon_t^* = W_t \varepsilon_t$, $H^* = W_t H W_t'$

Likelihood Evaluation with Missing Data

$$\ln L = \sum_{t=1}^{\mathcal{T}} ln l_t$$

where

$\ln l_t = 0$, if no elements of y_t are observed

$\log l_t = -\frac{1}{2}\left[N^* \log 2\pi + \left(\log |F_t^*| + v_t^{*\prime} F_t^{*-1} v_t^*\right)\right]$, otherwise

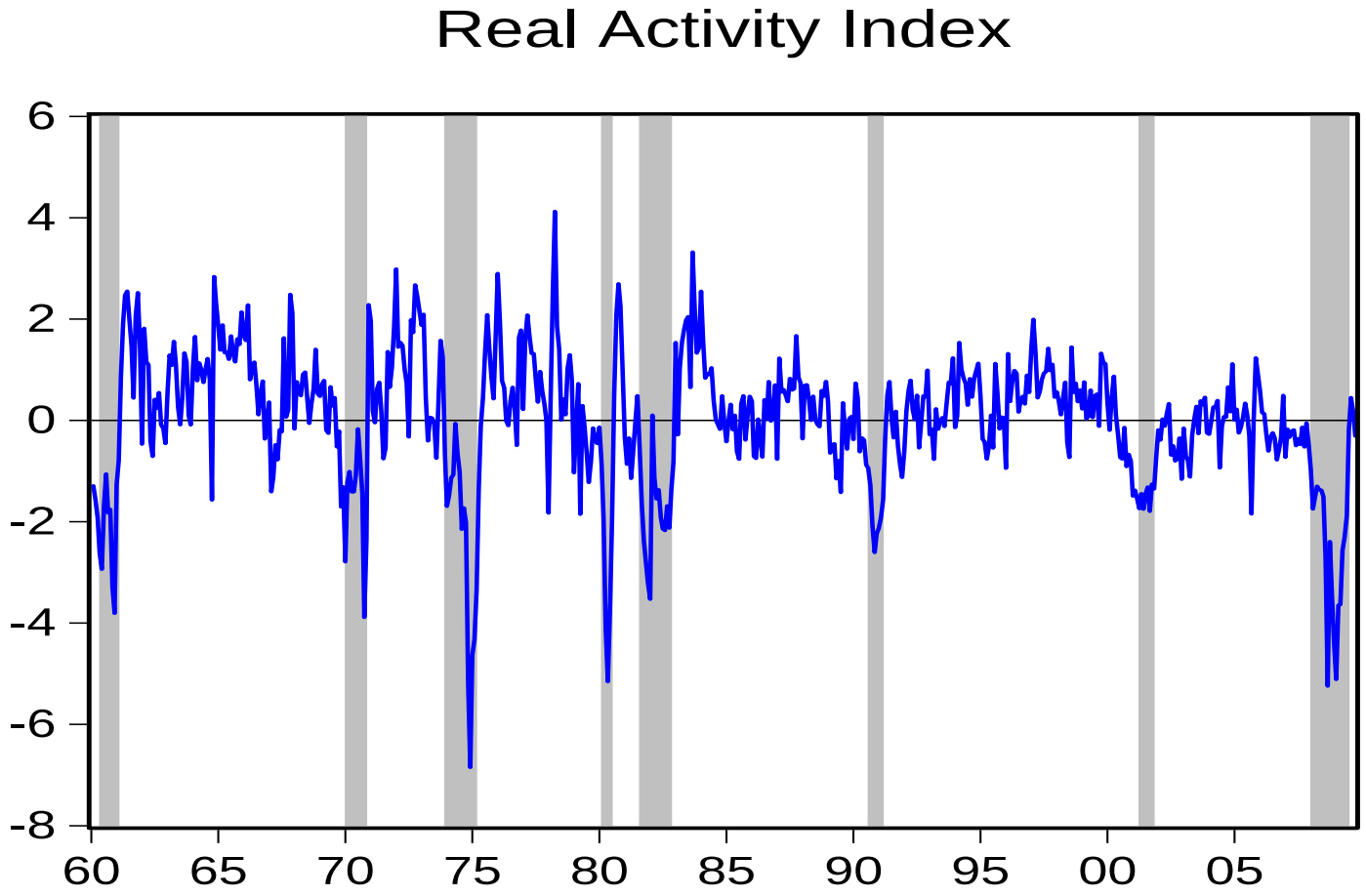
Substantive Macroeconomic Issues

- *What indicators* at what frequencies?
- How do real activity and inflation *behave*?
- How do real activity and inflation *interact*?
- What of the *recent recession*?
- Where is the economy *now*?

Penn
University of Pennsylvania

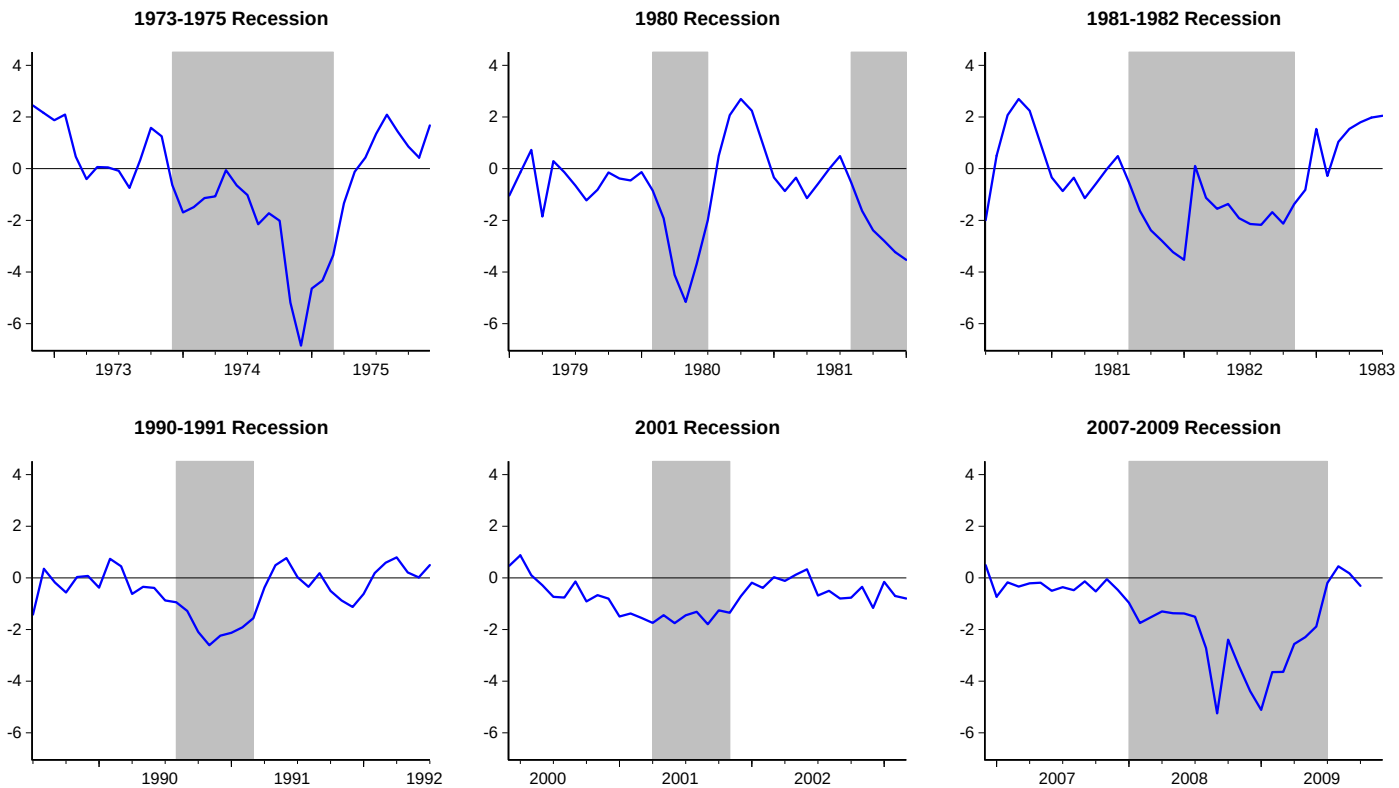
Real Activity

- [Initial unemployment claims (weekly)]
- Payroll employment (monthly)
- Industrial production (monthly)
- Personal income less transfers (monthly)
- Manufacturing and trade sales (monthly)
- GDP (quarterly)



- Coherence with NBER
- Less noisy than individual indicators
- "Great Moderation"
- Recent recession long and deep

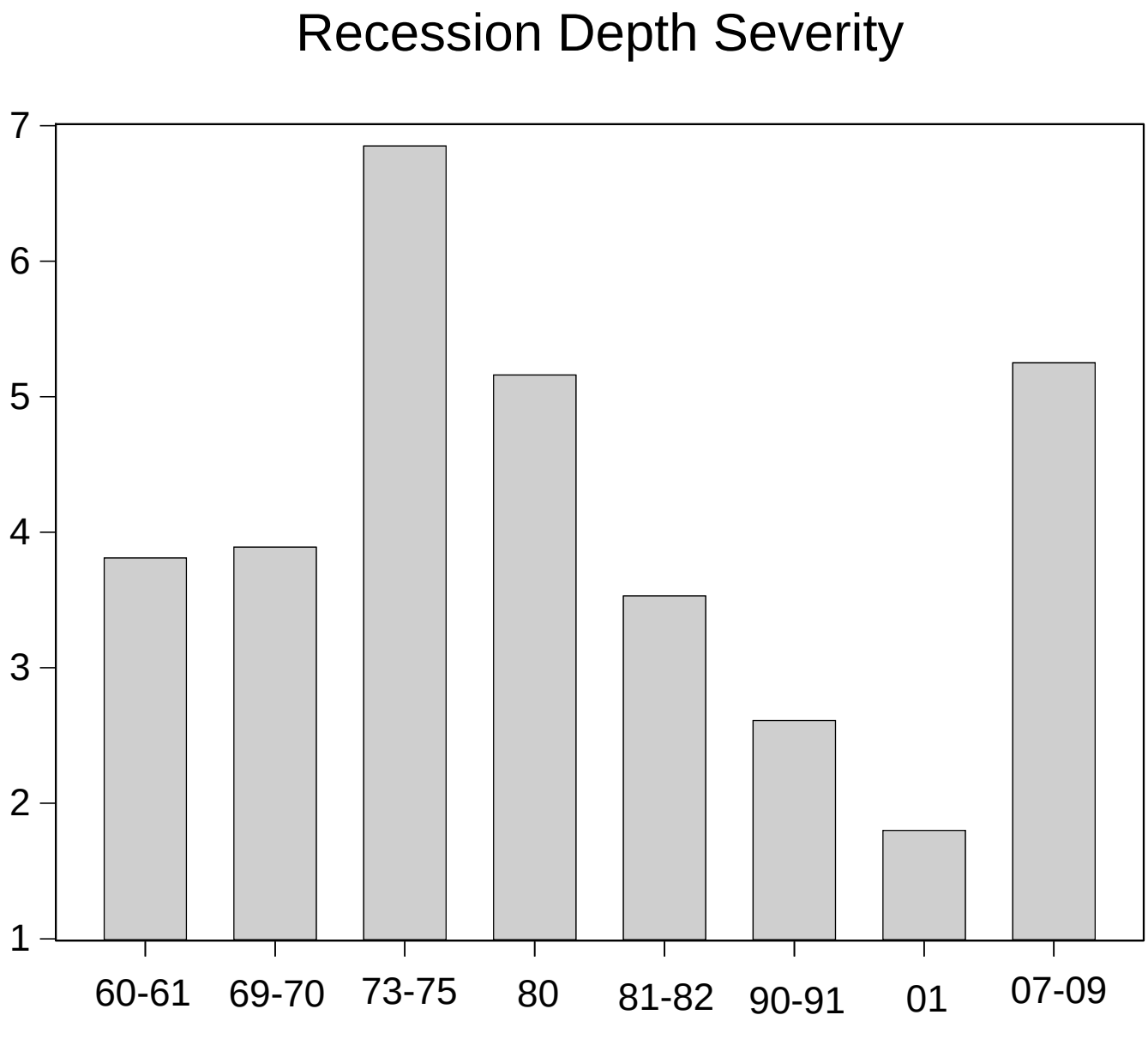
Real Activity Index During Recessions



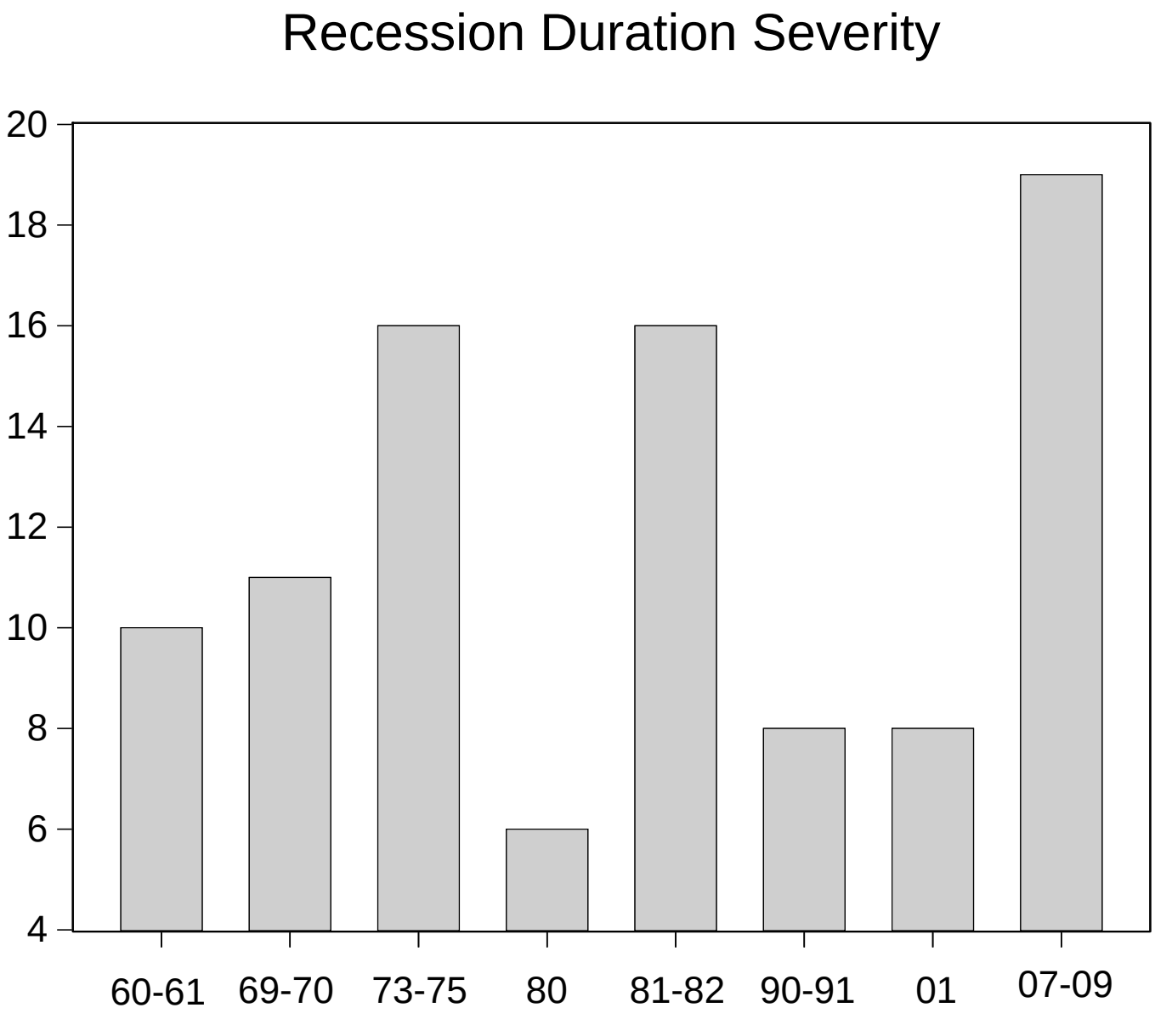
Recent recession:

- Moderately extreme depth severity
- Highly extreme duration severity

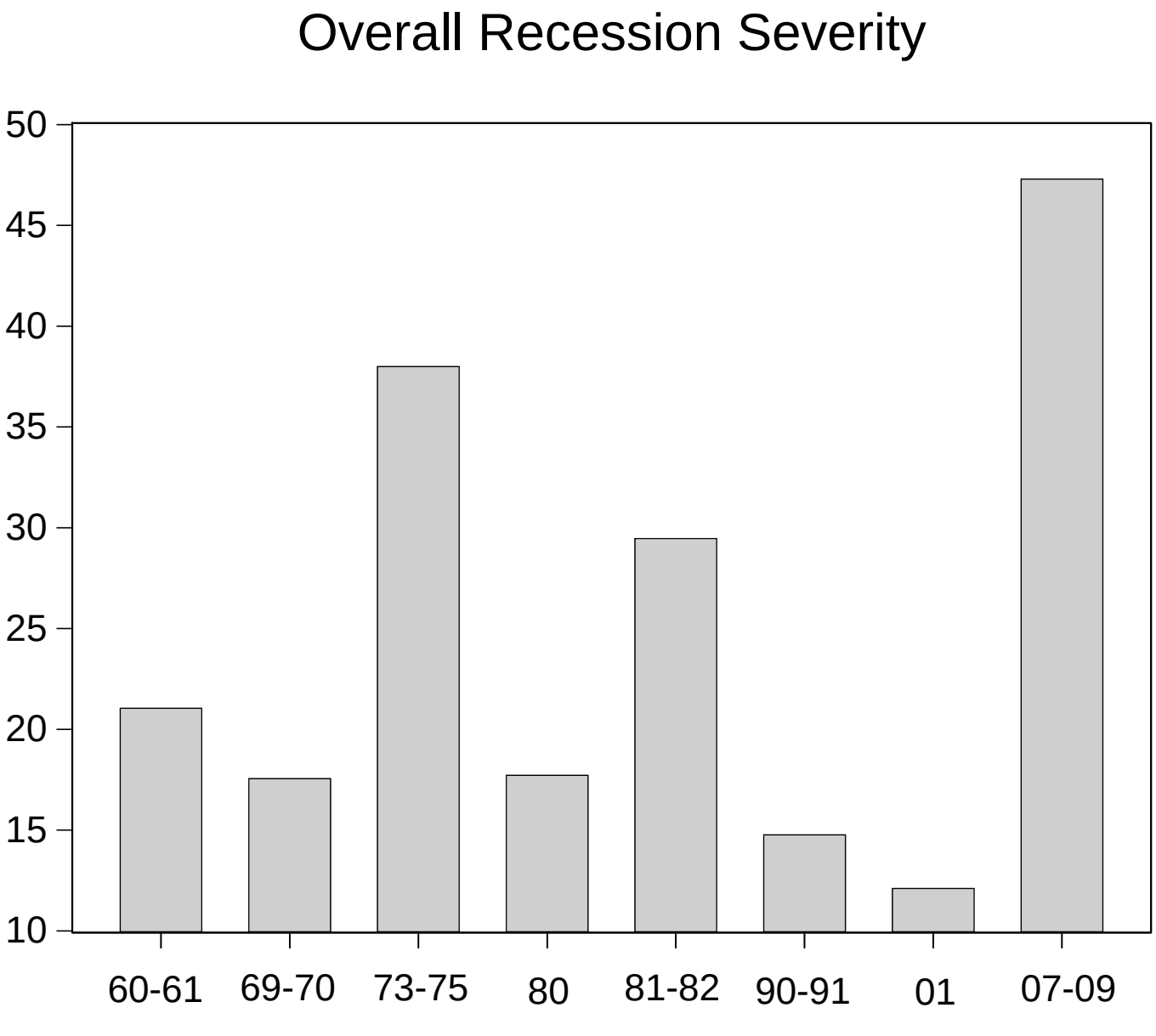
Moderately Extreme Depth Severity



Extreme Duration Severity



Highly Extreme Overall Severity

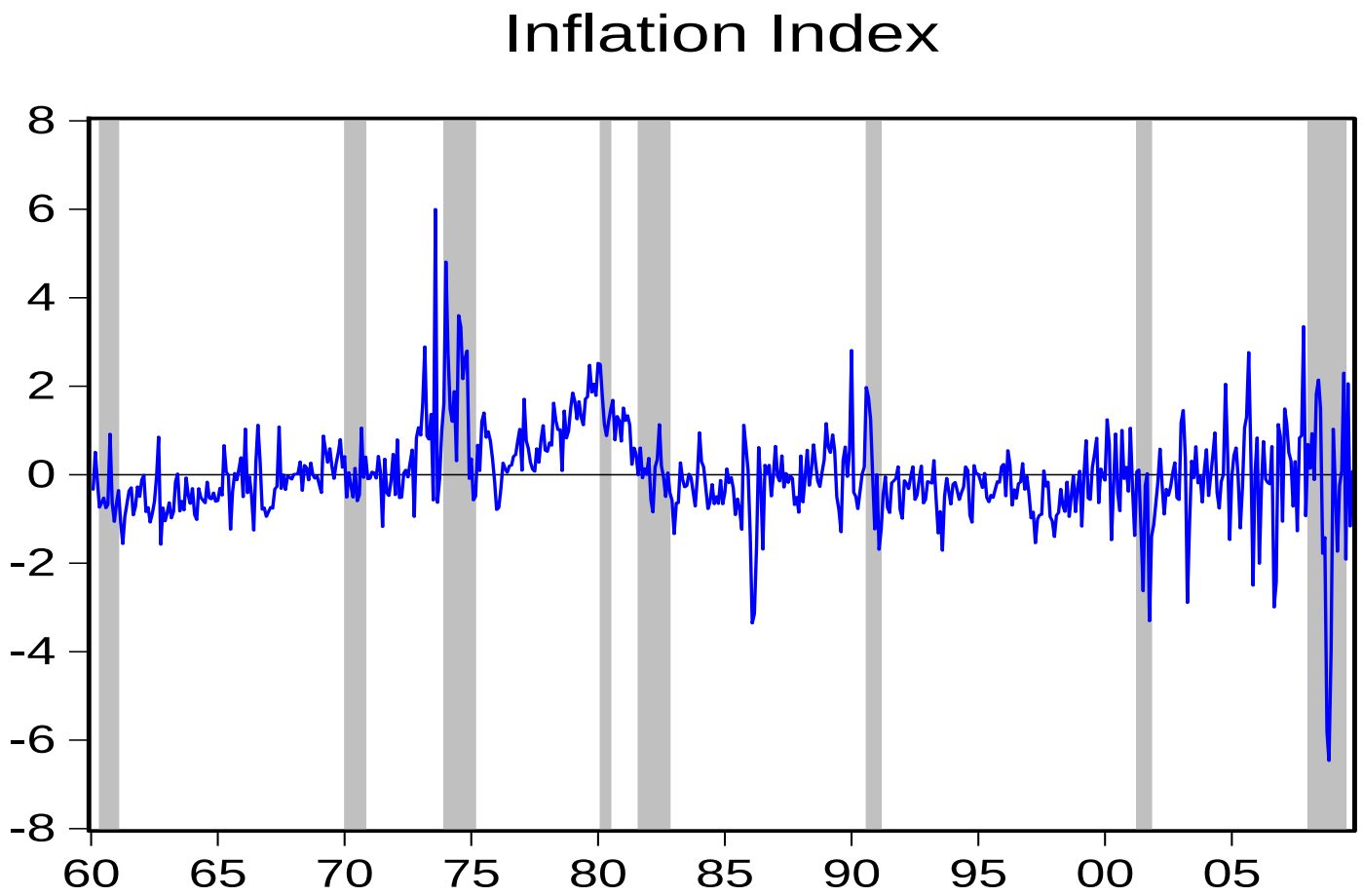


Real-time real activity index updates at:

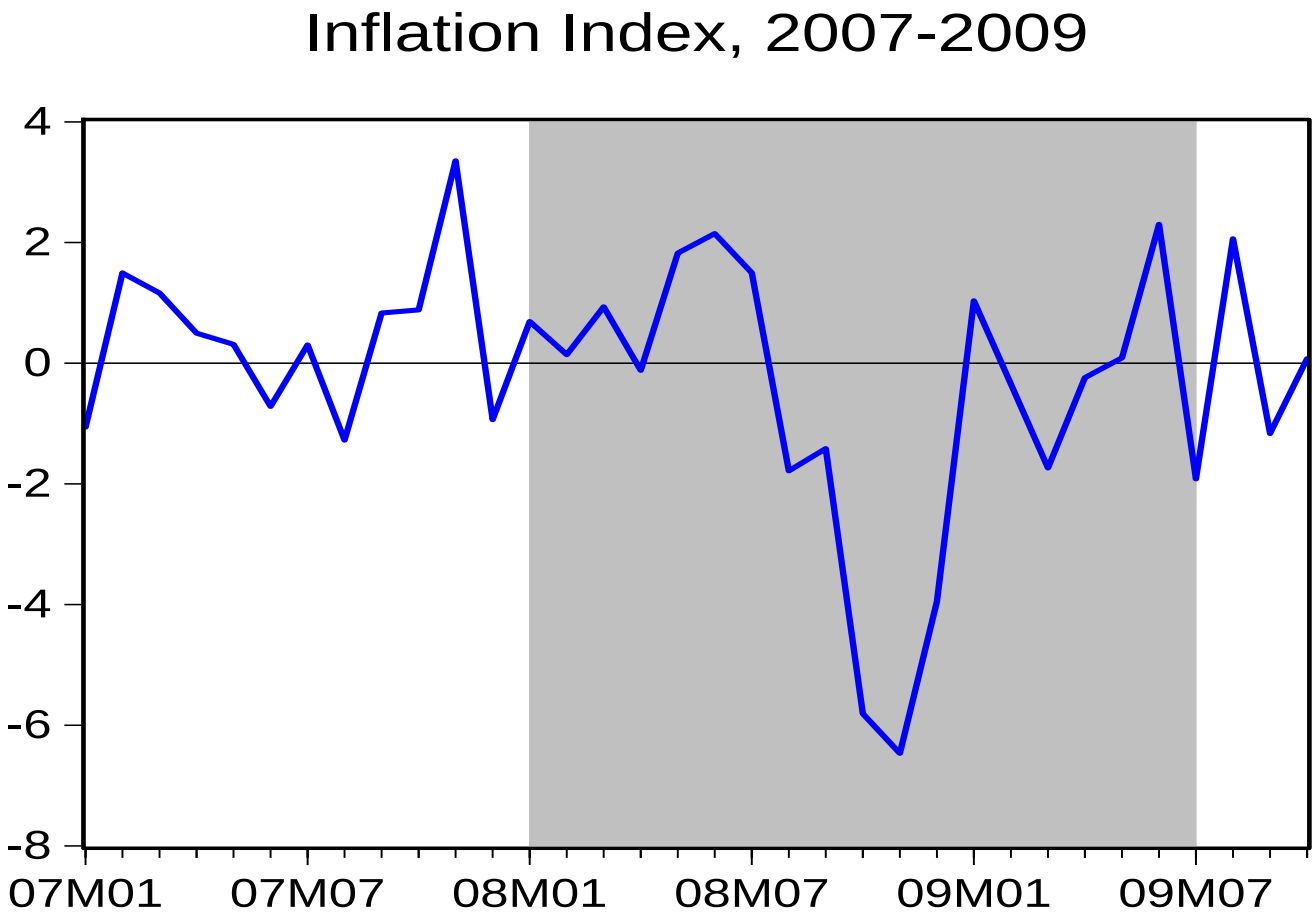
Federal Reserve Bank of Philadelphia

Inflation

- All items CPI (monthly)
- Finished goods PPI (monthly)
- Standard and Poor's GSCI Non-Energy Commodities Index (monthly)
- Spot price of West Texas intermediate crude oil (monthly)
- Hourly compensation in the non-farm business sector (quarterly)
- GDP deflator (quarterly)



- Great inflation, Volcker containment
- Increased volatility post-2000
- Recent episode

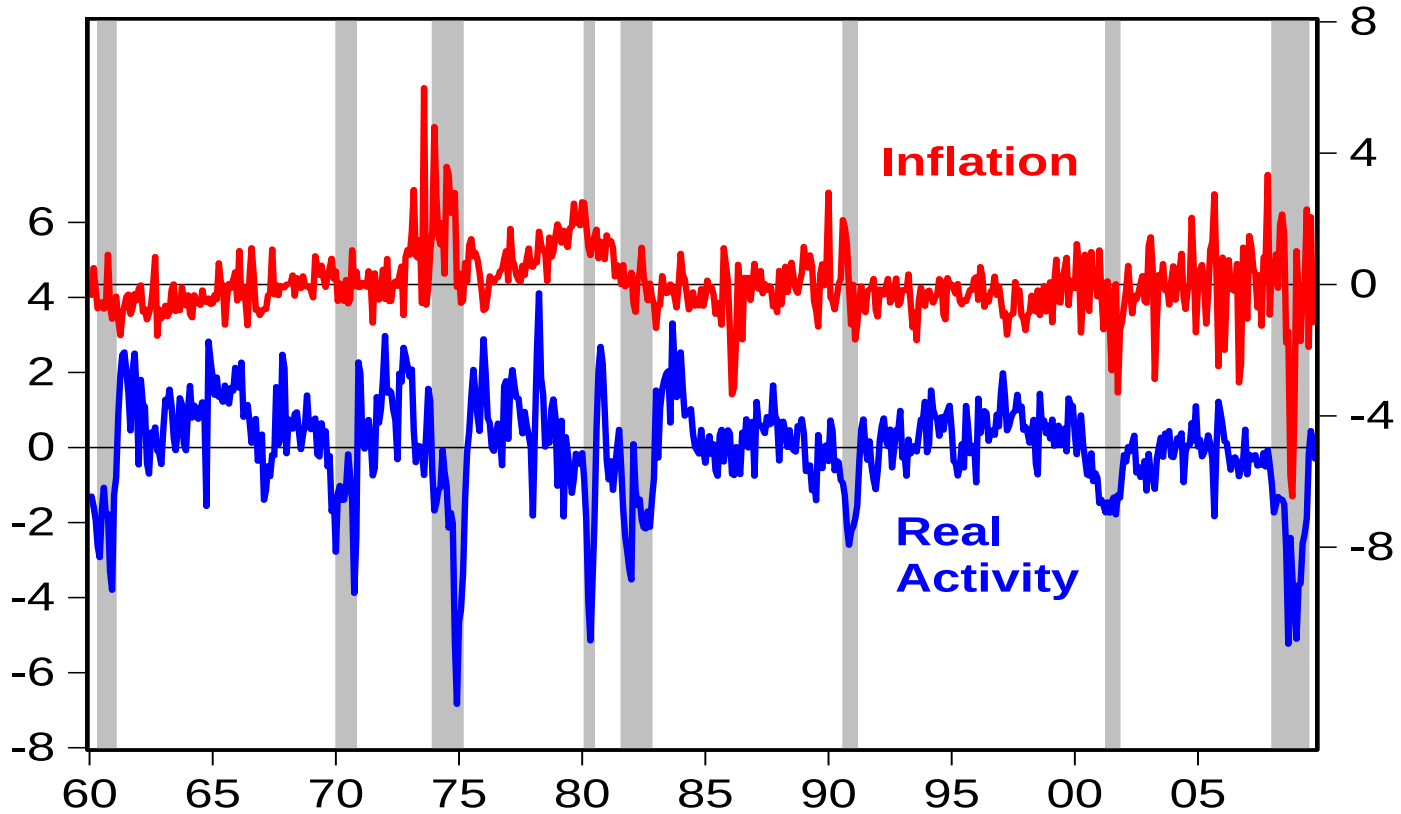


- Very steep but very brief decline

Real Activity and Inflation Interaction

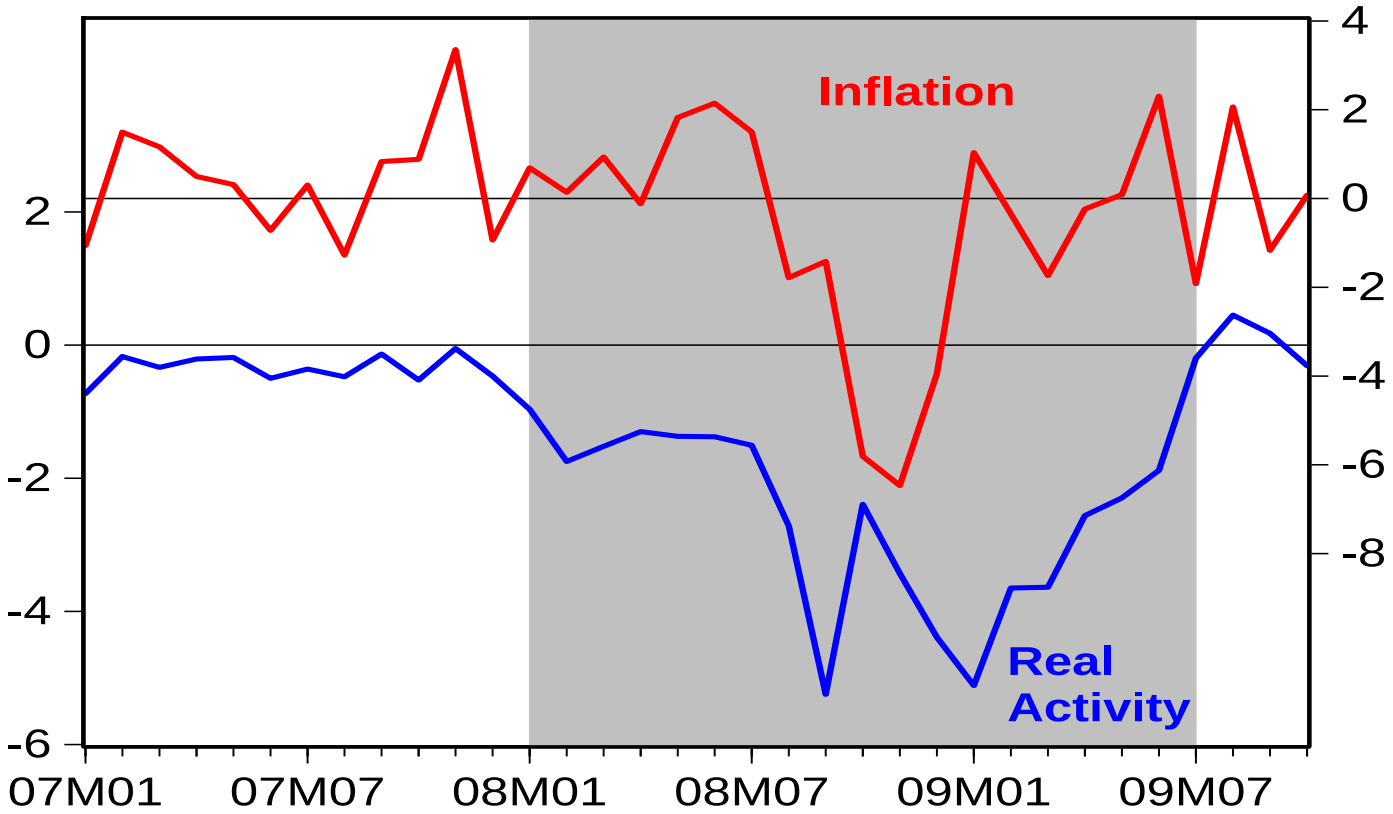
- Demand shocks: Real activity and inflation positively correlated
- Supply shocks: Real activity and inflation negatively correlated

Real Activity and Inflation Indexes



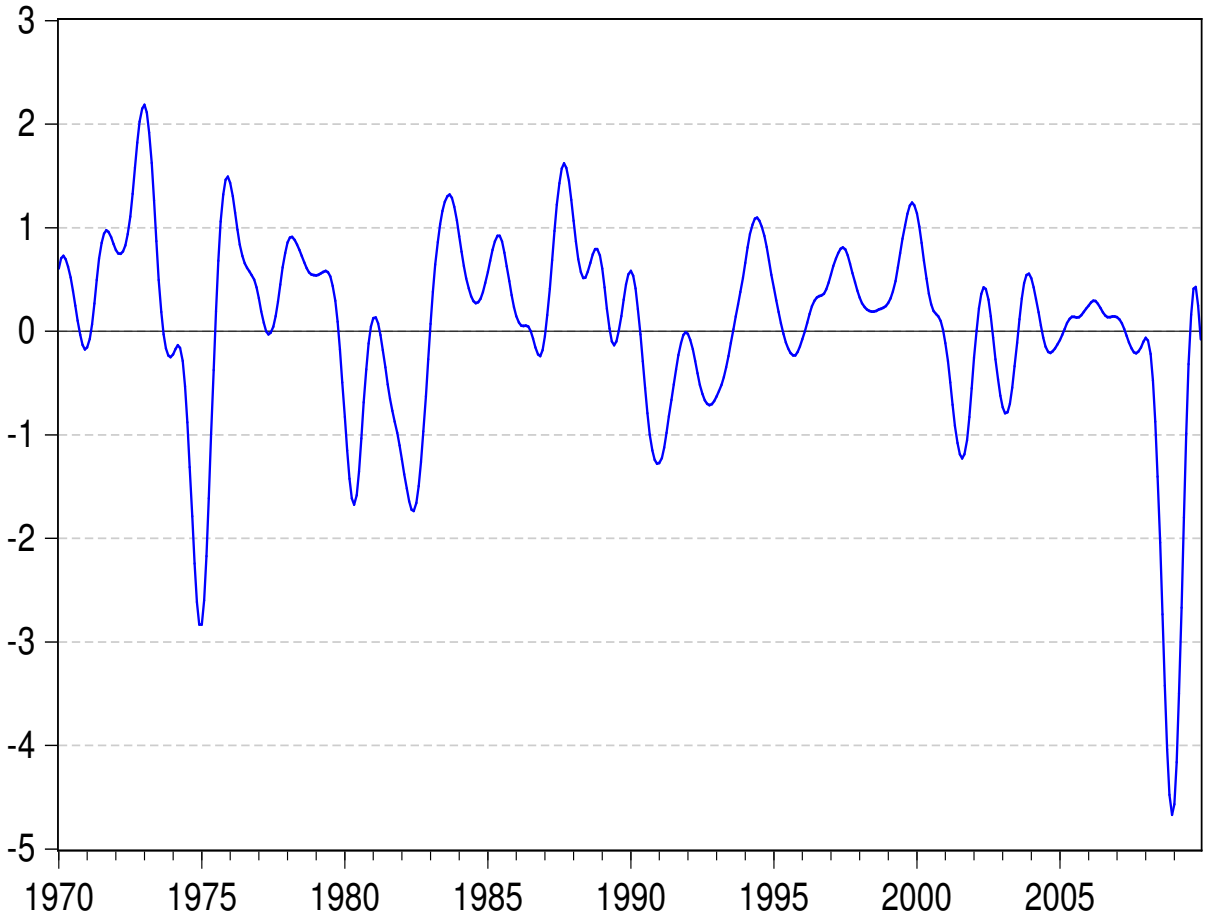
- Usually positively correlated
- Negatively correlated during oil shocks
- Recent episode

Real Activity and Inflation Indexes, 2007-2009

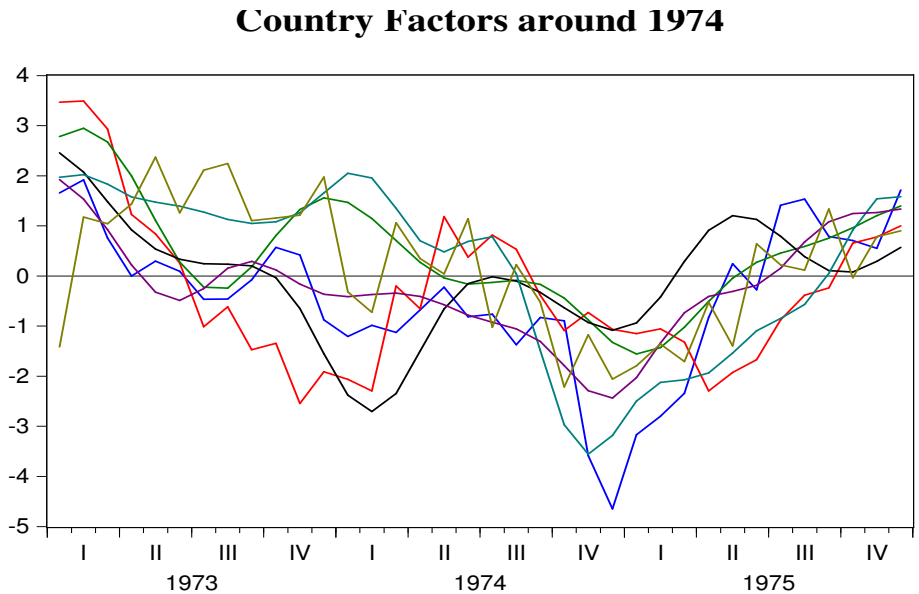


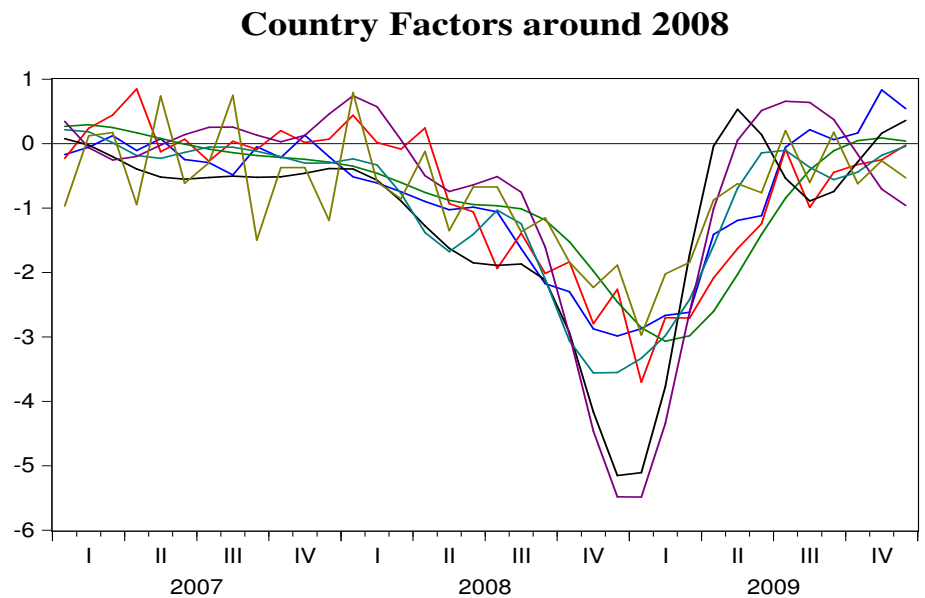
- Positive correlation
- A Keynesian demand-driven recession

Going Global: An Extracted G-7 Factor



Comparative Behavior of Country Factors in Two Recessions





Concluding Remarks

- This time was not different, but it was certainly severe.
- Interactions of global real and price/wage activity with financial markets (e.g., yield curve)