

Real-Time Nowcasting

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Economic and Financial 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

Our Approach

- ▶ Guide real people, making real decisions, in real time
- ▶ Nowcasting, updated in real-time

We want:

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

Real-Time Interest is Percolating

- ▶ Conferences
- ▶ Centers
- ▶ Handbook chapters
- ▶ Policy

Underlying High-Frequency Dynamic Factor Structure

Economic activity factor:

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

j^{th} indicator:

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

(Close Cousin: Stock and Watson, 1989)

Methodological Econometric Issues

- ▶ High-frequency, mixed-frequency, missing data
(Close cousin: Mariano and Murasawa, 2003)
- ▶ Time-varying system matrices
- ▶ Modified filtering and likelihood evaluation
- ▶ Optimal extraction of latent macroeconomic activity

State Space Representation

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

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

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

Kalman Filter Extraction of Latent Economic Activity

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

where

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

$$\begin{aligned}a_{t|t} &\equiv E(\alpha_t | \mathcal{Y}_t), \quad P_{t|t} = \text{var}(\alpha_t | \mathcal{Y}_t), \quad a_t \equiv E(\alpha_t | \mathcal{Y}_{t-1}), \\ P_t &= \text{var}(\alpha_t | \mathcal{Y}_{t-1}), \quad \mathcal{Y}_t \equiv \{y_1, \dots, y_t\}\end{aligned}$$

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.):

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

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

Likelihood Evaluation with Missing Data

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

where:

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

$\ln l_t = -\frac{1}{2} (N^* \log 2\pi + (\log |F_t^*| + v_t^{*'} F_t^{*-1} v_t^*))$, otherwise

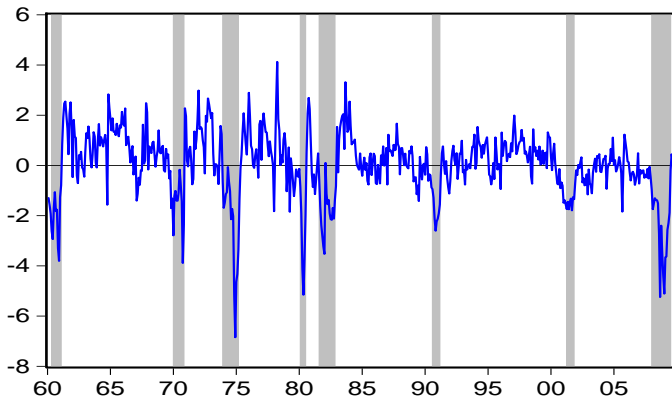
Substantive Macroeconomic Issues

- ▶ What indicators, at what frequencies?
- ▶ How has real activity behaved historically?
- ▶ What happened to real activity during the Great Crisis of 2007-2009?
- ▶ Where is the economy *now*?
- ▶ What about inflation?
- ▶ What about the global economy?

Real Activity

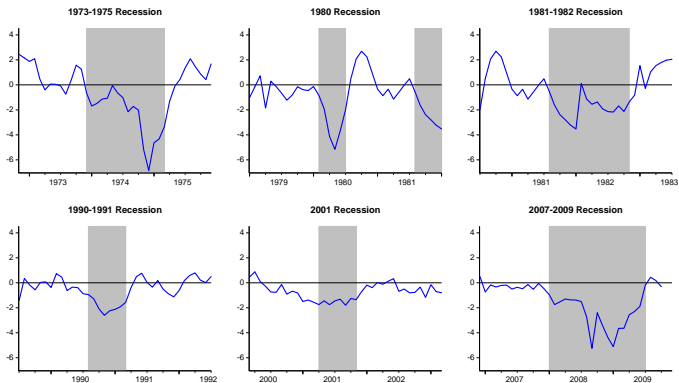
- ▶ [Initial unemployment claims (weekly)]
- ▶ Payroll employment (monthly)
- ▶ Industrial production (monthly)
- ▶ Personal income less transfers (monthly)
- ▶ Manufacturing and trade sales (monthly)
- ▶ GDP (quarterly)

Real Activity Index



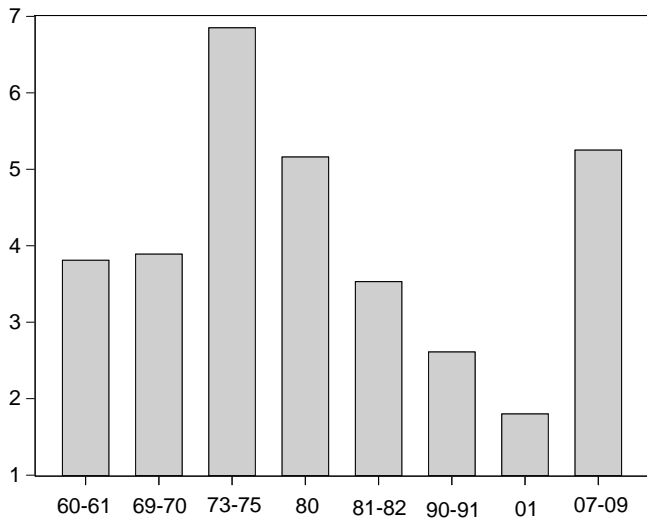
- ▶ Coherence with NBER
- ▶ Less noisy than individual indicators
- ▶ “Great Moderation”
- ▶ Recent episode

Real Activity Index During Recessions



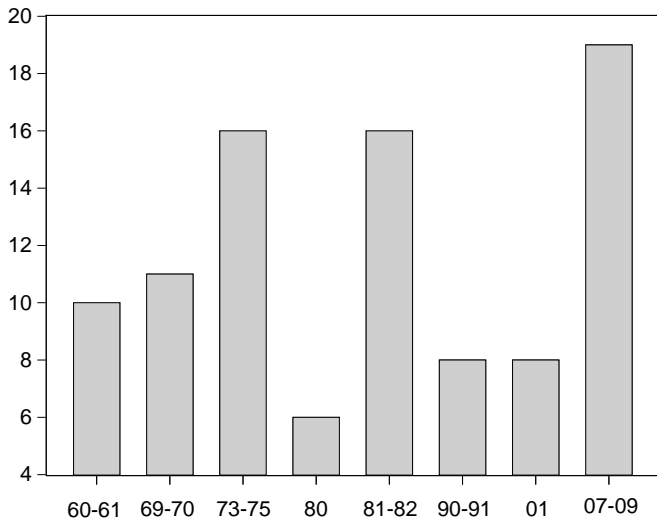
2007-2009: Moderately Extreme Depth Severity

Recession Depth Severity



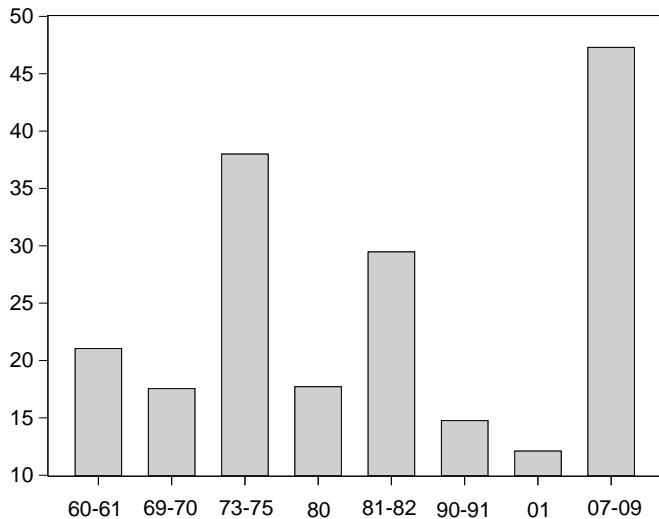
2007-2009: Extreme Duration Severity

Recession Duration Severity



2007-2009: Highly Extreme Overall Severity

Overall Recession Severity



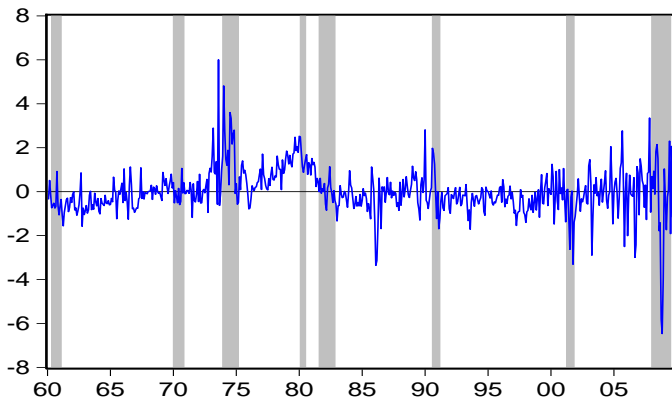
Real-time real activity index updates at:

Federal Reserve Bank of Philadelphia

Inflation

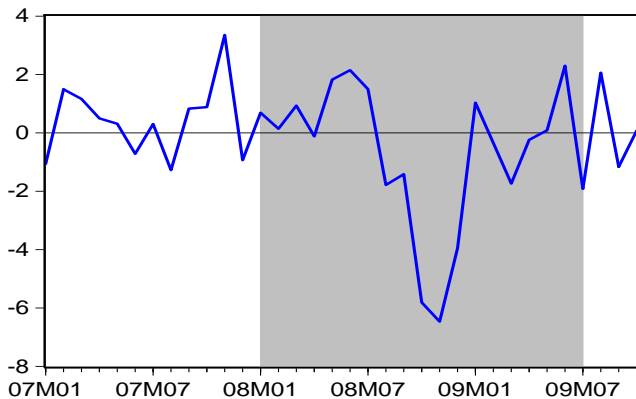
- ▶ All items CPI (monthly)
- ▶ Finished goods PPI (monthly)
- ▶ Standard and Poor's GSCI Non-Energy Commodities Index (monthly)
- ▶ Spot price of West Texas intermediate crude oil (monthly)
- ▶ Hourly compensation in the non-farm business sector (quarterly)
- ▶ GDP deflator (quarterly)

Inflation Index



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

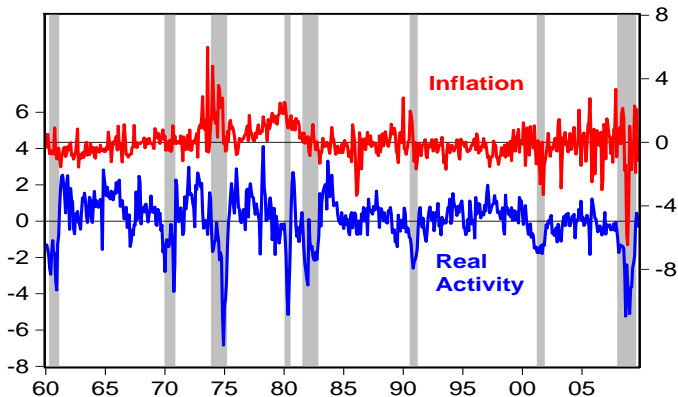
Inflation Index, 2007-2009



Real Activity and Inflation Interaction

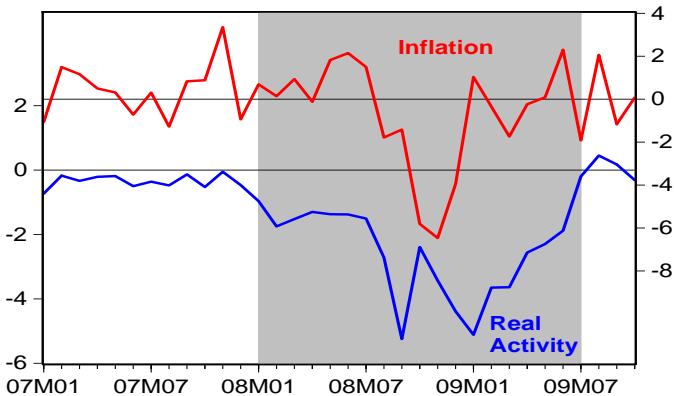
- ▶ Demand shocks: Real activity and inflation positively correlated
- ▶ Supply shocks: Real activity and inflation negatively correlated

Real Activity and Inflation Indexes



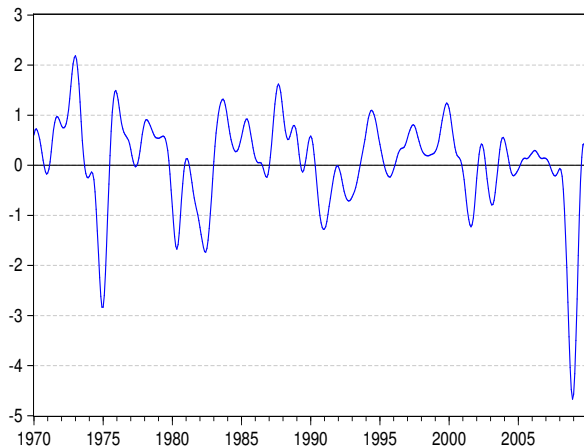
- ▶ Usually positively correlated
- ▶ Negatively correlated during oil shocks
- ▶ Recent episode

Real Activity and Inflation Indexes, 2007-2009



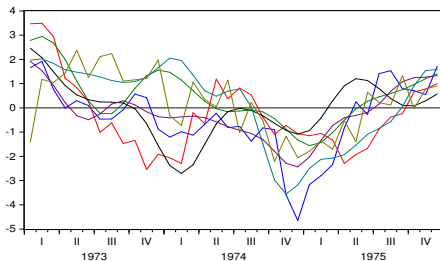
- ▶ Positive correlation
- ▶ A Keynesian demand-driven recession

Going Global: An Extracted G-7 Factor

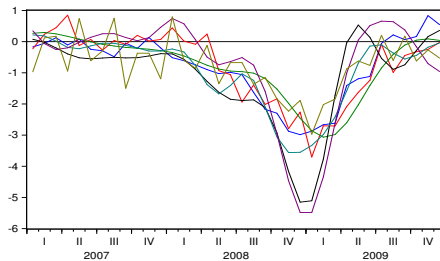


Comparative Behavior of Country Factors in Two Recessions

Country Factors around 1974



Country Factors around 2008



Conclusion

This time was not different, but it was certainly severe.

Several Authors/Papers/Teams...

Aruoba, Diebold and Scotti (2009, *J. Bus. and Econ. Stats.*)
“Real-Time Measurement of Business Conditions”

Aruoba, Diebold, et al. (2009-present, FRB Phila. RTDRC)
“Real-Time ADS Index” (website)

Aruoba and Diebold (2010, *American Economic Review*)
“Real-Time Macroeconomic Monitoring”

Aruoba, Diebold, Kose and Terrones (2011 NBER, in press)
“Globalization, the Business Cycle, and Macro Monitoring”

Extensions

- ▶ Richer component indicators
- ▶ Higher-frequency component indicators
- ▶ Regional aspects of the cycle