Real-Time Macroeconomic Monitoring

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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”  
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)
Interest is Percolating

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

\[ a_{t|t} = a_t + P_t Z' F_t^{-1} v_t \]
\[ P_{t|t} = P_t - P_t Z' F_t^{-1} Z P_t' \]
\[ a_{t+1} = T a_{t|t} \]
\[ P_{t+1} = T P_{t|t} T' + RQR' \]

where

\[ v_t = y_t - Z a_t - \Gamma w_t \]
\[ F_t = Z P_t Z' + H \]

\[ a_{t|t} \equiv E (\alpha_t | Y_t), P_{t|t} = \text{var} (\alpha_t | Y_t), a_t \equiv E (\alpha_t | Y_{t-1}), \]
\[ P_t = \text{var} (\alpha_t | Y_{t-1}), Y_t \equiv \{ y_1, \ldots, y_t \} \]
Filtering with Missing Data

All of $y_t$ missing (skip updating):

\[
a_{t+1} = T a_t \\
P_{t+1} = T P_t T' + RQR
\]

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

\[
y_t^* = Z^* \alpha_t + \Gamma^* w_t + \varepsilon_t^* \\
\varepsilon_t^* \sim N(0, H^*)
\]

\[
y_t^* = W_t y_t, \quad Z^* = W_t Z, \quad \Gamma^* = W_t \Gamma, \quad \varepsilon_t^* = W_t \varepsilon_t, \quad H^* = W_t H W_t'
\]
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

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

Recession Depth Severity

60-61 69-70 73-75 80 81-82 90-91 01 07-09
Extreme Duration Severity

Recession Duration Severity

60-61  69-70  73-75  80  81-82  90-91  01  07-09
Highly Extreme Overall Severity

Overall Recession Severity

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Severity</th>
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<td>60-61</td>
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<td>07-09</td>
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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
- Usually positively correlated
- Negatively correlated during oil shocks
- Recent episode
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**
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)