Surprise and Uncertainty Indexes: Real-time Aggregation of Real-Activity Macro Surprises

Chiara Scotti
Federal Reserve Board

The Causes and Macroeconomic Consequences of Uncertainty
Dallas Fed October 3-4, 2013
The views expressed in this paper are solely the responsibility of the author and should not be interpreted as reflecting the view of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.
I construct:

- a SURPRISE index: real-time, real activity index that summarizes (aggregates) recent economic data surprises and measures deviation from consensus expectations
  
  **INTERPRETATION:** A positive (negative) reading of the surprise index suggests that economic releases have on balance been higher (lower) than consensus, meaning that agents were more pessimistic (optimistic) about the economy.

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News Surprises

- News surprise \((s_t) = \text{announcement} \ (y_t) - \text{forecast} \ (y_t^f)\)

- Market participants react to the NEWS component of scheduled macroeconomic announcements

- Are Bloomberg forecasts efficient?

- Mincer–Zarnowitz test: \(s_t = \alpha + \beta y_t^f + u_t\)
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* 10 percent significance, ** 5 percent significance, and *** 1 percent significance
Why do we use Bloomberg forecasts?

Markets react to those forecasts!

\[ d\log(FX_t) = \alpha + \beta \times s_t + \epsilon_t \]

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<td>-0.106*</td>
<td>0.030</td>
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|                | CAD/$ Beta      | R2             | JPY/$ Beta     | R2             |
|                | 0.046**         | 0.005          | -0.053         | 0.005          |
| Employment     | -0.058          | 0.008          | 0.377***       | 0.210          |
| Retail sales   | -0.097**        | 0.024          | 0.215***       | 0.117          |
| Personal income| 0.036           | 0.003          | -0.057         | 0.010          |
| PMI            | -0.029          | 0.002          | 0.091**        | 0.022          |
| GDP            | 0.054*          | 0.006          | 0.025          | 0.002          |

|                | 0.030           | 0.006          | 0.025          | 0.002          |

|                | 0.034           | 0.035          | 0.035          | 0.029          |

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The Model - Underlying Factor Model

- The monthly variables:

\[ y_t^M = \mu^M + Z^M x_t + \varepsilon_t^M \]  \hspace{1cm} (1)
\[ \varepsilon_t^M = \alpha \varepsilon_{t-1}^M + e_t^M \]  \hspace{1cm} (2)

with \( e_t^M \sim i.i.d. N(0, \Sigma_e^M) \)

- The quarterly variables:

\[ y_t^Q = \mu^Q + Z^Q x_t + \varepsilon_t^Q \]  \hspace{1cm} (3)
\[ \varepsilon_t^Q = \rho \varepsilon_{t-1}^Q + e_t^Q \]  \hspace{1cm} (4)

with \( e_t^Q \sim i.i.d. N(0, \Sigma_e^Q) \)

- Unobserved factor is a VAR process of order \( p \):

\[ x_{t+1} = \Lambda x_t + \eta_t, \]  \hspace{1cm} (5)
\[ \eta_t \sim i.i.d. N(0, \sigma_\eta). \]  \hspace{1cm} (6)
The Model - State Space

\[ y_t = \mu + Z \alpha_t \]  \hspace{1cm} (7) \\
\[ \alpha_t = T \alpha_{t-1} + u_t, \quad u_t \sim i.i.d. N(0, \Sigma) \]  \hspace{1cm} (8)

where

\[ y_t = (y_t^M, y_t^Q)' \]

\[ \alpha_t = (x_t, x_{t-1}, x_{t-2}, x_{t-3}, x_{t-4}, \varepsilon_t^M, \varepsilon_t^Q, \varepsilon_{t-1}^Q, \varepsilon_{t-2}^Q, \varepsilon_{t-3}^Q, \varepsilon_{t-4}^Q)' \]
The Model - Weights

- As shown in Koopman and Harvey (2003)

\[ \alpha_{t|t} = \sum_{j=1}^{t} w_j(\alpha_{t|t})y_j. \]  

(9)

where \( y_t \) can contain vectors of monthly or quarterly series \((y_t^M, y_t^Q)\)

- WEIGHTS \( w_j \)
  - interpretation: represent the importance of the corresponding (past and present) macro variable releases in determining the common factor = underlying state of the economy
  - implicitly display a time decay feature with more recent data exhibiting higher importance in determining the factor
  - do not depend on time \( t \), but depend on the forecast horizon and the real-time release pattern of the data
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The Model - Surprise Index ($SI$)

Given

\[ x_{t|t} = \sum_{j=1}^{t} w_j y_j \]  \hfill (10)

we can rewrite the Surprise Index as

\[ SI_t = \sum_{j=1}^{t} w_j s_j \]  \hfill (11)

where

\[ s_t^i = \frac{y_t^i - E[y_t^i|F_t]}{\sigma_s} \]  \hfill (12)
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The Model - Uncertainty Index ($UI$)

Given

$$x_{t|t} = \sum_{j=1}^{t} w_j y_j$$

we can rewrite the Uncertainty Index as

$$UI_t = \sqrt{\sum_{j=1}^{t} w_j s_j^2}$$

where

$$s_t^i = \frac{y_t^i - E[y_t^i|F_t]}{\sigma_s}$$
The Model - Uncertainty Index ($\mathcal{UI}$)

Given

$$x_{t|t} = \sum_{j=1}^{t} w_j y_j$$  \hspace{1cm} (13)

we can rewrite the Uncertainty Index as

$$\mathcal{UI}_t = \sqrt{\sum_{j=1}^{t} w_j s_j^2}$$  \hspace{1cm} (14)

where

$$s_t^i = \frac{y_t^i - E[y_t^i | \mathcal{F}_t]}{\sigma_s}$$  \hspace{1cm} (15)
The construction of the indexes requires three steps:

(i) estimation of the state space model
(ii) determination of the weights $w_j$
(iii) construction of the indexes
Estimation


2. For each day on the real-time subsample (May 15, 2003 through September 30, 2012):
   - Run Kalman Filter
   - Compute Weights
   - Compute Surprise and Uncertainty indexes
Estimation


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   - Run Kalman Filter
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Results

1. Business Condition Indexes
2. Weights
3. Indexes: Surprise and Uncertainty
Business Conditions

Data

The Model

Estimation

Results

Applications

Conclusions

- United States
- Euro Area
- United Kingdom
- Canada
- Japan
- Aggregate

0 = average economic activity

Shading denotes recession dates.
Weights

United States

Euro Area

Data

The Model

Estimation

Results

Applications

Conclusions
Cumulative Weights

United States

Euro Area

NFP (solid)  IP (dotted)
Surprise Index: US and EA

**United States**

- Surprise Index (Right axis)
- Citigroup Economic Surprise Index (Left axis)

**Euro Area**

- (Graphs showing time series data for the United States and Euro Area from 2003 to 2012, with shaded areas indicating specific periods.)
Surprise Index: UK and CA
Surprise Index: JA and Aggregate
Uncertainty Index: US and EA

United States

- Uncertainty Index (Right axis)
- Implied Volatility (Left axis)
- Realized Volatility (Left axis)

Euro Area

- Implied Volatility (Left axis)
- Realized Volatility (Left axis)
Uncertainty Index: UK and CA
Uncertainty Index: JA and Aggregate

Shading denotes recession dates.
Application 1: Assessing the impact of the Surprise Index on FX returns

\[ \text{dlog}(FX_t) = \alpha + \beta \times d(S_t) + \varepsilon_t \]

<table>
<thead>
<tr>
<th></th>
<th>Euro/$</th>
<th></th>
<th>GBP/$</th>
<th></th>
<th>CAD/$</th>
<th></th>
<th>JPY/$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta )</td>
<td>( R^2 )</td>
<td>( \beta )</td>
<td>( R^2 )</td>
<td>( \beta )</td>
<td>( R^2 )</td>
<td>( \beta )</td>
<td>( R^2 )</td>
</tr>
<tr>
<td>US surprise index</td>
<td>0.362***</td>
<td>0.022</td>
<td>0.263***</td>
<td>0.014</td>
<td>-0.096</td>
<td>0.002</td>
<td>0.418***</td>
<td>0.031</td>
</tr>
<tr>
<td>Foreign surprise index</td>
<td>-0.332***</td>
<td>0.013</td>
<td>-0.140</td>
<td>0.007</td>
<td>-0.691***</td>
<td>0.042</td>
<td>0.128</td>
<td>0.002</td>
</tr>
</tbody>
</table>

** 5 percent significance, *** 1 percent significance
The solid line represents the uncertainty index which is compared against other common proxies for uncertainty, namely the Baker, Bloom and Davis measure, the Bachmann, Elstner and Sims measure, and the VIX. All series are demeaned and standardized. The horizontal line represents the 1.65 standard deviation limit.
Employment response to a 1 standard deviation shock in the different uncertainty proxies. The shaded area represents the +/- one standard error confidence interval for the uncertainty index.
Business Cycle

+/− one standard error confidence interval for the real-activity uncertainty shock and the VIX
I constructed a surprise index and an uncertainty index using only macroeconomic information. Looking into a number of possible extensions:

- construct indexes for nominal variables to gauge optimism/pessimism about inflation stance
- incorporate additional indicators and surprises for each country to construct a summary measure of real and nominal variables
- extend the framework to include U.S. macro surprises into foreign economies to exploit the correlation/causation across business cycles.
- include vintages of data so that the indexes change not only when new information is released but also when past information is revised.
- expand the dataset to construct indexes with a longer history
- experiment with different weight systems
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