Disentangling the Channels of the 2007-09 Recession

Jim Stock and Mark Watson
Framework

\[ X_t = \Theta(L) \varepsilon_t + e_t \]

- Vector of variables
- Common shocks
- Idiosyncratic shocks
Three Questions:

\[ X_t = \Theta(L) \varepsilon_t + e_t \]

Q1. Stability

- \( \Theta(L)_{<2007Q4} = \Theta(L)_{\geq2007Q4} \) ?
- Were there “new shocks” for \( t \geq 2007Q4 \) ?

Q2: Which shocks were important during 2007-09 recession?

- \( X_t = \sum_{i=1}^{r} \Theta_i(L)\varepsilon_{it} \)

Q3: Why is this recovery sluggish?

- \( X_{t+h/t} = \sum_{i=1}^{r} \Theta_i^h(L)\varepsilon_{it} \) \( (set \ t = 2009Q2 \ or \ previous \ trough \ date) \)
Empirical Model: DFM

\[ X_t = \Lambda F_t + e_t \]  
\[ (F_t = 6 \text{ factors, } e_t = \text{idiosyncratic disturbance}) \]

\[ \Phi(L)F_t = \eta_t = H\varepsilon_t \]  
\[ (\eta \text{ are innovations, } \varepsilon \text{ are structural shocks}) \]

\[ F_t \text{ and } \Lambda \text{ estimated by PC: } \hat{F}_t = (\hat{\Lambda}'\hat{\Lambda})^{-1}\hat{\Lambda}'X_t \]

\((\text{detail: } F \text{ and } \Lambda \text{ estimated using "disaggregates" only})\)

\[ \Phi \text{ estimated by OLS using } \hat{F} \]
\begin{equation}
X_t = \Lambda F_t + e_t \quad \Phi(L)F_t = \eta_t
\end{equation}

Q1: Stability, new shocks, etc.

\begin{align*}
\hat{\Lambda} \text{ from } t < 2007Q4 \text{ data} & \quad \text{and} \quad \hat{F}_t = (\hat{\Lambda}'\hat{\Lambda})^{-1}\hat{\Lambda}'X_t \text{ for all } t \\
X_t = \hat{\Lambda}\hat{F}_t + \hat{e}_t
\end{align*}

- How does “fit” over \( t \geq 2007Q4 \) compare to \( t < 2007Q4 \)?
- Does \( \hat{e}_t \) for \( t \geq 2007Q4 \) contain a common shock?
- Are \( \Lambda \) and \( \Phi \) stable across \( t = 2007Q4 \)?
\[ X_t = \Lambda F_t + e_t \quad \Phi(L)F_t = \eta_t = H\varepsilon_t \]

Q2: Which shocks were important during 2007-09?

- Innovation in \( X_{jt} = \lambda_{j}'\eta_t = \lambda_{j}'H\varepsilon_t \)

- SVAR analysis: \( \varepsilon_t = H^{-1}\eta_t \)

  - “External” instrument: \( Z_t \)
    - \( E(\varepsilon_{1t}Z_t) = \alpha \neq 0 \) (Relevance)
    - \( E(\varepsilon_{jt}Z_t) = 0, j = 2, \ldots, r \) (Exogeneity)
    - \( E(\varepsilon_t\varepsilon_t') = D \) (diagonal) (Uncorrelated shocks)
\[ X_t = \Lambda F_t + e_t \quad \Phi(L)F_t = \eta_t \]

Q3: Is this recovery different?

(i) \( S_t = (F_t' \ F_{t-1}' \ \ldots \ F_{t-p+1}')' \)
\[
\Pi = \text{companion matrix of VAR for } F
\]
\[
F_{t+h/t} = \Pi^h S_t
\]
\[
X_{j,t+h/t} = \lambda_j \Pi^h S_t
\]
Q3: Is this recovery different?

(ii) What about “trends”?

Data

- U.S., quarterly, 1959-2011Q2, 200 time series
- Almost all series analyzed in changes or growth rates
- All series detrended by local demeaning – approximately 15 year centered moving average:
Quarterly GDP growth (a.r.)

*Trend:* 3.7% → 2.5%

Quarterly productivity growth

2.3% → 1.8% → 2.2%
Results

1. Structural breaks post 2007Q4

Empirical analysis

1. Estimate DFM parameters using data through 2007Q3
   a. Compute factors using “old” factor loadings:
   b. \( \hat{F}_t = (\hat{\Lambda}'\hat{\Lambda})^{-1}\hat{\Lambda}'X_t \), where \( \hat{\Lambda} \) are pre-07Q3 factor loadings
   c. How well do pre-07Q3 factors & factor loadings do in explaining post-07Q4 macro variables?

2. Formal stability tests:
   a. Stability of \( \Lambda \)
   b. Test for new factor (excess covariance among idiosyncratic disturbances)
1.1. Fit of pre-07Q3 parameters and factors, post-07Q4

Figures:

*Plot of 4-Q growth (100ln(X_t/X_{t-4})) or 4-Q change:*
  solid = actual
  dashed = common component (pre-07Q3 model)

*Average \( R^2 \) \hspace{1cm} 2007Q4 \( R^2 \)*

Average \( R^2 \) = 1-quarter \( R^2 \) of “\( \Lambda F_t \)”, NBER peak to peak + 14 quarters, averaged over previous 7 recessions, 1960Q1, …, 2001Q1

2007Q4 \( R^2 \) = value for 2007Q4 – 2011Q2.
average $R^2$: 0.78  
2007Q4 $R^2$: 0.64
Cons:Svc

average $R^2$: 0.29         2007Q4 $R^2$: 0.83
average $R^2$: 0.66  
2007Q4 $R^2$: 0.86
average $R^2$: 0.54    2007Q4 $R^2$: 0.62
average $R^2$: 0.59

2007Q4 $R^2$: 0.53
average $R^2$: 0.38

2007Q4 $R^2$: 0.55
average $R^2$: 0.39  
2007Q4 $R^2$: -1.54
average $R^2$: 0.22  
2007Q4 $R^2$: -0.03
average $R^2$: 0.43

2007Q4 $R^2$: 0.78
average $R^2$: 0.43

2007Q4 $R^2$: 0.78
S&P 500

average $R^2$: 0.67

2007Q4 $R^2$: 0.87
average $R^2$: 0.12

2007Q4 $R^2$: 0.89
Table 2: Subsample $R^2$ of common component of quarterly macro variables by category, based on the six-factor benchmark DFM estimated over 1959Q1 – 2007Q3.

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
<th>1959-2007Q3</th>
<th>1984-2007Q3</th>
<th>Computed over 15 quarters starting at NBER peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60Q1</td>
</tr>
<tr>
<td>NIPA</td>
<td>21</td>
<td>0.56</td>
<td>0.43</td>
<td>0.56</td>
</tr>
<tr>
<td>Industrial production</td>
<td>13</td>
<td>0.72</td>
<td>0.60</td>
<td>0.78</td>
</tr>
<tr>
<td>Employment &amp; Unemp</td>
<td>46</td>
<td>0.62</td>
<td>0.50</td>
<td>0.64</td>
</tr>
<tr>
<td>Housing starts</td>
<td>8</td>
<td>0.37</td>
<td>0.21</td>
<td>0.09</td>
</tr>
<tr>
<td>Inventories, orders, &amp; sales</td>
<td>8</td>
<td>0.54</td>
<td>0.35</td>
<td>0.39</td>
</tr>
<tr>
<td>Prices</td>
<td>39</td>
<td>0.15</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Earnings &amp; productivity</td>
<td>13</td>
<td>0.37</td>
<td>0.29</td>
<td>0.52</td>
</tr>
<tr>
<td>Interest rates</td>
<td>18</td>
<td>0.40</td>
<td>0.30</td>
<td>-0.07</td>
</tr>
<tr>
<td>Money &amp; credit</td>
<td>12</td>
<td>0.44</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>Stock prices &amp; wealth</td>
<td>11</td>
<td>0.47</td>
<td>0.52</td>
<td>0.00</td>
</tr>
<tr>
<td>Housing prices</td>
<td>3</td>
<td>0.67</td>
<td>0.67</td>
<td>.</td>
</tr>
<tr>
<td>Exchange rates</td>
<td>6</td>
<td>0.56</td>
<td>0.66</td>
<td>-2.64</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0.42</td>
<td>0.42</td>
<td>-0.40</td>
</tr>
</tbody>
</table>
1.2. Tests: Stability of $\Lambda$? Evidence of a “missing factor”?

Stability of $\Lambda$

- Andrews (1993) end-of-sample stability tests (Table 3)
- 13% of series reject at 5% level, relative to 1984Q1-2007Q3 $\Lambda$’s
- Main rejections are in prices, money & credit, interest rates, housing
Missing factors?

Unusually large covariance among idiosyncratic errors following 07Q4?

Let $\gamma_{i,\tau}$ denote the ordered eigenvalues of $\Gamma_\tau = \sum_{t=\tau}^{\tau+7} \hat{e}_t \hat{e}_t'$ (a sample covariance matrix over 8 observations),

Let $\kappa_\tau = \frac{\gamma_{1,\tau}}{\sum_{i=1}^{8} \gamma_{i,\tau}}$.

$\kappa$ will be large if $e$ is dominated by single shock.
Missing factors? ctd.

Is $\kappa$ unusually large during this recession?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Values of $\kappa$ in different recessions</td>
<td>0.84</td>
<td>0.61</td>
<td>0.67</td>
<td>0.62</td>
<td>0.61</td>
<td>0.37</td>
<td>0.60</td>
<td>0.63</td>
</tr>
</tbody>
</table>

The value in 2007:4 (0.63) corresponds to the $42^{\text{th}}$ percentile of the empirical distribution of $\kappa$ in the sample (where $\kappa$ is computed over all 8 quarter periods.)

Repeating the exercise over 15 periods following peak: The value in 2007:4 (0.42) corresponds to the $10^{\text{th}}$ percentile of the empirical distribution of $\kappa$ in the sample (where $\kappa$ is computed over all 15 quarter periods.)
Summary:

Q1: Stability, new shocks, etc.

\[ \hat{\Lambda} \text{ from } t < 2007Q4 \text{ data and } \hat{F}_t = (\hat{\Lambda}' \hat{\Lambda})^{-1} \hat{\Lambda}' X_t \text{ for all } t \]

\[ X_t = \hat{\Lambda} \hat{F}_t + \hat{e}_t \]

- How does “fit” over \( t \geq 2007Q4 \) compare to \( t < 2007Q4 \)?

- Does \( \hat{e}_t \) for \( t \geq 2007Q4 \) contain a common shock?

- Are \( \Lambda \) and \( \Phi \) stable across \( t = 2007Q4 \)?
Q2: Which shocks were important during 2007-09?

- Innovation in $X_{jt} = \lambda_j' \eta_t = \lambda_j' H \varepsilon_t$
Table 5: Innovations to factor components of selected series, by quarter, 2007Q1 – 2011Q2: Standardized innovations

<table>
<thead>
<tr>
<th>Date</th>
<th>GDP</th>
<th>Consumption</th>
<th>Investment</th>
<th>Employment</th>
<th>Productivity</th>
<th>Housing Starts</th>
<th>Oil Price</th>
<th>Fed Funds</th>
<th>Ted spread</th>
<th>VIX</th>
<th>Wealth (FoF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007Q1</td>
<td>-0.9</td>
<td>-1.3</td>
<td>-0.4</td>
<td>-0.7</td>
<td>-1.2</td>
<td>0.2</td>
<td>1.7</td>
<td>0.3</td>
<td>0.0</td>
<td>-0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>2007Q2</td>
<td>0.3</td>
<td>-0.2</td>
<td>0.5</td>
<td>-0.1</td>
<td>0.2</td>
<td>0.8</td>
<td>1.1</td>
<td>0.5</td>
<td>-0.9</td>
<td>-1.4</td>
<td>0.8</td>
</tr>
<tr>
<td>2007Q3</td>
<td>-0.3</td>
<td>-0.8</td>
<td>0.0</td>
<td>-0.7</td>
<td>0.0</td>
<td>-0.7</td>
<td>0.3</td>
<td>-0.6</td>
<td>0.7</td>
<td>1.2</td>
<td>-1.0</td>
</tr>
<tr>
<td>2007Q4</td>
<td>-0.3</td>
<td>-1.3</td>
<td>0.1</td>
<td>0.3</td>
<td>-0.7</td>
<td>-1.3</td>
<td>1.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>-0.9</td>
</tr>
<tr>
<td>2008Q1</td>
<td>-0.3</td>
<td>-0.7</td>
<td>0.1</td>
<td>0.2</td>
<td>-0.4</td>
<td>-1.3</td>
<td>0.2</td>
<td>-0.1</td>
<td>1.4</td>
<td>2.2</td>
<td>-2.0</td>
</tr>
<tr>
<td>2008Q2</td>
<td>-1.4</td>
<td>-2.1</td>
<td>-0.4</td>
<td>-1.1</td>
<td>-2.1</td>
<td>1.0</td>
<td>3.4</td>
<td>0.5</td>
<td>0.1</td>
<td>-0.4</td>
<td>-0.8</td>
</tr>
<tr>
<td>2008Q3</td>
<td>-1.7</td>
<td>-1.7</td>
<td>-1.0</td>
<td>-0.7</td>
<td>-1.4</td>
<td>-3.5</td>
<td>-0.6</td>
<td>0.2</td>
<td>3.9</td>
<td>2.9</td>
<td>-2.6</td>
</tr>
<tr>
<td>2008Q4</td>
<td>1.0</td>
<td>2.1</td>
<td>-0.1</td>
<td>-0.4</td>
<td>4.6</td>
<td>-8.3</td>
<td>-10.3</td>
<td>-2.5</td>
<td>7.7</td>
<td>8.3</td>
<td>-4.1</td>
</tr>
<tr>
<td>2009Q1</td>
<td>0.3</td>
<td>-2.7</td>
<td>2.3</td>
<td>0.9</td>
<td>-0.3</td>
<td>-4.7</td>
<td>2.5</td>
<td>3.5</td>
<td>4.0</td>
<td>1.4</td>
<td>-3.3</td>
</tr>
<tr>
<td>2009Q2</td>
<td>2.9</td>
<td>1.8</td>
<td>3.3</td>
<td>3.8</td>
<td>0.7</td>
<td>2.9</td>
<td>2.8</td>
<td>3.8</td>
<td>-3.0</td>
<td>-3.4</td>
<td>1.2</td>
</tr>
<tr>
<td>2009Q3</td>
<td>1.6</td>
<td>0.4</td>
<td>1.9</td>
<td>2.3</td>
<td>-0.6</td>
<td>4.8</td>
<td>5.0</td>
<td>1.5</td>
<td>-5.2</td>
<td>-3.5</td>
<td>1.5</td>
</tr>
<tr>
<td>2009Q4</td>
<td>-1.2</td>
<td>-0.9</td>
<td>-2.0</td>
<td>-2.1</td>
<td>-0.2</td>
<td>0.1</td>
<td>-0.4</td>
<td>-2.1</td>
<td>-1.7</td>
<td>-2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>2010Q1</td>
<td>0.3</td>
<td>-0.1</td>
<td>0.6</td>
<td>0.5</td>
<td>0.0</td>
<td>-0.5</td>
<td>0.3</td>
<td>1.2</td>
<td>0.9</td>
<td>0.0</td>
<td>-0.6</td>
</tr>
<tr>
<td>2010Q2</td>
<td>0.7</td>
<td>0.3</td>
<td>0.7</td>
<td>0.3</td>
<td>1.3</td>
<td>-2.4</td>
<td>-1.8</td>
<td>0.3</td>
<td>2.1</td>
<td>1.6</td>
<td>-1.2</td>
</tr>
<tr>
<td>2010Q3</td>
<td>0.8</td>
<td>-0.3</td>
<td>1.1</td>
<td>0.4</td>
<td>0.9</td>
<td>-1.7</td>
<td>0.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.3</td>
<td>-0.7</td>
</tr>
<tr>
<td>2010Q4</td>
<td>0.3</td>
<td>-0.6</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>1.7</td>
<td>0.8</td>
<td>-1.0</td>
<td>-1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>2011Q1</td>
<td>0.4</td>
<td>-0.6</td>
<td>1.1</td>
<td>0.5</td>
<td>-0.6</td>
<td>1.5</td>
<td>2.8</td>
<td>1.2</td>
<td>-0.9</td>
<td>-0.8</td>
<td>-0.5</td>
</tr>
<tr>
<td>2011Q2</td>
<td>-0.9</td>
<td>-0.8</td>
<td>-1.1</td>
<td>-1.3</td>
<td>-0.6</td>
<td>0.5</td>
<td>-1.5</td>
<td>-0.7</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>
What are these big shocks?

Digression: SDFM and SVAR identification

\[ \Phi(L)F_t = \eta_t, \quad \eta_t = H\varepsilon_t, \]

What is column of \( H \) corresponding to “Oil shock”?

Strategy: Method of “external instruments”

Use shocks from the literature as instruments. Let \( Z_t^{KO} \) be Killian OPEC Oil Supply Shortfall variable (the instrument).

Selected references.

Method of external instruments, ctd.

Standard approach is to use a constructed exogenous shock series $Z_t$ as a regressor – as a shock itself. But in general $Z_t$ is only part of the shock, and has measurement error, so including $Z_t$ as a regressor (as the shock itself) won’t yield consistent estimation.

Instead, treat $Z_t$ as an instrument

Assume:

(i) $E\left(\varepsilon^O_{il_t} Z^{KO}_{t}\right) \neq 0$ (Relevance)

(ii) $E\left(\varepsilon^i_t Z^{KO}_{t}\right) = 0$ for all other shocks $i$ (Exogeneity)

(iii) $E(\varepsilon^O_{il_t} \varepsilon^i_{t}) = 0$ for all other shocks $i$

Then we can estimate $H^{Oil}$ and $\varepsilon^O_{il_t}$.

Note $Z$ can be multidimensional, and this imposed OID.
Identification using external instruments (multiple instruments)

\[ u_t = H \epsilon_t = \begin{bmatrix} H_1 & \cdots & H_r \end{bmatrix} \begin{bmatrix} \epsilon_{1t} \\ \vdots \\ \epsilon_{rt} \end{bmatrix} \]

Suppose you have an instrumental variable \( Z_t \) (not in \( Y_t \)) such that

(i) \( E(\epsilon_{1t} Z'_t) = \alpha' \neq 0 \) (relevance)

(ii) \( E(\epsilon_{jt} Z'_t) = 0, j = 2, \ldots, r \) (exogeneity)

(iii) \( E(\epsilon_t \epsilon'_t) = \Sigma_{\epsilon \epsilon} = I_r \) (or diagonal)

Under (i) and (ii), you can identify \( H_1 \) up to scale

\[ E(u_t Z'_t) = E(H \epsilon_t Z'_t) = \begin{bmatrix} H_1 & \cdots & H_r \end{bmatrix} \begin{bmatrix} E(\epsilon_{1t} Z'_t) \\ \vdots \\ E(\epsilon_{rt} Z'_t) \end{bmatrix} = H_1 \alpha' \]
Identification using external instruments, ctd.

1. Identification of $H_1$

$$E(\eta_tZ_t') = E(H\varepsilon_tZ_t') = \begin{bmatrix} H_1 & \cdots & H_r \end{bmatrix} \begin{pmatrix} E(\varepsilon_{1t}Z_t') \\ \vdots \\ E(\varepsilon_{rt}Z_t') \end{pmatrix} = H_1 \alpha'$$

The scale of $H_1$ can be set by a normalization – e.g. a unit positive value of shock 1 is defined to have a unit positive effect on the innovation to variable 1, which is $u_{1t}$. This corresponds to

(iv) $H_{11} = 1$ ($H_{11}$ is the first element of $H_1$) (unit shock normalization)
Identification using external instruments, ctd.

2. Identification of $\varepsilon_{1t}$

The shock $\varepsilon_{1t}$ is identified using (iii) (recall the partitioned matrix inversion argument). It is also identified by letting $\Phi$ be the coefficient matrix of the population regression of $Z_t$ onto $u_t$:

$$
\Phi = E(Z_t\eta_t') \Sigma_\eta^{-1} = \alpha H_1'(HH')^{-1} = \alpha H_1' H'^{-1} H^{-1} = \alpha H^1'
$$

because $H^{-1} H_1 = (1 \ 0 \ \ldots \ 0)'$. Thus $\varepsilon_{1t}$ is identified up to scale by

$$
\Phi \eta_t = \alpha H^1' \eta_t = \alpha \varepsilon_{1t}
$$

This projection is the population predicted value in the reduced rank regression of $Z_t$ on $\eta_t$.
Identification using external instruments, ctd.

Comments

1. Nearly all papers that use this approach don’t actually do IV, they report reduced-form regressions of variables of interest onto $Z_t$. In general the reduced form regressions don’t give you the structural coefficients of interest.

2. Multiple instruments per shock result in overidentification

3. For $r = 2$, a single instrument identifies both structural shocks (why?). Thus if each shock has its own instrument, the system is overidentified. (This generalizes to $r > 2$.)
External Instruments: Inference

GMM estimation of $H_1$

Impose the normalization condition $H_{11} = 1$ and let $H_1 = (H_{11} \, H_1.')'$. The moment condition is,

$$E(u_tZ_t') = H_1 \alpha' \quad \text{or} \quad E(\eta_t \otimes Z_t) = \alpha \otimes \begin{pmatrix} 1 \\ H_{1.} \end{pmatrix}$$

This can be estimated by GMM using the sample moments,

$$T^{-1} \sum_{t=1}^{T} (\hat{\eta}_t \otimes Z_t)$$

Specialize to case of a single instrument (exact identification):

$$E \eta_t Z_t = \begin{pmatrix} \alpha \\ \alpha H_{1.} \end{pmatrix}$$

so the GMM estimator is,

$$\hat{H}_{2.} = \frac{T^{-1} \sum_{t=1}^{T} \hat{\eta}_{t.} Z_t}{T^{-1} \sum_{t=1}^{T} \hat{\eta}_{1.} Z_t} \quad \text{where} \quad \eta_t = \begin{pmatrix} \eta_{t1} \\ \eta_{t.} \end{pmatrix}.$$
GMM estimation of $H^1$

The moment condition is,

$$E(Z_t\eta_t')\Sigma_{\eta}^{-1} = \alpha H^1' \quad \text{or} \quad E(Z_t \otimes \Sigma_{\eta}^{-1}\eta_t) = H^1 \otimes \alpha$$

This can be estimated by GMM using the sample moments,

$$T^{-1}\sum_{t=1}^{T}\left(Z_t \otimes \hat{\Sigma}_{\hat{\eta}}^{-1}\hat{\eta}_t\right)$$

**Exact identification:**

$H^1$ is estimated (up to scale) by the regression of $Z_t$ on $\hat{\eta}_t$

**Overidentification/no-HAC.** If these moments have a Kronecker structure (no serial correlation/no heteroskedasticity), the GMM estimator simplifies to reduced rank regression:

$$Z_t = \Phi\hat{\eta}_t + \nu_t$$

Overidentifying restrictions can be tested by testing the reduced rank regression restrictions.
2. What are the shocks? Results I

1. Oil Shocks
   a. Hamilton (2003) net oil price increases
   b. Killian (2008) OPEC supply shortfalls

2. Monetary Policy
   b. Smets-Wouters (2007) monetary policy shock
   c. Sims-Zha (2007) MS-VAR-based shock
   d. Gürkaynak, Sack, and Swanson (2005), FF futures market

3. Productivity
   a. Gali (200x) long-run shock to labor productivity
   b. Smets-Wouters (2007) productivity shock
4. Uncertainty
   a. VIX/Bloom (2009)

5. Liquidity
   a. Spread: Gilchrist-Zakrajšek (2011) excess bond premium
   b. TED Spread
   c. Bassett, Chosak, Driscoll, Zakrajšek (2011) bank lending shock

6. Fiscal Policy
   a. Ramey (2011) spending news
2. What are the shocks? Results I, ctd.

Table 6: Historical importance of shocks

Table 7: Correlation matrix of 18 identified shocks

Table 8: Contributions of shocks to Post-2007 growth
### 2. What are the shocks? Results I, ctd.

**Correlation matrix of identified shocks**

<table>
<thead>
<tr>
<th></th>
<th>O_H</th>
<th>O_K</th>
<th>O_RV</th>
<th>M_RR</th>
<th>M_SW</th>
<th>M_SZ</th>
<th>M_GSS</th>
<th>P_F</th>
<th>P_G</th>
<th>P_SW</th>
<th>U_B</th>
<th>U_BBD</th>
<th>S_GZ</th>
<th>S_TED</th>
<th>B_BCDZ</th>
<th>F_R</th>
<th>F_FP</th>
<th>F_RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>O_H</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O_K</td>
<td>0.42</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O_RV</td>
<td>0.15</td>
<td>0.60</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M_RR</td>
<td>0.37</td>
<td>0.65</td>
<td>0.77</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M_SW</td>
<td>0.09</td>
<td>0.11</td>
<td>0.39</td>
<td>0.09</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M_SZ</td>
<td>0.33</td>
<td>0.35</td>
<td>0.68</td>
<td>0.93</td>
<td>0.16</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M_GSS</td>
<td>0.44</td>
<td>-0.12</td>
<td>-0.08</td>
<td>0.24</td>
<td>0.43</td>
<td>0.39</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_F</td>
<td>-0.64</td>
<td>0.30</td>
<td>0.24</td>
<td>0.20</td>
<td>-0.09</td>
<td>0.06</td>
<td>-0.57</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_G</td>
<td>-0.40</td>
<td>0.34</td>
<td>0.01</td>
<td>-0.30</td>
<td>0.35</td>
<td>-0.53</td>
<td>-0.37</td>
<td>0.52</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_SW</td>
<td>-0.91</td>
<td>-0.03</td>
<td>0.00</td>
<td>-0.24</td>
<td>-0.07</td>
<td>-0.36</td>
<td>-0.59</td>
<td>0.82</td>
<td>0.68</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U_B</td>
<td>-0.37</td>
<td>-0.37</td>
<td>-0.58</td>
<td>-0.39</td>
<td>0.30</td>
<td>-0.29</td>
<td>0.37</td>
<td>0.19</td>
<td>0.34</td>
<td>0.27</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U_BBD</td>
<td>0.10</td>
<td>0.11</td>
<td>-0.37</td>
<td>-0.17</td>
<td>0.45</td>
<td>-0.22</td>
<td>0.57</td>
<td>-0.06</td>
<td>0.45</td>
<td>-0.01</td>
<td>0.78</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L_GZ</td>
<td>-0.20</td>
<td>-0.42</td>
<td>-0.51</td>
<td>-0.41</td>
<td>0.44</td>
<td>-0.24</td>
<td>0.34</td>
<td>0.07</td>
<td>0.24</td>
<td>0.08</td>
<td>0.92</td>
<td>0.66</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L_TED</td>
<td>-0.09</td>
<td>0.01</td>
<td>-0.05</td>
<td>0.03</td>
<td>0.73</td>
<td>0.10</td>
<td>0.48</td>
<td>0.21</td>
<td>0.37</td>
<td>0.09</td>
<td>0.80</td>
<td>0.76</td>
<td>0.84</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L_BCDZ</td>
<td>0.04</td>
<td>0.22</td>
<td>0.79</td>
<td>0.56</td>
<td>0.13</td>
<td>0.55</td>
<td>0.04</td>
<td>-0.09</td>
<td>-0.28</td>
<td>-0.06</td>
<td>-0.69</td>
<td>-0.54</td>
<td>-0.73</td>
<td>-0.40</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_R</td>
<td>-0.17</td>
<td>-0.64</td>
<td>-0.77</td>
<td>-0.84</td>
<td>-0.32</td>
<td>-0.72</td>
<td>-0.34</td>
<td>-0.17</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.26</td>
<td>-0.08</td>
<td>0.40</td>
<td>-0.13</td>
<td>-0.13</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_FP</td>
<td>0.04</td>
<td>-0.21</td>
<td>-0.35</td>
<td>-0.72</td>
<td>0.20</td>
<td>-0.78</td>
<td>-0.03</td>
<td>-0.49</td>
<td>0.40</td>
<td>-0.02</td>
<td>0.03</td>
<td>0.25</td>
<td>0.03</td>
<td>-0.12</td>
<td>-0.12</td>
<td>0.38</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>F_RR</td>
<td>0.20</td>
<td>0.15</td>
<td>0.30</td>
<td>0.77</td>
<td>-0.10</td>
<td>0.88</td>
<td>0.37</td>
<td>0.18</td>
<td>-0.59</td>
<td>-0.28</td>
<td>0.01</td>
<td>-0.10</td>
<td>0.02</td>
<td>0.19</td>
<td>0.19</td>
<td>-0.45</td>
<td>-0.93</td>
<td>1.00</td>
</tr>
</tbody>
</table>
2. What are the shocks? Results II

Contribution to 4-Q GDP growth (1959-2011Q2) of first principal component of two term spread shocks & two uncertainty shocks

a. GDP
Q3. Slow Recoveries, 2007Q4 and otherwise

Compute trend and cycle components of recoveries

3.1 Trend
• As before – approximately 15 year centered MA

3.2 Cycle
• Different recessionary shocks lead to different recoveries

\[ X_t = \Lambda F_t + e_t \]
\[ \Phi(L)F_t = \eta_t \]
State Vector: \( (F_t' F_{t-1}' \ldots F_{t-3}')' \)

• Cyclical component: forecast of employment growth, made using factors at the NBER trough
3.1 Slow Recoveries: Cyclical component, 1961Q1 – 1980Q3

Quarterly employment growth from NBER troughs, predicted & actual
Cyclical component, 1982Q4 – 2009Q2

Quarterly employment growth from NBER troughs, predicted & actual
3.2. Slow Recoveries: Trend component
Table 9
Predicted and actual cumulative growth of output, employment, and productivity in the 8 quarters following a NBER trough

<table>
<thead>
<tr>
<th>Trough date</th>
<th>Source</th>
<th>GDP</th>
<th>Nonfarm Employment</th>
<th>Output per Hour (nonfarm business)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cyclical</td>
<td>1.1</td>
<td>-1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>1961Q1</td>
<td>Trend</td>
<td>7.5</td>
<td>4.9</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8.7</td>
<td>4.0</td>
<td>6.8</td>
</tr>
<tr>
<td>1970Q4</td>
<td>Cyclical</td>
<td>2.4</td>
<td>0.0</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.9</td>
<td>4.7</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9.3</td>
<td>4.6</td>
<td>6.6</td>
</tr>
<tr>
<td>1975Q1</td>
<td>Cyclical</td>
<td>3.3</td>
<td>-1.8</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.6</td>
<td>4.5</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9.9</td>
<td>2.7</td>
<td>9.1</td>
</tr>
<tr>
<td>1980Q3</td>
<td>Cyclical</td>
<td>1.1</td>
<td>-1.5</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.3</td>
<td>4.2</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7.5</td>
<td>2.7</td>
<td>6.4</td>
</tr>
</tbody>
</table>
Predicted and actual growth, ctd.

<table>
<thead>
<tr>
<th>Trough date</th>
<th>Source</th>
<th>GDP</th>
<th>Nonfarm Employment</th>
<th>Output per Hour (nonfarm business)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982Q4</td>
<td>Cyclical</td>
<td>5.0</td>
<td>1.1</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.2</td>
<td>4.1</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11.2</td>
<td>5.2</td>
<td>7.8</td>
</tr>
<tr>
<td>1991Q1</td>
<td>Cyclical</td>
<td>0.8</td>
<td>-1.6</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>5.9</td>
<td>3.3</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6.7</td>
<td>1.6</td>
<td>6.3</td>
</tr>
<tr>
<td>2001Q4</td>
<td>Cyclical</td>
<td>2.9</td>
<td>0.5</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>5.1</td>
<td>2.1</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8.0</td>
<td>2.6</td>
<td>6.9</td>
</tr>
<tr>
<td>2009Q2</td>
<td>Cyclical</td>
<td>2.4</td>
<td>-3.1</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>4.4</td>
<td>1.2</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6.8</td>
<td>-1.9</td>
<td>10.8</td>
</tr>
</tbody>
</table>
## Predicted and actual growth, ctd.

<table>
<thead>
<tr>
<th>Trough date</th>
<th>Source</th>
<th>GDP</th>
<th>Nonfarm Employment</th>
<th>Output per Hour (nonfarm business)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Averages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960-1982</td>
<td>Cyclical</td>
<td>3.0</td>
<td>-0.4</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.8</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9.8</td>
<td>4.1</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>Actual(^a)</td>
<td>11.0</td>
<td>5.9</td>
<td>7.3</td>
</tr>
<tr>
<td>1960-2001</td>
<td>Cyclical</td>
<td>2.6</td>
<td>-0.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>6.4</td>
<td>3.9</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9.0</td>
<td>3.5</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>Actual(^a)</td>
<td>9.2</td>
<td>4.0</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Differences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009Q2 – average, 1960-1982</td>
<td>Cyclical</td>
<td>-0.6</td>
<td>-2.7</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-2.4</td>
<td>-3.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-3.0</td>
<td>-6.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Our interpretation & caveats – Q1

1. The shocks of this recession weren’t new – just bigger versions of things we have seen before.

2. The macro responses to those “old” shocks were the same as they were historically, given the size of the shocks.

Caveat/issue of interpretation:
- Structural break analysis limited by sample size (power)
- There were new shocks (Lehman, TARP, QE) – but it seems that their (net) effect on macro variables was the same as other financial/uncertainty shocks historically
Our interpretation & caveats – Q2

3. Some combination of financial/uncertainty shocks seems to account for most of the recession

Caveat

- The (structural VAR, and maybe DSGE) literature isn’t ready to identify separately independent financial/uncertainty shocks.
Our interpretation & caveats – Q3

4. Slow trend employment growth from demographic shifts underlies slow employment growth from the 2001Q4 and 2009Q2 recoveries.

*Caveat*

- Demographic shifts make trends sound exogenous – but long-term labor supply decisions have endogenous components.