Forecasting with Dynamic Factor Models during and after the Great Recession

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7th EC-OECD Workshop on recent advances in Business and Consumer Surveys – Paris, Nov. 30th - Dec. 1st 2015
Purpose of the paper

- Estimate large-scale DFM
dfor 6 advanced economies (France, Germany, Italy, Japan, the UK and the US).
- Understand where DFM forecast revisions come from at different horizons, distinguishing between:
  - Business Tendency Surveys (both EC surveys and PMIs)
  - Real indicators
  - Financial indicators
  - International environment indicators
  - Revisions induced by the evolution of model parameters over time

- Assess the short-term forecasting performance of large-scale DFM
d(up to 6 months before the GDP release date) during and after the Great Recession (2008-2014).
- Compare it to the forecasting performance of small-scale bridge models.
Estimation of DFMs for 6 advanced economies (1/2)

Structure of Dynamic Factor Models (DFMs):

\[
\begin{align*}
\text{Static part: } & \quad \begin{pmatrix} X_{1t} \\ \vdots \\ X_{nt} \end{pmatrix} = \left( \begin{array}{cccc} \Lambda_{11} & \cdots & \Lambda_{1r} \\ \vdots & \ddots & \vdots \\ \Lambda_{n1} & \cdots & \Lambda_{nr} \end{array} \right) \begin{pmatrix} F_{1t} \\ \vdots \\ F_{rt} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \vdots \\ \varepsilon_{nt} \end{pmatrix} \\
\text{Dynamic part (state equation): } & \quad \begin{pmatrix} F_{1t} \\ \vdots \\ F_{rt} \end{pmatrix} = A(L) \begin{pmatrix} F_{1t} \\ \vdots \\ F_{rt} \end{pmatrix} + \begin{pmatrix} \eta_{1t} \\ \vdots \\ \eta_{rt} \end{pmatrix}
\end{align*}
\]

Given model parameters, \( E \left[ \begin{pmatrix} F_{1t} \\ \vdots \\ F_{rt} \end{pmatrix} | \begin{pmatrix} X_{1t} & \cdots & X_{11} \\ \vdots & \ddots & \vdots \\ X_{nt} & \cdots & X_{n1} \end{pmatrix} \right] \) can be inferred (Kalman smoother).

Quarterly bridge equation: \( Y_t^Q = \alpha + \sum_{i=1}^{r} \beta_i \tilde{F}_{it}^Q + \omega_t \)

GDP growth rate

Monthly indicators: Typically between 75 and 125, not all available at the same time (ragged-edge data)
Estimation of DFMss for 6 advanced economies (2/2)

4 model characteristics are chosen to minimize average RMSFEs before the Great Recession (2003Q1-2007Q4) and fixed thereafter:

- number of monthly indicators
- number of factors
- estimation strategy (PCA or QML allowing for missing data points)
- number of GDP lags (0 or 1) in the quarterly bridge equation

Main conclusions:

- Targeting predictors (i.e. excluding indicators that are only very weakly correlated with GDP) always helps.
- QML estimation quasi always helps (5 out of 6 countries).
- Including one lag of GDP in the equation bridging GDP with factors helps for some countries (Germany and the UK).

Model parameters are re-estimated each month, when new indicators become available, for the forecasting exercise over 2008Q1-2014Q4.
### Chronology of Forecasts

<table>
<thead>
<tr>
<th>Country</th>
<th>Quarter (Q-1)</th>
<th>Quarter Q</th>
<th>Quarter (Q+1)</th>
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<td></td>
<td>m1 m2 m3</td>
<td>m1 m2 m3</td>
<td>m1 m2 m3</td>
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<tr>
<td>Forecast at</td>
<td>m-6 m-5</td>
<td>m-4 m-3</td>
<td>m-2 m-1 m-0</td>
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<tr>
<td>France</td>
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<tr>
<td>Germany</td>
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<td></td>
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<tr>
<td>Italy</td>
<td></td>
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<td></td>
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<tr>
<td>Japan</td>
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<table>
<thead>
<tr>
<th>Country</th>
<th>Quarter (Q-1)</th>
<th>Quarter Q</th>
<th>Quarter (Q+1)</th>
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<tr>
<td>Forecast at</td>
<td>m-6 m-5</td>
<td>m-4 m-3</td>
<td>m-2 m-1 m-0</td>
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</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
News are defined as the unexpected component of the monthly information flow arriving at each date:

$$I_t \equiv \left( \begin{array}{c} X_{1,t-lag(1)} - E[X_{1,t-lag(1)}|\Omega_{t-1}] \\ \vdots \\ X_{n,t-lag(n)} - E[X_{n,t-lag(n)}|\Omega_{t-1}] \end{array} \right)$$

with $\Omega_{t-1}$: quasi real time dataset at date (t-1)

lag(i): delay with which indicator i is available (e.g.: 2 months for industrial production, 0 month for tendency surveys).

Smoothed factors are updated with this information flow:

- $E[F_\tau|\Omega_t] = E[F_\tau|\Omega_{t-1}] + E[F_\tau|I_t]$
- $E[F_\tau|I_t] = \frac{E[F_\tau I_t'] \cdot E[I_t I_t']^{-1}}{I_t}$ can be computed based on model parameters

In the end, GDP forecast updates only depend on $E[F_\tau|I_t]$. 

Understanding where DFM forecast revisions come from (1/3)
Understanding where DFM forecast revisions come from (2/3)

Contributions to forecast revisions at different horizons (2008Q1-2014Q4)
Main conclusions:
- Real indicators mainly influence quarter Q forecasts when they become available for this quarter, i.e. in the few months before the GDP release date.
- Surveys (BTS / CS) may induce forecast revisions at all horizons, not only at longer horizons when real indicators are still unavailable.
- Revisions induced by the evolution of parameters over time can be very significant during the Great Recession, making it difficult to explain forecast revisions to economic policy makers.
Bridge models as a benchmark

- In the econometric literature, DFM forecasts are usually compared to very simple constant-growth or AR forecasts.

- Bridge models, in spite of their relevance for professional forecasters, are rarely used as a benchmark.

  A few exceptions: Barhoumi et al. (2008) but the forecasting performance of both model classes is compared before the Great Recession; Girardi et al. (2014) but benchmark bridge models only include real indicators.

- Bridge models estimated here may include industrial production, retail sales, private consumption, consumer confidence and business confidence / purchasing managers’ indices.

  VAR models are used to forecast monthly indicators when they are not available in real time.

  Note that indicators reflecting idiosyncrasies of the 2008-09 crisis were deliberately excluded to ensure that results are not biased against DFM.
DFMs and bridge models during and after the Great Recession (2008-2014)

Ratio of RMSFEs between DFMs and bridge models:

<table>
<thead>
<tr>
<th>Country</th>
<th>M-0</th>
<th>M-1</th>
<th>M-2</th>
<th>M-3</th>
<th>M-4</th>
<th>M-5</th>
<th>M-6</th>
<th>Average</th>
</tr>
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<tbody>
<tr>
<td>United States</td>
<td>1.01</td>
<td>0.98</td>
<td>1.02</td>
<td>0.98</td>
<td>0.97</td>
<td>0.91</td>
<td>1.01</td>
<td>0.98</td>
</tr>
<tr>
<td>Germany</td>
<td>1.85</td>
<td>1.47</td>
<td>1.18</td>
<td>1.12</td>
<td>1.08</td>
<td>0.98</td>
<td>0.87</td>
<td>1.14</td>
</tr>
<tr>
<td>France</td>
<td>1.05</td>
<td>0.86</td>
<td>0.80</td>
<td>0.81</td>
<td>0.83</td>
<td>0.89</td>
<td>0.93</td>
<td>0.87</td>
</tr>
<tr>
<td>Italy</td>
<td>0.89</td>
<td>0.93</td>
<td>0.99</td>
<td>0.92</td>
<td>0.95</td>
<td>0.92</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.04</td>
<td>1.07</td>
<td>0.98</td>
<td>0.89</td>
<td>0.93</td>
<td>1.02</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Japan</td>
<td>1.06</td>
<td>0.96</td>
<td>0.94</td>
<td>0.75</td>
<td>0.77</td>
<td>0.89</td>
<td>0.97</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Conclusion: Large information sets, even if carefully selected and exploited with state-of-the-art DFMs, would not have systematically improved the forecasting performance during and after the Great Recession, compared to realistic small-scale bridge models.

In other words, considering a large number of monthly indicators rather than a few would not have eliminated the historical forecast failure at the time of the Great Recession, even in the short term.