Directional Forecasts of GDP and Inflation: A Joint Evaluation With an Application to Federal Reserve Predictions

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Motivation

“...directional forecasting...is now an increasingly popular metric for forecasting performance...”

- Directional forecasts matter for both private and public policymakers.
- In particular, the Federal Reserve monetary policy stance is often characterized as either expansionary (loose) or restrictive (tight).
Motivation 2

- Almost always forecasts for inflation and real GDP growth are made simultaneously by the same economists and are presented together.
- Previous studies, however, have analyzed the directional forecasts of real GDP growth and inflation separately.
- We instead propose to evaluate them jointly.
Outline of the Talk

- Methodology for Evaluating Directional Forecasts
  - The 2x2 contingency table
  - Joint evaluation: the 4x4 contingency table
  - Test Statistics
- Application:
  Are the Fed’s Forecasts Jointly Valuable?
  - Data
  - Results
- Conclusions and Implications
- Extensions
Evaluating Directional Forecasts

- We define forecasts as “valuable” if they perform better than the naïve no-change prediction.
  - For joint evaluation, we focus on rejecting predictive failure.
- For our application, we will evaluate the performance of directional forecasts of the change in real GDP and the change in inflation.
  - Whether real GDP growth (the change in GDP) was positive or negative.
  - Whether inflation increased or decreased (whether the change in inflation was positive or negative).
  - Examining the direction of change provides sufficient positive and negative observations for analysis.
The 2x2 Contingency Table

- Consider evaluating GDP growth by itself.
- GDP growth can be either positive or negative (group no-change with negative).
- The forecaster has two possible forecasts: positive or negative.
- The actual outcome has two possibilities: positive or negative.
- This leads to a 2x2 contingency table.
The 2x2 Contingency Table

<table>
<thead>
<tr>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0</td>
<td>≤ 0</td>
</tr>
<tr>
<td>n1</td>
<td>N2-n2</td>
</tr>
<tr>
<td>N1-n1</td>
<td>n2</td>
</tr>
<tr>
<td>N1</td>
<td>N2</td>
</tr>
</tbody>
</table>

N: Total Observations  
n: Total Predicted Positive  
N1: Total Actual Positive  
N2: Total Actual Negative (or zero)  
n1: Total Positive for both Predicted and Actual  
n2: Total Negative (or zero) for both Predicted and Actual
Example: Real GDP Growth

<table>
<thead>
<tr>
<th>Predicted Outcome</th>
<th>Real GDP Growth &gt; 0</th>
<th>Real GDP Growth ≤ 0</th>
<th>Actual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real GDP Growth &gt; 0</td>
<td>113</td>
<td>6</td>
<td>119</td>
</tr>
<tr>
<td>Real GDP Growth ≤ 0</td>
<td>5</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>118</td>
<td>21</td>
<td>139</td>
</tr>
</tbody>
</table>

Table 2a: The 2x2 Contingency Table for Real GDP Growth for the Zero Month Lead
The 4x4 Contingency Table

- Now consider jointly evaluating forecasts of GDP growth and the change in inflation.
- The forecaster and the actuals now each have four possibilities:
  1) GDP growth positive, inflation increasing
  2) GDP growth positive, inflation decreasing
  3) GDP growth negative, inflation increasing
  4) GDP growth negative, inflation decreasing
- This leads to a 4x4 contingency table.
- The 4x4 contingency table has not previously been used in the literature for forecast evaluation.
## The 4x4 Contingency Table

### Table 1a: The Relationship between Predicted and Actual Outcomes

<table>
<thead>
<tr>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP &gt; 0, Δinf &gt; 0</td>
<td>n1</td>
</tr>
<tr>
<td>GDP &gt; 0, Δinf ≤ 0</td>
<td>n2,1</td>
</tr>
<tr>
<td>GDP ≤ 0, Δinf &gt; 0</td>
<td>n3,1</td>
</tr>
<tr>
<td>GDP ≤ 0, Δinf ≤ 0</td>
<td>n4,1</td>
</tr>
<tr>
<td>N1</td>
<td>N</td>
</tr>
</tbody>
</table>

N: Total Observations
N1 thru N4: Column Totals
n1,0 thru n4,0: Row Totals
n1 thru n4: Predicted matches Actual
### Example: 4x4 Contingency Table

#### Table A1: The 4x4 Contingency Table for the Zero Month Lead

<table>
<thead>
<tr>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
<th>(\Delta) GDP &gt; 0, (\Delta) inf &gt; 0</th>
<th>(\Delta) GDP &gt; 0, (\Delta) inf (\leq) 0</th>
<th>(\Delta) GDP (\leq) 0, (\Delta) inf &gt; 0</th>
<th>(\Delta) GDP (\leq) 0, (\Delta) inf (\leq) 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta) GDP &gt; 0, (\Delta) inf &gt; 0</td>
<td></td>
<td>49</td>
<td>13</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(\Delta) GDP &gt; 0, (\Delta) inf (\leq) 0</td>
<td></td>
<td>7</td>
<td>43</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>(\Delta) GDP (\leq) 0, (\Delta) inf &gt; 0</td>
<td></td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>(\Delta) GDP (\leq) 0, (\Delta) inf (\leq) 0</td>
<td></td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
Test Statistics

- The statistical methodology tests whether or not the forecasts predict the associated directions of change.
- For the 2x2 case, the hypothesis of predictive failure is equivalent to the hypothesis of independence.
- For the 4x4 case, independence implies predictive failure, but not vice-versa.
Three Test Statistics

- Two test statistics focus on independence:
  - Chi-square test.
  - Fisher’s exact test.

- The third test statistic focuses on predictive failure:
  - Pesaran and Timmermann (1992)
Chi-Square Test

- The Chi-square test is the most common method used in evaluating contingency tables.
- Drawbacks:
  - Chi-square distribution is a continuous distribution while the test statistic is calculated using discrete categories.
    - Use the Yates’ Continuity Correction for 2x2.
  - The test may be too conservative in the sense that independence may not be rejected often enough (Wickens, 1989).
  - Requires expected frequencies in the cells to not be too small for standard distribution of the test statistic (a problem for the off-diagonals, particularly in the 4x4 case).
Fisher’s Exact Test

- Fisher’s Exact Test avoids the problem of small expected frequencies.
- This method uses the hypergeometric distribution to directly calculate the probability of independence.
Pesaran and Timmermann’s Test

- Pesaran and Timmermann (1992) propose a more appropriate test statistic for our joint forecast evaluation.
  - Tests predictive failure instead of independence.
  - Does not require that the two forecasts be independent of each other.
Application: Are the Fed’s Forecasts Jointly Valuable?

- Evaluating the Fed’s directional forecasts of GDP growth and inflation changes.

- Joint evaluation: the two forecasts often come from the same forecasting model.

- Only inflation and GDP: they are the only two included in the Taylor Rule.
Forecast Data

- Greenbook forecasts of inflation (based on GDP deflator) and real GDP growth
- 1262 observations from the first quarter of 1966 through the 4th quarter of 1997.
  - Multiple observations per quarter depending on the number of FOMC meetings that quarter.
    - The FOMC met more frequently per quarter in the 1960s and 1970s than later in the sample.
- We only examine forecasts for the current quarter and 1 quarter ahead.
  - Focus on short horizons to avoid the effect of any changes in monetary policy.
# Leads

<table>
<thead>
<tr>
<th>Forecast Date</th>
<th>Current Quarter Forecast Lead</th>
<th>One-Quarter-Ahead Forecast Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>First month of quarter</td>
<td>Two month lead</td>
<td>Five month lead</td>
</tr>
<tr>
<td>Second month of quarter</td>
<td>One month lead</td>
<td>Four month lead</td>
</tr>
<tr>
<td>Third month of quarter</td>
<td>Zero month lead</td>
<td>Three month lead</td>
</tr>
</tbody>
</table>
Actual Outcome Data

- Assume the objective is to forecast data released 45-60 days after the end of the quarter.
  - Avoids definitional and classification changes.
  - Terminology for these data releases varied over the sample:
    - Before 1974, the “final” data: 45 days after the end of the quarter.
    - Starting in 1974, “1st revision” (second revision about 75 days out).
    - Since 1988, the “preliminary” data are released approximately two months after the quarter.
## 2x2 Results

### Table 3: Probability of Null Hypothesis, GDP Growth and ΔInflation Separately

<table>
<thead>
<tr>
<th>Lead</th>
<th>Real GDP growth</th>
<th>Δ Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yates Chi-Square</td>
<td>Fisher Exact</td>
</tr>
<tr>
<td>0</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4</td>
<td>0.021</td>
<td>0.017</td>
</tr>
<tr>
<td>5</td>
<td>&lt;0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Comparison with Joutz-Stekler (2000)

- Real GDP Growth
  - Joutz and Stekler found forecasts were valuable at all six lead times.
  - We found all except one: the Pesaran Timmermann statistic did not reject for lead 4.

- Inflation Changes
  - Joutz and Stekler found that only current quarter forecasts were valuable (leads 0 thru 2).
  - We found that lead 3 was also valuable, but not 4 or 5.
# 4x4 Results

Table 4: Probabilities for 4x4 Contingency Table

<table>
<thead>
<tr>
<th>Lead</th>
<th>Chi-Square</th>
<th>Fisher Exact</th>
<th>Pesaran-Timmermann</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>1</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>2</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>3</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>4</td>
<td>0.01</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>5</td>
<td>0.001</td>
<td>&lt; 0.001</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Interpreting 4x4 Results

- Only one exception where the forecasts were not jointly valuable.

- Inflation forecasts by themselves are not always valuable (particularly at longer leads).

- But, the joint pattern of GDP and inflation direction of change forecasts was generally in accord with the economy’s actual performance.
Conclusions and Implications

- We developed a simple method for joint evaluations of directional forecasts.
- It appears that forecasts by the Fed of GDP and inflation are in general informative about the true state of the economy.
- A caveat: The method gives equal weight to forecasts made at any point in time.
  - Forecasts may be more difficult around turning points.
Extensions

- New work underway by Sinclair, Stekler, and Reid: A procedure for jointly evaluating quantitative predictions.
- We also need procedures for testing for joint rationality.
  - Hanson and Whitehorn (2006)
  - Work underway by Sinclair and Stekler.
  - Also work underway by Ivana Komunjer (UCSD) and Michael Owyang (STL Fed).