Predicting Restaurant Recessions

- Timothy Park, Howard Elitzak, and Abby Okrent
- Economic Research Service, USDA
- FCSM 2018 Research and Policy Conference

The views expressed are those of the author(s) and should not be attributed to the Economic Research Service or USDA.
Plan for Presentation

• **Research Issue:**
  Need for accurate predictions of restaurant recessions
  Current focus: an array of economic and financial variables
  Changes in Gross Domestic Product
  Short and long-term interest rates

• **Econometric approach**
  Forecasts from a probit model

• **Evaluating predictive performance from competing models**
  – Receiver Operating Curve
  – Statistical measures for this measure
  – Comparing model performance and identifying better models

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The USDA Food Expenditures Series

FES: more comprehensive than other data series!

- FES: accounts for sales to ALL U.S. food purchasers—
  Households == Government == Business

- FES: more accurate as it excludes non food items sold by U.S. retailers:
  Drugs == Branded supplies == Pet food == Ice

- Alternatives series
  Personal consumption expenditures (BEA)
  Consumer Expenditure Series (BLS)
  These series only cover sales to U.S. *households.*
The USDA Food Expenditures Series

Data Sources

Census:
- Annual and Monthly Retail Trade Survey = Quarterly Services Survey
- Annual Survey of Manufacturers = Census of Population
- Census of Agriculture

Other sources:
- Amtrak Annual Report = SIPP = USDA/FNS = IRI
- NCES = SAS = OJJDP = CPI/PPI
- CACFP = AHA = Department of Defense

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Applications of the Data

FAFH Now Higher than FAH

Share of total food expenditures, by final purchasers

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Based on monthly food sales data from the Census Bureau, excluding food revenues at schools and colleges, the value of FAFH furnished to employees or part of a secondary activity, and donations and government assistance.
Restaurant Performance Indexes

Same-store sales compares same-store sales volume in the reference month versus the same month in the previous year.
Customer traffic compares customer traffic in the reference month versus the same month in the previous year.
Predicting recessions with restaurant sales

Validity of using restaurant sales
Mentioned as a leading indicator of business cycles

• Little empirical research in this area
  Food industry analysts often discuss “food recessions”

• Binary probit model: assess factors influencing restaurant sales
  Restaurant sales are food away from home $= \text{FAFH}$
  Grocery sales are food at home $= \text{FAH}$

• Incorporate data from the Food Expenditure Series
  Economic Research Service, USDA
Restaurant sales and the macroeconomy?

- **Restaurant analysts assert a close relationship exists**
  - Restaurant sales performance in 2016 was similar to the second half of 2000 and the first half of 2007
  - Periods which immediately preceded the last two recessions
  - In the first half of 2007, month-to-month sales dropped three times
  - In the second half of 2016, month-to-month sales dropped three times
  - Restaurant sales declined in January, 2017

The restaurant recession has arrived

By Tonya Garcia and Ciara Linnane
Published: Nov 8, 2016 3:16 p.m. ET

Moody’s slashes its profit growth outlook as consumers struggle to pay bills and restaurants grapple with weak traffic

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# Data for Predicting Recessions

- **Monthly data from January 1997 – August 2017**
- **Dependent Variable** = FAFH Recession Indicator
- **Independent Variables** =
  - Spread: Difference: 10-year and 3-month Treasury yields
  - \( \text{Spread}_{t-6} \): Spread lagged 6 months
  - gdpPCH: % Change in GDP
  - FAH: Food at Home expenditures
  - \( \text{FAH}_{t-6} \): Food at Home lagged 6 months

- **Model 1**
  - gdpPCH, Spread, \( \text{Spread}_{t-6} \)

- **Model 2**
  - gdpPCH, Spread, \( \text{Spread}_{t-6} \), **PLUS** FAH

- Probit models

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Features of the Sample

- Time period: 1997 to 2017
- Quarterly declines in GDP = 29% of the time
- Quarterly declines in FAFH = 50% of the time

- **FAFH and GDP declines**
  - Probability of FAFH decline | Given drop in GDP: 58%
  - Probability of GDP decline | Given drop in FAFH: 33%

- **Size of drop in FAFH**
  - Percent decline in FAFH | Given drop in FAFH: 4.5%
  - Percent decline in FAFH | Given drop in GDP: 0.14%
Out of Sample Predictive Performance

- Estimate each probit model
  January 1997 – December 1999
- Predict recession probability
  January 2000 – August 2017
- Predictions for 1-month ahead, 6-months ahead
  Update sample and re-estimate probit model each period
- Evaluation based on Receiver Operating Characteristics Curve
  ROC Curve
  AUROC = Area under ROC
  = Summary measure of performance
# Measuring Predictive Accuracy

**True Positive Rate** = \( \frac{TP}{TP + FN} \)

**False Positive Rate** = \( \frac{FP}{FP + TN} \)

<table>
<thead>
<tr>
<th>PREDICTED</th>
<th>OBSERVED</th>
<th>OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recession</td>
<td>TP</td>
<td>FP</td>
</tr>
<tr>
<td>Expansion</td>
<td>FN</td>
<td>TN</td>
</tr>
</tbody>
</table>

*OBSERVED OUTCOMES

Recession Expansion

**OUTCOME

- TP: True Positive
- FP: False Positive
- FN: False Negative
- TN: True Negative

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Multidimensional Performance Assessment

Receiver operator characteristic (ROC) curve

- Predicting true recession events
  - Recession occurred
  - Correctly predicted a recession
- Predicting false recession events
  - Recession did not occur
  - Incorrectly predicted a recession
- Combine in a summary statistic

Graph combining FPR & TPR (in % terms)

- \(( FPR, TPR )\) \(( FPR, TPR )\)
- \(( 0, 1.00 )\) \(( 0.76, 0.76 )\)

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### Predicting Recessions with the ROC Methodology

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_t$</td>
<td>true state of economy (1 if FAFH recession, 0, otherwise)</td>
</tr>
<tr>
<td>$P_t$</td>
<td>probability of FAFH recession from probit model</td>
</tr>
<tr>
<td>$C^*$</td>
<td>thresholds for defining a recession, [0.0.05, ......, 0.95, 1 ]</td>
</tr>
</tbody>
</table>

Given a threshold $C^*$, we define the predicted outcome:

- $Z_t = 1$, if $P_t \geq C^*$
- $Z_t = 0$, if $P_t < C^*$

- Compare true $Z_t$ with predicted $Z_{\hat{t}}$
  - Calculate true positive rate
  - Calculate the false positive rate

- For each $C^*$, plot $(FPR_i, TPR_i)$
  - Plot the coordinates for each threshold
    - $FPR_i$ on X axis
    - $TPR_i$ on Y-axis
  - Connect the coordinates == the **ROC** curve

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GDP Model == 1-month ahead Forecasts

Area under ROC curve = 0.7368

GDP Model = Spread, Spread_{t-6}, gdpPCH

AUROC = 0.737

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ROC: Measure of Predictive Performance

- Two models A and B
  \[
  \text{ROC}_A(r) > \text{ROC}_B(r) \implies \text{Model A stochastically dominates Model B}
  \]

- \(\text{AUROC}_A > \text{AUROC}_B \neq > \text{ROC}_A(r) > \text{ROC}_B(r)\)

- \(\text{AUROC} \in [0.5, 1.0]\) is bounded between 0.5 ... 1.0

- Other Notes:
  - Simple non-parametric estimates of AUROC are available
  - AUROC is asymptotically normal
# Summary of Results

- **FAH Model**  
  Spread, Spread\(_{t-6}\)  
  gdpPCH  
  FAH

- **GDP**  
  Spread, Spread\(_{t-6}\)  
  gdpPCH

### 1-month ahead forecasts

- **GDP Model**  
  AUROC = 0.737

- **FAH Model**  
  AUROC = **0.778**

### 6-month ahead forecasts

- **GDP Model**  
  AUROC = 0.577

- **FAH Model**  
  AUROC = 0.535

- **Predictive ability DECLINES** as forecast horizon **INCREASES**

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GDP Model == 1-month ahead forecasts

GDP Model = \textit{Spread, Spread}_{t-6}, \textit{gdpPCH}

\textbf{AUROC = 0.737}

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GDP Model == 6-month ahead Forecasts

GDP Model = Spread, Spread_{t-6}, gdpPCH

AUROC = 0.577
Comparing Models: 1-month forecasts

AUROC
GDP Model = 0.737

AUROC
FAH Model = 0.778

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Comparing Models: 6-month forecasts

FAH Model = Spread, Spread_{t-6}, gdpPCH, FAH

AUROC
GDP Model = 0.577

AUROC
FAH Model = 0.53
Assessment of Results

• Does the FAH model outperform the GDP Model?
  AUROC for FAH is **HIGHER** than AUROC for GDP Model
  Differences in areas are statistically significant
  Distributed as a $\chi^2$ statistic with 1 degree of freedom

  True for both the 1-month and 6-month forecasts

• Assessing improvement in forecasting – is the information useful?
  – Adding FAH variables
    • AUROC increases by 15%
  – Add macro variables to the GDP Model
    • AUROC increases by 6% when including Unemployment Insurance UI variable
    • Findings by Liu and Moench

• Economic implications
Comparing Forecasts: 1-month, 6-month forecasts

FAH Model = Spread, Spread_{t-6}, gdpPCH, FAH
Conclusions and Future Work

• ROC curve for multidimensional performance
  – Allows comparison across estimated models
    Models with different explanatory variables
    Models estimated over different populations or time periods
  – Move beyond a binary indicator [recession, expansion]

• Other criteria in evaluating model performance
  – Predicting recessions
    • and MINIMIZE predictions of false recessions
    • Stekler and Ye propose a precision – recall curve (PR)

• Missing: economic model of predictive performance

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• References to papers available
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FAH Model == 1-month ahead forecasts

FAH Model = Spread, Spread_{t-6}, gdpPCH, FAH

AUROC = 0.594
FAH Model == 6-month ahead forecasts

FAH Model = Spread, Spread_{t-6}, gdpPCH, FAH

AUROC = 0.629