Forecasting in Economics

Barbara Rossi

ICREA-Univ. Pompeu Fabra, Barcelona GSE, CREI
Why Forecasting?

- Why forecasting?
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You do forecasting every day... Can you think of examples?
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- You forecast the weather to decide how to dress before getting out of your house...
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- Investors forecast exchange rates to decide in which country to invest their money...
- Central Banks forecast inflation and output growth in order to decide monetary policy...
Forecasting: how?

- How to forecast?
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- How to forecast?
- Forecasting is difficult ...
Forecasting: how?

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- Forecasting is difficult ...

- We want better methods than flipping a coin...
Plan

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- Forecasting specific economic variables:
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Which models do we use?

Forecasting specific economic variables:
  - Output
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- Forecasting in practice: the European Central Bank
An important quantity we care about in economics is Gross Domestic Product (GDP) (think about it as a measure of the goods and services we produce). Here is a picture...
By the way, a great place to get data is the Federal Reserve Bank of St Louis Database:
Data Transformations

Typically, economists take logs of quantities they are interested in (useful for various reasons... e.g. calculating rate of growth... more later...) Here is how it looks like:

\[ y(t) \equiv y_t = \ln(GDP(t)) \]
What kind of model could I use to predict lnGDP in 2014? Suggestions?
What kind of model could I use to predict lnGDP in 2014? Suggestions?

I could fit a line... e.g. \( y(t) = k + a \cdot t \)... This is called a "deterministic trend"
Problems...

- Trend is the very long-run behavior... and would not work well around 2001-2002...
Why It Does Not Work Well?

- Is there a better way?
Why It Does Not Work Well?

- Is there a better way?
- Let’s calculate the rate of growth as:

\[
\text{GDP}(t) - \text{GDP}(t-1) = \frac{\ln(\text{GDP}(t)) - \ln(\text{GDP}(t-1))}{t - (t-1)}
\]

(this formula can be proved by approximating \(\ln(1+x)\) for small \(x\)...

Let \(y(t) = \ln(\text{GDP}(t))\) and the rate of growth be denoted by \(\Delta y(t)\).

What would be the rate of growth for the deterministic trend model \(y(t) = k + at\)?

It’s a! That is, rate of growth is constant...
Why It Does Not Work Well?

- Is there a better way?
- Let’s calculate the rate of growth as:
  \[
  \frac{GDP(t) - GDP(t-1)}{GDP(t-1)} \approx \ln(GDP(t)) - \ln(GDP(t-1))
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  \]
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The Rate of Growth of GDP

- Here is the rate of growth of GDP... Is it constant?
The AR model

- What else could we do?
What else could we do?

\[ \Delta y(t) = a + b \cdot \Delta y(t - 1) + error(t) \]
The AR model

- What else could we do?
- \( \Delta y(t) = a + b \cdot \Delta y(t-1) + \text{error}(t) \)
- Autoregressive Model, or AR(1)
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Autoregressive Model, or AR(1)

Here are the forecasts of \( y(t) \) made at time \( (t-1) \) plotted against the realized \( y(t) \)
What else could we do?

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Autoregressive Model, or AR(1)

Here are the forecasts of \( y(t) \) made at time \( (t-1) \) plotted against the realized \( y(t) \)

(Red line = \( \Delta y(t) = \)data; black dotted line = forecast = \( \Delta y(t|t-1) \))
The AR model

US Output Growth -- Forecasts at Horizon 1

Percent

1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2


Time

Actual Data
VAR forecast
DSGE forecast
AR forecast
How Were These Forecasts Constructed?

\[ (y_1, x_0) \quad (y_2, x_1) \quad (y_R, x_{R-1}) \]

\[ e_{R+1} = y_{R+1} - b_R x_R \]

\[ 1 \quad 2 \quad \ldots \quad R \quad R+1 \]

\[ (y_1, x_0) \quad (y_2, x_1) \quad (y_3, x_2) \quad \ldots \quad (y_{R+1}, x_R) \]

\[ e_{R+2} = y_{R+2} - b_{R+1} x_{R+1} \]

\[ 1 \quad 2 \quad 3 \quad \ldots \quad R+1 \quad R+2 \]

\[ \ldots \]

\[ e_{T+1} = y_{T+1} - b_T x_T \]

\[ (y_1, x_0) \quad (y_2, x_1) \quad (y_3, x_2) \quad (y_{T-1}, x_{T-2}) \quad (y_T, x_{T-1}) \]

\[ 1 \quad 2 \quad 3 \quad \ldots \quad T-1 \quad T \quad T+1 \]
What else could we do?
What else could we do?

Use other variables... For example, economic theory says that there is a relationship between output growth ($\Delta y(t)$), inflation ($\pi(t)$) and the interest rate ($r(t)$). They are all jointly determined in equilibrium...

\[ \Delta y(t) = a + b \Delta y(t-1) + c \pi(t-1) + d r(t-1) + \text{error}(t) \] (this is one equation of a model called VAR...)
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(this is one equation of a model called VAR...)

You could try other models... For example, DSGE is a complicated economic model...
How Good Are These Forecasts?

- How good are these forecasts?

Forecast error:

\[ e_{t+1} = \Delta y_{t+1} + \Delta y_{t} \]

Root Mean Squared Forecast Error (RMSFE):

\[ \text{RMSFE} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (e_{t+1})^2} \]
How Good Are These Forecasts?

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- How would you decide which of these forecasts is best?

Forecast error:
\[ e_t = \Delta y_t + 1 \]

RMSFE:
\[ \text{RMSFE} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} e_t^2} = \sqrt{\Delta y_t^2 + 1} \]
How Good Are These Forecasts?

- How good are these forecasts?
- How would you decide which of these forecasts is best?
- Forecast error $e_{t+1|t} = \Delta y_{t+1} - \Delta y_{t+1|t}$
How Good Are These Forecasts?

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- Forecast error: $e_{t+1|t} = \Delta y_{t+1} - \Delta y_{t+1|t}$
- RMSFE: $\frac{1}{T} \sum_{t=1}^{T} \left( \Delta y_{t+1} - \Delta y_{t+1|t} \right)^2$
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- Forecast error: \( e_{t+1|t} = \Delta y_{t+1} - \Delta y_{t+1|t} \)
- RMSFE: \( \frac{1}{T} \sum_{t=1}^{T} (\Delta y_{t+1} - \Delta y_{t+1|t})^2 \)

<table>
<thead>
<tr>
<th>Output</th>
<th>RMSFE</th>
<th>DM: Model-DSGE</th>
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<tbody>
<tr>
<td></td>
<td>DSGE</td>
<td>VAR</td>
</tr>
<tr>
<td>1</td>
<td>0.54</td>
<td>1.09</td>
</tr>
<tr>
<td>2</td>
<td>0.46</td>
<td>1.31</td>
</tr>
<tr>
<td>3</td>
<td>0.46</td>
<td>1.41</td>
</tr>
<tr>
<td>4</td>
<td>0.46</td>
<td>1.46</td>
</tr>
<tr>
<td>5</td>
<td>0.48</td>
<td>1.24</td>
</tr>
<tr>
<td>6</td>
<td>0.48</td>
<td>1.39</td>
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How About Inflation?

- Another variable that is of interest to forecast is inflation:
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[Note: this work is taken from Gurkaynak, Kisacikoglu and Rossi (2013), Do DSGE Models Forecast More Accurately Out-of-Sample than Reduced-Form Models?]
Another variable that is important to forecast is exchange rates...

The best model is:

\[ s(t) = s(t-1) + \text{error}(t) \]

called the RANDOM WALK...

This says that changes in exchange rates, \( s(t) \), are completely unpredictable.

So what is the best forecast of the exchange rate tomorrow? The best forecast of exchange rates tomorrow is the exchange rate today.
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An interesting finding in the literature is that exchange rates \( s(t) \) (in logs) are very difficult to forecast...

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There is no shortage of predictors used in the literature: prices, interest rates, output, money supply, trade balance, net foreign asset positions, commodity prices, etc.
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There is no shortage of predictors used in the literature: prices, interest rates, output, money supply, trade balance, net foreign asset positions, commodity prices, etc.

Are any of these predictors capable of forecasting future exchange rates better than simply using the exchange rate value today, which is what the random walk would predict?
Second, one has to choose a model.
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Again, there is no shortage of models used in the literature: linear, non-linear, non-parametric, panel, factor, forecast combinations, Bayesian model averaging, etc.
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Example: (agnostic) forecast combination: try all the predictors you have, say \( n \), one-at-a-time, and get a bunch of forecasts: 

\[ \Delta y_{t+1|t} (x_i, t) \]; then your (equal weight) forecast combination is: 

\[ \frac{1}{n} \sum_{i=1}^{n} \Delta y_{t+1|t} (x_i, t) \]
Third, one has to specify the data to use for forecasting.
Third, one has to specify the data to use for forecasting.

For example, should one use forecasts based on revised or real-time data. Should they be filtered, de-trended or raw? Which frequency and countries should be considered and at what forecast horizon?
Finally, there is the issue of criteria for forecast evaluation.
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Should one use mean squared forecast error, mean absolute errors, utility-based or direction of prediction measures? Should the focus be on in-sample or out-of-sample tests? What about measures of relative or absolute forecasting performance, etc?
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Example: \[ \text{RMSFE} = \frac{1}{T} \sum_{t=1}^{T} (\Delta y(t) - \Delta y(t|t-1))^2 \] versus \[ \text{RMAFE} = \frac{1}{T} \sum_{t=1}^{T} |\Delta y(t) - \Delta y(t|t-1)| \] versus asymmetric losses...
Which Predictors Work in Forecasting Exchange Rates?
How Precise Are GDP Forecasts?

- There is uncertainty around the forecasts we make.
How Precise Are GDP Forecasts?

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- How "confident" are we about the possibility that the forecast will realize itself?
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- How "confident" are we about the possibility that the forecast will realize itself?
- Ideally, we would like forecasts that are very precise...
How Precise Are GDP Forecasts?

- An example of a useless forecast

"The long-range forecast includes rain, sunshine, fog, snow, mild spells and high winds - now prove that wrong!"
Forecasts and Confidence Bands

Figure 3. One Quarter-ahead Forecasts of Annualized U.S. Real GDP Growth, Their Uncertainty and Actual Realizations
Two examples:
Two examples:

1. Forecasts at the European Central Bank
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1. Forecasts at the European Central Bank

2. The CEPR Business Cycle Dating Committee
The ECB is responsible for choosing interest rates in the Euro-area.
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Forecasting is an important component of the job of the ECB
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### Macroeconomic projections for the euro area

(annual percentage changes)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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</thead>
<tbody>
<tr>
<td>Real GDP ¹)</td>
<td>1.7</td>
<td>1.7</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>[1.6 - 1.8]²)</td>
<td>[1.1 - 2.3]²)</td>
<td>[0.6 - 2.6]²)</td>
<td>[0.4 - 2.8]²)</td>
</tr>
<tr>
<td>Private consumption</td>
<td>1.7</td>
<td>1.5</td>
<td>1.5</td>
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</tr>
<tr>
<td>Government consumption</td>
<td>2.0</td>
<td>1.3</td>
<td>1.1</td>
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<tr>
<td>Gross fixed capital formation</td>
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<td>3.1</td>
<td>3.1</td>
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<tr>
<td>Exports ³)</td>
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<td>Imports ³)</td>
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<td>4.1</td>
<td>4.3</td>
<td>4.1</td>
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<td>Employment</td>
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<tr>
<td>Unemployment rate (percentage of labour force)</td>
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<td>9.5</td>
<td>9.1</td>
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<tr>
<td>HICP</td>
<td>0.2</td>
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<td>1.5</td>
<td>1.7</td>
</tr>
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</table>
Macroeconomic projections

Euro area real GDP

Euro area HICP

(quarterly data)

(quarter-on-quarter percentage changes)

(year-on-year percentage changes)
## Comparison of forecasts for euro area real GDP growth and HICP inflation

(annual percentage changes)

<table>
<thead>
<tr>
<th></th>
<th>Date of release</th>
<th>GDP growth</th>
<th>HICP inflation</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>2016</td>
<td>2017</td>
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<tr>
<td><strong>Eurosystem staff projections</strong></td>
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<td>1.7</td>
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<td>[1.6-1.8]</td>
<td>[1.1-2.3]</td>
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<td><strong>European Commission</strong></td>
<td>November 2016</td>
<td>1.7</td>
<td>1.5</td>
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<td><strong>OECD</strong></td>
<td>November 2016</td>
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<td><strong>Euro Zone Barometer</strong></td>
<td>November 2016</td>
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<td><strong>Consensus Economics Forecasts</strong></td>
<td>November 2016</td>
<td>1.6</td>
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<td><strong>Survey of Professional Forecasters</strong></td>
<td>October 2016</td>
<td>1.6</td>
<td>1.4</td>
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<td><strong>IMF</strong></td>
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The Euro-Area Business Cycle Dating Committee

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![Chart showing CEPR based Recession Indicator for Euro Area Business Cycles. The end of the last recession period has not been determined yet.](chart.png)
The Euro-Area Business Cycle Dating Committee

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The Euro-Area Business Cycle Dating Committee

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- We want better methods than flipping a coin...
- Economic research in forecasting is helping us getting there... and it is a very exciting area to work on!!!
THANKS!