Econometric Forecasting Models

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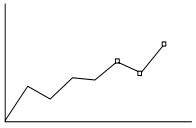
Two Conferences

- **The 15th Federal Forecasters Conference (FFC/2006) - September 28, 2006**
- **Conference Theme: Aging: Implications for Forecasting**
- **Macroeconomic Advisors LLC**
- **2006 Annual Washington Policy Seminar held on Thursday, September 7 at the Georgetown University Conference Center.**
- **Conference Theme: 'Global Aging and Financial Markets'**



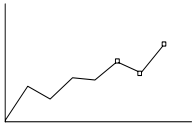
1. What is a forecast?

- **"Anything can be forecast, but not everything can be predicted."**

- **Predict** – implies inference from laws of nature, whereas
- **Forecast** – more probabilistic

- **Etymology of "forecast"**
  - **Fore** – is clear, denoting "in front" or "in advance"
  - **Cast** – dice, lots, spells, horoscopes are all cast

- **Casting a fly**, chancing one's luck, cast about all link the notion of forecasting to gamblers and even charlatans.



1. What is a forecast?

- **A forecast is any statement about the future**
- **There are two basic methods of forecasting**

1. **A "crystal ball" that can see the future,**
2. Extrapolate from present information

Of course:

"Never a crystal ball when you need one"

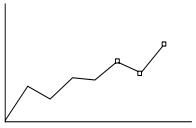
Robert J. Samuelson, *Washington Post,* 6/16/2001

(1) is not available

(2) clearly an inferior method

We adopt a Forecasting Rule:

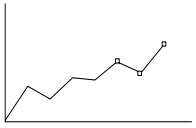
A systematic operational procedure for making statements about future events.



1. What is a forecast?

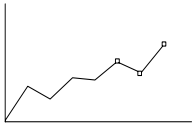
- **Synonyms for forecast, forecasters, forecasting:**

- **augury, Cassandra**
- **clairvoyance**
- **foreboding, foresee foreshadow, omen**
- **precognition**
- **presage**
- **portend**,
- **prescience, scry**



Methods of Economic Forecasting

1. **Guessing, rules of thumb**,
2. **Extrapolation**
3. **Leading indicators**
4. **Surveys**
5. **Time series models**
6. **Econometric forecasting models**



Successful forecasting requires that:

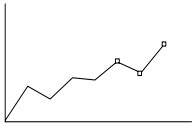
1. There are regularities to be captured,

2. The regularities are informative about the future,

3. The proposed method captures those regularities, and yet

4. It excludes non-regularities.

===> Build Congruent Models



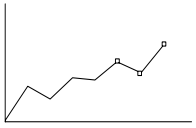
Forecast Uncertainty is Intrinsic and Ubiquitous

- Maxine Singer (1997) ***"Thoughts of a Nonmillenarian"***
- Two reasons on why forecasting the future is uncertain

1. Because of the things we don't know [that] we don't know, the future is largely unpredictable.

2. Because some developments can be anticipated, or at least imagined, on the basis of existing knowledge. (This is known as measurable uncertainty.)

- The first source is the basic problem. The second one can make us too confident or arrogant of our ability to forecast.

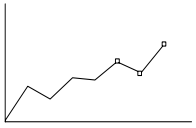


"Because of the things we don't know [that] we don't know, the future is largely unpredictable."

For example, suppose that you engage in a game of dice with Tony Soprano.

You know the probability any pair of numbers will be face up.

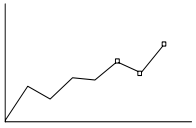
What you don't know and will not know is whether the dice are loaded.



Traditional Theory of Economic Forecasting

- Based on two key assumptions

1. The econometric model is a good representation of the economy
2. The structure of the economy remains relatively constant.

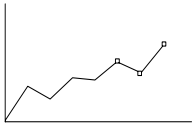


A Traditional Approach to Forecast Errors

- The traditional approach assumes the DGP in the most extreme case. The models are linear. We begin with a bivariate unconditional model and examine a multivariate model. These are followed by the unconditional models where the explanatory variables are known with (measurement) error. Suppose that this variable is known with certainty during the forecast period; then we have an unconditional forecast. The true model is:

$$y_t = \alpha + \beta * x_t + \varepsilon_t; \ \ where \ \ \varepsilon \sim IN(0, \sigma_\varepsilon^2).$$

Let a, b, and s^2 be the respective OLS of the parameters.



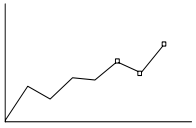
A Traditional Approach to Forecast Errors

We can construct the forecast and forecast error as

$$f_{t,1} = a + b * x_{t+1}$$

$$\begin{aligned} \varepsilon_{t+1} &= y_{t+1} - f_{t,1} \\ &= (\alpha - a) + (\beta - b)x_{t+1} + \varepsilon_{t+1} \end{aligned}$$

What are the sources of the of the forecast errors?



A Traditional Approach to Forecast Errors

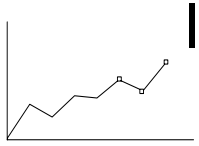
What are the properties of the forecast error(s)?

$$E[\varepsilon_{t,1}] = E[\alpha - a] + E[\beta - b]x_{t+1} - E[\varepsilon_{t+1}]$$

$$E[\varepsilon_{t,1}^2] = E[\alpha - a]^2 + E[\beta - b]^2 x_{t+1}^2 + E[\varepsilon_{t+1}^2] + 2*E[(\alpha - a)(\beta - b)]x_{t+1}$$

$$\sigma_{t,1}^2 = Var(a) + Var(b)x_{t+1}^2 + 2*Cov(a,b)x_{t+1} + \sigma_{\varepsilon}^2$$

Variance and covariance of estimates *a* and *b*
Sample mean and variance of x
Sample variance of residual – ***is it constant***?
I(0) vs I(1) process for *y*

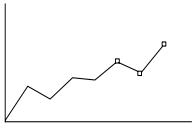


Traditional Theory of Economic Forecasting

- Clearly, this theory has failed.
- At best forecasting models are crude approximations of the true data generating process, DGP.
- The economy is subject to major unanticipated shifts.
- Inaccurate forecasts are far too common.

- ***We often hear that macroeconomic forecasters have predicted 8 of the last 3 recessions***

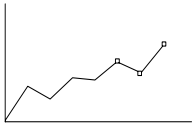
- The degree of uncertainty accompanying a forecast can suggest that its value ranges from highly informative or utterly useless.



Failure of Traditional Theory of Economic Forecasting

- Macroeconomic forecasting models are asked to perform well in a complex environment with numerous interrelated actions and decisions occurring simultaneously by heterogeneous agents with competing and conflicting agendas.

- Modern economies are evolving; there is both gradual and sudden structural change and shifts due to institutional, technological, financial, international competitiveness, political, social, and legal change.



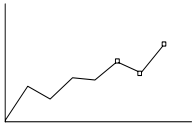
Failure of Traditional Theory of Economic Forecasting

- Forecasting models are supposed to capture these factors empirically in an environment where the data are non-stationary; the degree of misspecification is unknown for the DGP, but no doubt large.

- The onus of congruence is a heavy one.

- The data available may be 1) inaccurate, 2) a proxy for theoretical constructs and agent's decision making criteria, 3) produced with a lag, and subject to revision.

- For example, models based on seasonally adjusted data and ignoring the first two data problems incur a further problem as the seasonal factors for the most recent observations are subject to change as well.



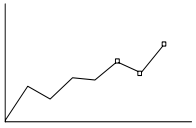
Failure of Traditional Theory of Economic Forecasting

- Non-stationarities and infrequent large structural shocks can lead to forecasting problems and **forecasting failure** – a significant deterioration in the forecast performance relative to the anticipated outcome.

- The goal is to avoid systematic forecast failure.

- A theory of economic forecasting must have the realistic assumptions that

1. **Forecasting models may be incorrect in unknown ways.**
2. **The economy itself is complicated.**
3. **The economy is changing over time – I(1) rather than I(0).**
4. **The economy is often measured inaccurately.**

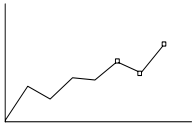


A Taxonomy of the Sources of Model-Based Forecast Error	
Predictable Uncertainty *"What we know that we don't know"*	2. **Unpredictable Uncertainty** *"What we don't know that we don't know"*
(a) discounted accumulation of future shocks (innovations) to the economy	(a) currently unknown future changes in the economy
(b) inaccuracies in the forecast model parameters	(b) mis-specification in the forecast model
	(c) mis-measurement of the base period data

Source: Ericsson (2002) p.22

“New” Economic Forecasting Theory

- The “new” economic forecasting theory focuses on the first four problems as the primary source of forecast failure.
- It does not support claims for imposing restrictions from economic theory to improve forecast accuracy.
- In addition, it does not necessarily support inventing “better” estimation methods.
- Since true shocks cannot be forecast, it is better to have an adaptive forecasting process, to incorporate the information and avoid a sequence of poor forecasts.



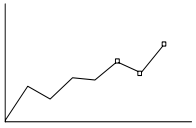
Re-Examining the Taxonomy of Sources of Forecast Errors

Economists often take two tacks in building forecasting models.

Traditional, start with a theoretical model and impose it on the data in either a single equation format or structural time series approach.

More recently,

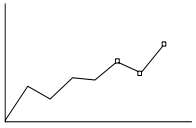
1. Understand the time series properties of the DGP (data generating process.)
2. Consider competing economic theories when specifying the variables to be used at the outset.
3. Develop evaluation criteria and model design criteria to address properties like integration, cointegration, error-correction, and model congruency.



Three Basic Components of Forecasting Models

1. **Deterministic terms** like intercepts, trends, seasonal factors, or other factors with known values,
2. **Observed stochastic variables** which the model attempts to characterize and have unknown future values, and
3. **Past, present, and future** innovations.

- Each component is vulnerable to many types of mistakes; among them are inaccurate measurement, misspecification, inaccurate estimation, fluctuations in unexpected ways.
- This suggests there are twelve possible types of mistakes: three components and four types each. Below, I only focus on the sources from the first two components.



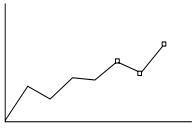
Re-Examining the Taxonomy of Sources of Forecast Errors

- Lets begin with a first order stationary Vector Autoregression following Clements and Hendry (2002).
- The sources of the forecast error can then be related to a vector equilibrium correction model, VEqCM.

$$y_t = \phi + \Pi y_{t-1} + \varepsilon_t \;\; with \;\; \varepsilon_t \sim IN_n(0, \Omega_\varepsilon)$$

The unconditional mean of y_t *is* given by

$$\begin{aligned} E[y_t] &= \phi + \Pi E[y_{t-1}] \\ &= (I_n - \Pi)^{-1} \phi \\ &= \varphi. \end{aligned}$$



Re-Examining the Taxonomy of Sources of Forecast Errors

The DGP can be rewritten in mean adjusted form

$$y_t - \varphi = \Pi (y_{t-1} - \varphi) + \varepsilon_t$$

Conditional on the information set from t=1,…,T, the one through h-step ahead forecasts can be constructed.

$$\hat{y}_{T+1,T} - \hat{\varphi} = \hat{\Pi}(\hat{y}_{T,T} - \hat{\varphi}) \text{ where } E\left[\hat{y}_{T,T}\right] = y_T$$

$$\hat{y}_{T+2,T} - \hat{\varphi} = \hat{\Pi}(\hat{y}_{T+1,T} - \hat{\varphi}) = \hat{\Pi}^2 (y_T - \hat{\varphi})$$

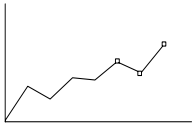
.

.

.

$$\hat{y}_{T+h,T} - \hat{\varphi} = \hat{\Pi}(\hat{y}_{T+h-1,T} - \hat{\varphi})$$

$$\hat{y}_{T+h,T} = \hat{\varphi} + \hat{\Pi}^h (y_T - \hat{\varphi})$$



Re-Examining the Taxonomy of Sources of Forecast Errors

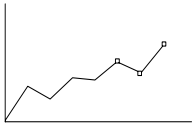
The forecaster by definition does not know the true data generation process.

The model therefore may be mis-specified leading to inconsistent parameter estimates.

Examples include zero and non-zero coefficients from omitted and or incorrect variables estimated in the rows of the dynamic matrix.

In addition, the intercepts may have been suppressed.

Economic Forecasters need to account for (structural) shifts and breaks



Re-Examining the Taxonomy of Sources of Forecast Errors

The impact of (structural) shifts and breaks depends on the time since they occurred.

The U.S, federal budget was in surplus by $200B in 2000.

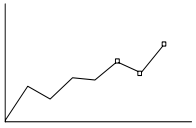
Last year the U.S. had a federal budget deficit of -$400B.

Suppose that a permanent break occurs in the first period after the forecast was made. It was unknown at time T.

The model parameters change from $\{\phi \Pi\}$ to $\{\phi^* \Pi^*\}$

This implies that the DGP starting in T+1 is generated by

$$y_{T+h} = \phi^* + \Pi^* y_{T+h-1} + \varepsilon_{T+h} \quad : \; h = 1, 2, \ldots$$



Re-Examining the Taxonomy of Sources of Forecast Errors

Assume the distribution properties of the innovation processes has not changed.

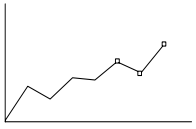
The future path for *y* looks like

$$y_{T+h} - \varphi^* = \Pi^*(y_{T+h-1,T} - \varphi^*) + \varepsilon_{T+h}$$

$$y_{T+h} = \varphi^* + \left(\Pi^*\right)^h (y_T - \varphi^*) + \sum_{i=0}^{h-1} \left(\Pi^*\right)^i \varepsilon_{T+h-i}$$

Where $\varphi^* = \left(I_n - \Pi^*\right)^{-1} \phi^*$

What are the characteristics of the future realizations for {*y*}?



Re-Examining the Taxonomy of Sources of Forecast Errors

From before we can write the h-step ahead forecast error as

$$\hat{\varepsilon}_{T+h,T} = \varphi^* - \hat{\varphi} + \left(\Pi^*\right)^h (y_T - \varphi^*) - \hat{\Pi}^h (\hat{y}_T - \hat{\varphi}) + u_{T+h}\,.$$

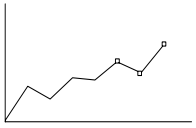
We can write the difference between the sample estimates and the population values (ignoring interaction terms of limited importance.)

$$\delta_{\varphi} = \hat{\phi} - \phi_p$$

$$\delta_p = \left(I_n - \Pi_p \right)^{-1} \phi_p$$

$$\delta_n = \hat{\Pi} - \Pi_p$$

$$\delta_y = \left(\hat{y}_T - y_T \right)$$



Forecast Error Taxonomy

Sources of $\hat{\varepsilon}_{T+h,t}$	**Description**
$+\left(\left(\Pi^*\right)^h - \Pi^h\right)\left(y_T - \varphi\right)$	(i.a) Slope change
$+\left(I_n - \left(\Pi^*\right)^h \right)\left(\varphi^* - \varphi \right)$	(i.b) Equilibrium mean change
$+\left(\Pi^h - \Pi_p^h\right)\left(y_T - \varphi\right)$	(ii.a) Slope mis-specification
$+\left(I_n - \Pi_p^h \right)\left(\varphi - \varphi_p \right)$	(ii.b) Equilibrium mean mis-specification
$-F_h\ \delta_\Pi$	(iii.a) Slope estimation
$-\left(I_n - \Pi_p^h \right)\delta_\varphi$	(iii.b) Equilibrium mean estimation
$-\left(\Pi_p^h + C_h\right)\delta_y$	(iv) Forecast origin uncertainty
$+\sum_{i=0}^{h-1}\left(\Pi^*\right)^i \varepsilon_{T+h-i}$	(v) Discounted error accumulation

Source: Clements and Hendry (2002) p.

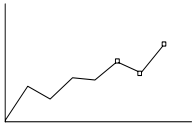
“New” Economic Forecasting Theory

- Based on the taxonomy there appear to be 8 main sources of forecast errors.

- A review of real world data and monte carlo simulations suggests that 2 sources are of most concern.

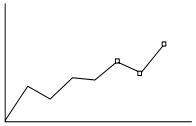
1. **Mis-specification of the mean (ii.b) and**
2. **Non-constant equilibrium mean (i.b)**

These lead to systematic forecast failure and bias



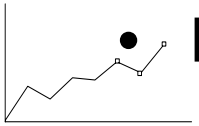
“New” Economic Forecasting Theory

- Forecasting with deterministic variables
- Their specification and estimation matter.
- Unanticipated changes in the values of deterministic terms matter. In particular the economy moves and the model forecasts do not.
- Deterministic shifts may reflect changes elsewhere in the economy that are interacting with the incomplete specification.
- Formulating models to minimize the effects of possible changes in deterministic terms is generally beneficial. This is true despite the potential costs in terms of poorer representation of the economy theory and data.
- Successful modeling of deterministic terms pays handsome dividends, even if only by using simply corrections



What are the main problems in economic forecasting?

- The main problem appears to be **unanticipated shifts in the underlying mean of the series or its trend.**
- In some cases these may be easy to detect.
- If so a flexible model can adapt to the shifts a reduce future forecast problems
- Recognizing causality relationships from pure statistical ones.
- Bandwagon or herding effects.



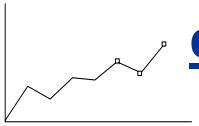
Do these problems have potential solutions?

In the non-stationary data case frequently observed with economic variables, there are three potential solutions.

1. **Specify in differences or even acceleration to convert intercept shifts to pulses or blips.** It is near impossible to forecast breaks in levels, but differences appear to be robust estimators once the break is past. Second differences removes the linear trend and thus reduces the shifts in the growth rate to blips.

2. **Updating** is necessary to adapt to changing properties in the data. This can come at the cost of precision though.

3. When the first of a sequence of forecasts is in error, the remaining forecasts often suffer similarly. An **intercept shift or add factor equal to the last error** may improve forecast performance.

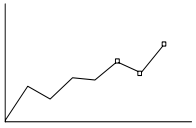


Conclusions and Questions

Examine forecast performance.

Look for evidence of forecast failure.

1. Persistent bias,
2. Incorrect trend, and
3. Autocorrelation



Conclusions and Questions

How can actuaries and economic forecasters contribute to the Global Warming Debate and Policy Discussion?

What are the costs of responding or not responding to the threat of Global Warming?

How is the insurance industry responding to Global Warming? Is it more forward-looking than the public sector?

How will we know the if and when the structural breaks or threshholds have occurred?

Why do meteorologists get new super-computers when weather forecasts are wrong and when economists forecast incorrectly their budgets are cut?