Aston Business School

Forecasting in Business

BN2255 – Business Analytics in Practice

Forecasting: an introduction

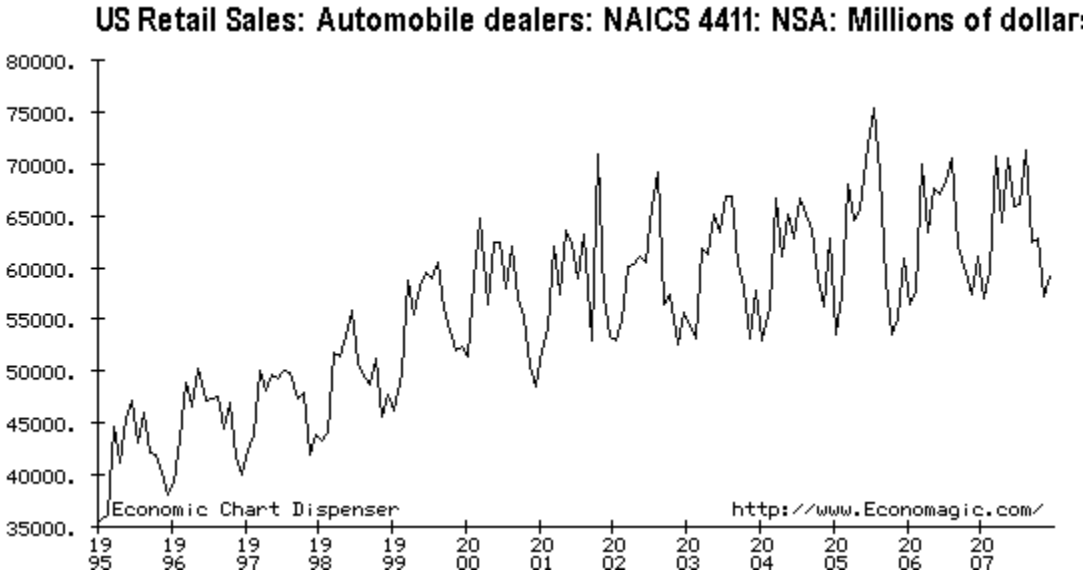
- What is forecasting?
  - predicting the future as accurately as possible, using information from past experiences (historical data) and knowledge of any future events that might impact the forecasts
- Forecasting in business
  - inventory control/production planning – forecasting product demand
  - investment policy – forecasting financial information
    - no reliable approach as of yet!
  - economic policy – forecasting macroeconomic indicators

Key features

- the elements that are relevant to all forecasting methods are:
  - the concept of the future and time;
  - uncertainty;
  - reliance on historical data.

- Time dimension
  - Short-term: forecasts of demand for scheduling of personnel, production and transportation.
  - Medium-term: more forward-looking demand forecasts to determine future resource requirements (purchase raw materials, hire personnel, or buy machinery and equipment).
  - Long-term: forecasts for strategic planning. Such decisions must take account of market opportunities, environmental factors and internal resources.

Historical data



- Graphs are always helpful!
  - know your data

Year	Quarter	Sales
1995	Q1	9316402
1995	Q2	12333879
1995	Q3	12331270
1995	Q4	11120133
1996	Q1	23131643
1996	Q2	11144063
1996	Q3	20339408
1996	Q4	19628835
1997	Q1	10836253
1997	Q2	14947200
1997	Q3	15647475
1997	Q4	11233730
1998	Q1	13739233
1998	Q2	14460752
1998	Q3	18348894
1998	Q4	15644622
1999	Q1	10654745
1999	Q2	17773343
1999	Q3	15975444
1999	Q4	19558288
2000	Q1	17775056
2000	Q2	20681387
2000	Q3	13376934
2000	Q4	17254405

Forecasting approaches

- Qualitative
  - Delphi – panel of experts
- Quantitative
  - ‘Naïve’ methods
    - Moving average
    - Exponential smoothing
  - Time Series Econometrics [not part of this module]
    - Trend analysis
    - Autoregressive Integrated Moving Average (ARIMA) models
  - Exploratory Econometrics
    - Regression analysis
  - Artificial Intelligence methods [not part of this module]
    - Neural Networks

Moving Average

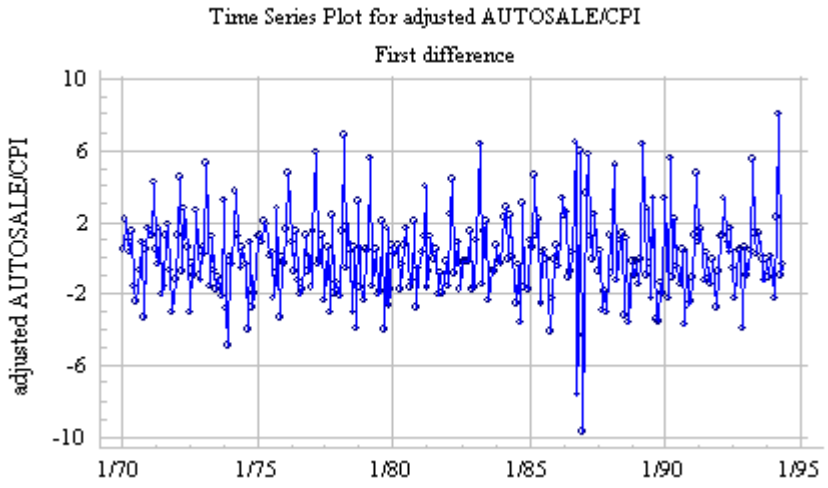
- Moving average
  - forecast is the average of a sample of observations, starting with the most recent and moving backwards; the number of observations determined at the start of the analysis

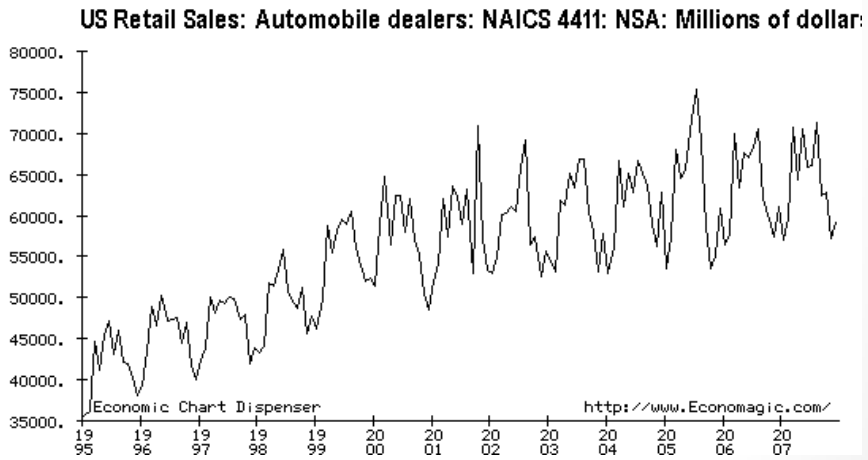
Year	Quarter	Sales	3 Quarter MA	5 Quarter MA
1995	Q1	932		
1995	Q2	1,233		
1995	Q3	1,233		
1995	Q4	1,112	1,133	
1996	Q1	2,313	1,193	
1996	Q2	1,114	1,553	1,365
1996	Q3	2,034	1,513	1,401
1996	Q4	1,963	1,821	1,561
1997	Q1	1,084	1,704	1,707
1997	Q2	1,495	1,693	1,702
1997	Q3	1,565	1,514	1,538
1997	Q4	1,123	1,381	1,628

- Advantages
  - easy to calculate, small data requirements
- Disadvantages
  - equal weight given to all observations (but can be mitigated by exponential smoothing)
  - assumes that data is stationary

Stationarity

- **Statistical stationarity:** A *stationary* time series is one whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time.





Stationary (with possible seasonality)

Non-stationary

Achieving stationarity

- a stationary series is easy to predict
  - its statistical properties in the future will be the same as in the past
- most series are not stationary; some however can be transformed into a stationary series
  - De-trending
  - Deflating (price changes)
  - Log-transforming
    - turns multiplicative relationships to additive
  - Differencing – changes from a period to the next
    - if a series is not stationary, maybe the *changes* in the series will be

First Difference of Y_t =	$Y_t - Y_{t-1}$

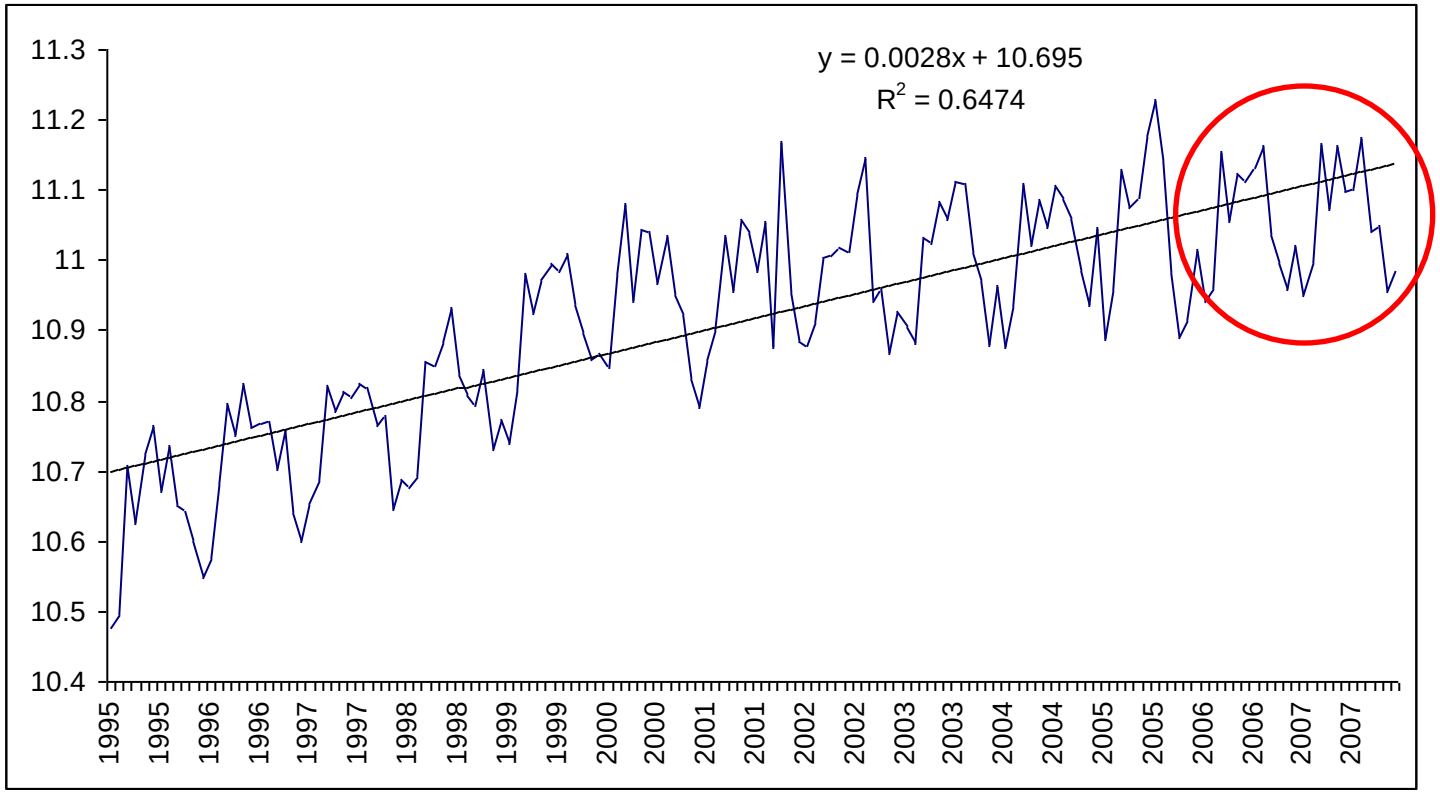
Trend analysis

- Common components of a non-stationary series
  - Time trend - b
  - Seasonal component - c^s
  - Cyclical component - c^c
  - Noise (error of the prediction) - e_t

$$Y_t = a + bt + c^s S_i + c^c C + e_t$$

- Parameters are derived via Least Squares (regression)
  - seasonal and cyclical components are represented by dummy variables
- Easy to implement, but simplistic approach
  - need to identify cyclical movements beforehand
  - forecast might be inappropriate, since goodness of fit at the edges of the sample is often limited

Trend Analysis



ARIMA models (1)

- Autoregressive (AR), Integrated (I), Moving Average (MA) models
  - most general class of models for forecasting a time series which can be stationarised by transformations such as differencing and logging
  - fine-tuned version of MA and exponential smoothing approaches
    - by adding lags of the (differenced) series and/or lags of the forecast errors

- AR model

$$Y_t = a + \sum_{i=1}^{p} \phi_i Y_{t-i} + e_t$$

- MA model

$$Y_t = \mu + \sum_{i=1}^{q} \theta_i e_{t-i} + e_t$$

- ARIMA(1,1,1) model

$$Y_t - Y_{t-1} = \mu + \phi(Y_{t-1} - Y_{t-2}) + \theta e_{t-1} + e_t$$

ARIMA models (2)

- assumes that future values of a series depend on
  - past values of the series (AR part)
  - a series of unobserved shocks (MA part)
  - integration is used to achieve stationarity

- AR models can be parameterised using OLS, but the inclusion of MA requires more complex techniques

- Advantages
  - ARIMA models are the most theoretically complete family of time series models
  - small data requirements
- Disadvantages
  - relatively complex method
  - may be difficult to explain to non-specialists
  - more common amongst economists (forecasting macroeconomic variables), rather than business practitioners

Exploratory econometrics (1)

- assumes that it is possible to identify the underlying factors that might influence the variable that is being forecast
- Train passenger demand – function of:
  - Ticket prices
  - Journey time
  - Punctuality and crowding
  - Cost of alternative transportation (car/bus)
  - Macroeconomic factors (GDP/capita, population, employment, etc)
- Multi-part analysis
  - need to describe the function
  - need to derive forecasts of the explanatory factors
    - these may also rely on exploratory econometrics (eg cost of alternative transport is heavily influenced by the price of petrol)

Exploratory econometrics (2)

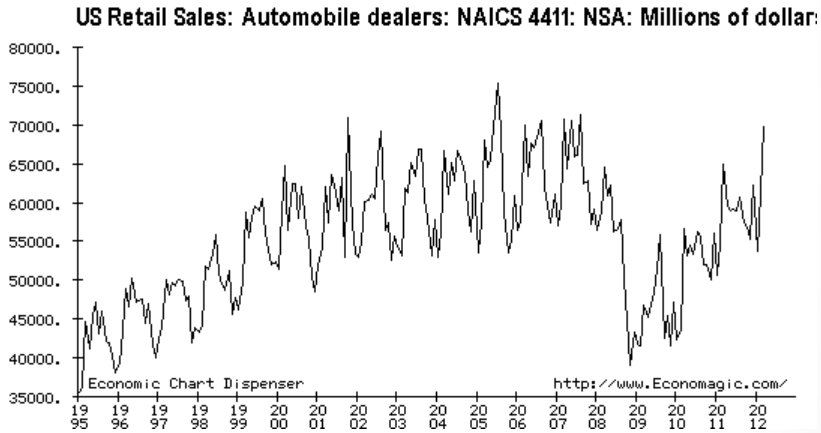
- Advantages
  - potentially quite accurate
    - depends on existence of well-defined relationships and independent variables that are easier to forecast
  - potentially robust when conditions change significantly (after a structural break)
  - easier for management to accept (buy-in)
- Disadvantages
  - large data requirements
  - increased complexity

Artificial Intelligence methods

- Based on data mining (exploratory analysis of very large datasets)
  - neural networks
  - support vector machines
  - regression trees
- Neural networks –computational structure that combines a large number of different input using a set of weights to create the forecast
  - the set of weights is decided on internally through a very large number of attempts to minimise forecasting error (adaptive learning)
- Many applications, especially in e-commerce
  - Amazon recommendations
  - Netflix ratings

Words of warning!

- Forecasting relies on past experience - no guarantee that the conditions in the past will persist into the future
  - structural breaks
- Spurious correlations - forecasting stock markets based on hem lines, football results and butter production in Bangladesh



"Prediction is very difficult, especially if it's about the future."
--Nils Bohr, Nobel laureate in Physics