ARMAX Lecture: Events and Forecast

Dr. Goutam Chakraborty

1

Events

- An *event* is anything that changes the underlying process that generates time series data.
- The analysis of events includes two activities:
  - exploration to identify the functional form of the effect of the event
  - inference to determine whether the event has a statistically significant effect
- Other names for the analysis of events are the following:
  - ***intervention analysis***
  - interrupted time series analysis

Intervention Analysis

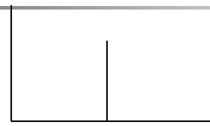
- Intervention analysis can be defined as follows:
  - special case of *transfer function modeling* in which the predictor variable is a deterministic categorical variable
  - derived from the concept of a public policy *intervention* having an effect on a socio-economic variable
    - Example: Raising the minimum wage increases the unemployment rate.
    - Example: Implementing a severe drunk-driving law reduces automobile fatalities.

Event and Intervention Analysis Practices

- In retail sales, the term *event* is often used and includes the following:
  - promotional events: discounts, sales, featured displays, and so on
  - advertising events: broadcast, internet, and print media advertising campaigns, sponsored events, celebrity spokespersons, and so on
- In economics and the social sciences, the term *intervention* is often used and includes these:
  - catastrophic events
  - events related to a key player (CEO, spokesperson): imprisonment, scandal, illness, injury, or death
  - public policy changes

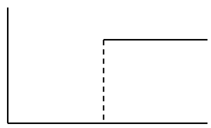
Primary Event Variables

Point/Pulse



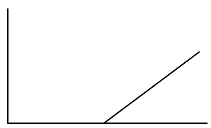
$$J_t = \begin{cases} 1 & \text{for } t = t_{\text{event}} \\ 0 & \text{for } t \neq t_{\text{event}} \end{cases}$$

Step



$$I_t = \begin{cases} 1 & \text{for } t \geq t_{\text{event}} \\ 0 & \text{for } t < t_{\text{event}} \end{cases}$$

Ramp



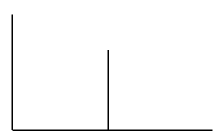
$$R_t = \begin{cases} t - t_{\text{event}} & \text{for } t \geq t_{\text{event}} \\ 0 & \text{for } t < t_{\text{event}} \end{cases}$$

t_{event}

Examples of Input Variables

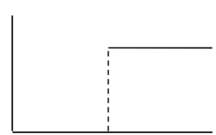
Point/Pulse

X	0	0	0	1	0	0	0	…
Y	0	0	0	8	0	0	0	
t	1	2	3	4	5	6	7	



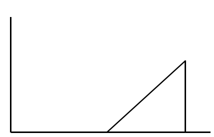
Step

X	0	0	0	1	1	1	1	…
Y	0	0	0	8	8	8	8	
t	1	2	3	4	5	6	7	



Ramp

X	0	0	0	1	2	3	0	…
Y	0	0	0	2	4	6	0	
t	1	2	3	4	5	6	7	



t_{event}

In-Sample versus Out-of-Sample Forecasts

In-Sample Forecasts	Out-of-Sample Forecasts
The forecasted sample was part of the calibration sample.	Forecasted sample was *not* part of the training sample.
It can be obtained using the LEAD=k and BACK=k options in PROC ARIMA.	It can be obtained using data preparation before using PROC ARIMA.
Accuracy measures using these forecasts do *not* reflect *Honest Assessment*.	Accuracy measures using these forecasts reflect *Honest Assessment*.

The Stochastic Input Variable Conundrum

- Future values of the input variable are either of the following:
  - deterministic (known)
  - stochastic (unknown, and therefore, estimated)
- A stochastic input, X_t, must be forecast for *T* periods so that Y_t can be forecast for *T* periods.
- The forecast accuracy of Y_t depends, in part, on the forecast accuracy of the stochastic input variable.

8

Examples of This Conundrum

To accurately forecast future _______ for the next year, you need to first accurately forecast ________.

- crop yields : rainfall or precipitation amount
- gasoline prices : the price of crude oil per barrel
- solar power generation : cloud cover

- Can you accurately forecast rainfall or precipitation, the price of oil per barrel, or cloud cover over the next *T* time periods?

9

Scenario Analysis or What-If Analysis

- Choose future values of the stochastic input variable to generate different forecasts for Y_t.
- Run the same model, and replace the chosen future values each time.
  This reduces a complex process into a series of simple Boolean conditional statements.
  - For example, for period t+2:
    - If $X_{t+2} = X_1$, then $Y_{t+2} = Y_1$
    - If $X_{t+2} = X_2$, then $Y_{t+2} = Y_2$
    - …
    - If $X_{t+2} = X_k$, then $Y_{t+2} = Y_k$
  - For k, chosen future values of X_{t+2}

10

Example of A Scenario

Suppose the cost of oil per barrel (X_t) is $85 at period *t*. The forecast for the cost of oil per barrel in one future time period (X_{t+1}) is $88. Running the ARMAX(1,0) model and forecasting one period ahead produces a forecast for Y_{t+1}. Because X_{t+2} cannot be accurately forecast, different scenarios can be run in its place.

The chart on the right runs five scenarios for X_{t+2}. Based on the forecast from X_{t+1}, the scenarios for X_{t+2} were whether the cost of oil per barrel does the following:

- drops by $4 from *t*+1 to *t*+2
- drops by $2 from *t*+1 to *t*+2
- stays the same from *t*+1 to *t*+2
- rises by $2 from *t*+1 to *t*+2
- rises by $4 from *t*+1 to *t*+2

Period	X	Y
t+1	$88	Y_{t+1} forecast
t+2	$84	Y_{t+2} forecast if X drops $4 from *t*+1 to *t*+2
	$86	Y_{t+2} forecast if X drops $2 from *t*+1 to *t*+2
	$88	Y_{t+2} forecast if X remains the same from *t*+1 to *t*+2
	$90	Y_{t+2} forecast if X increases $2 from *t*+1 to *t*+2
	$92	Y_{t+2} forecast if X increases $4 from *t*+1 to *t*+2