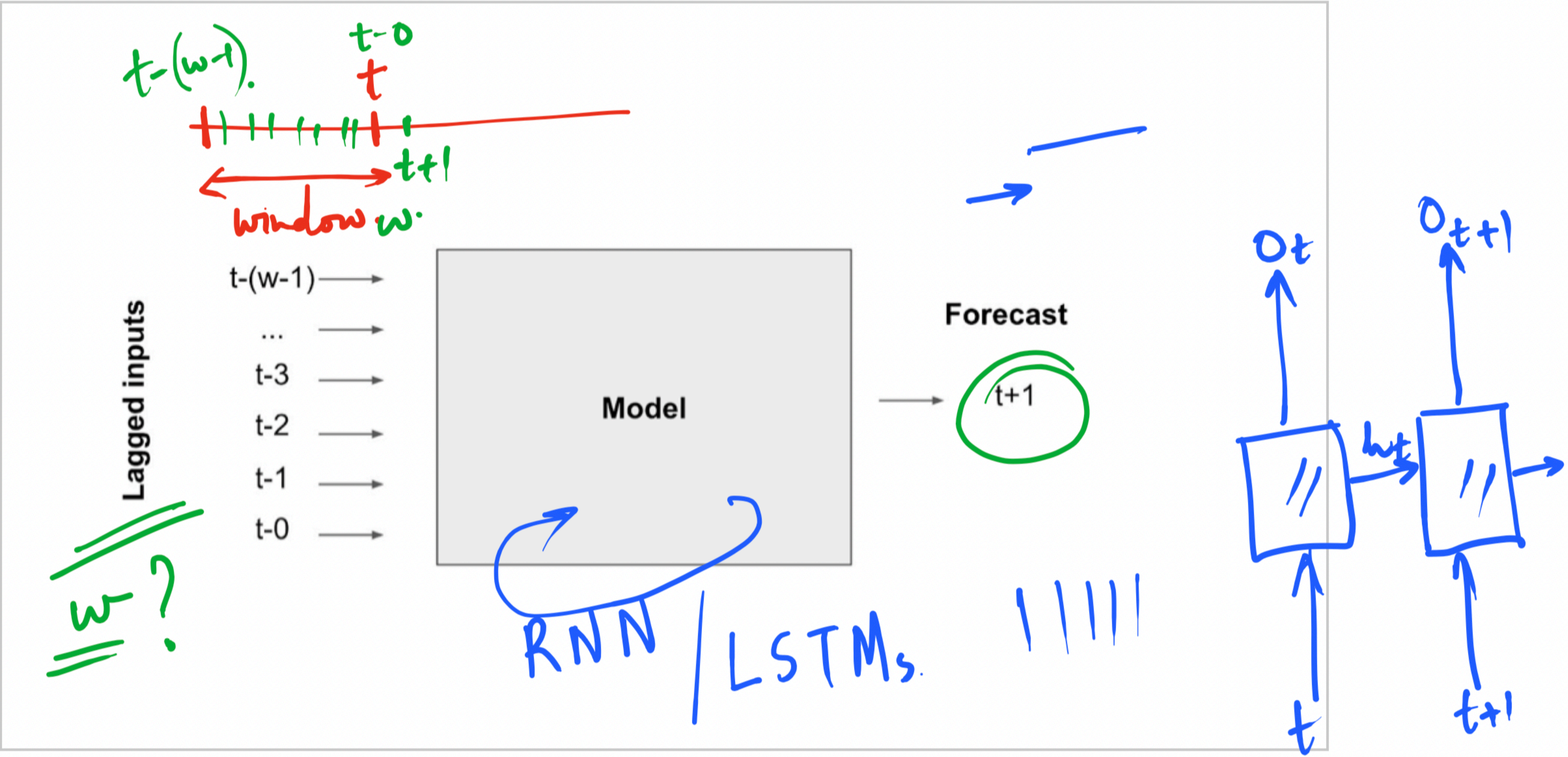
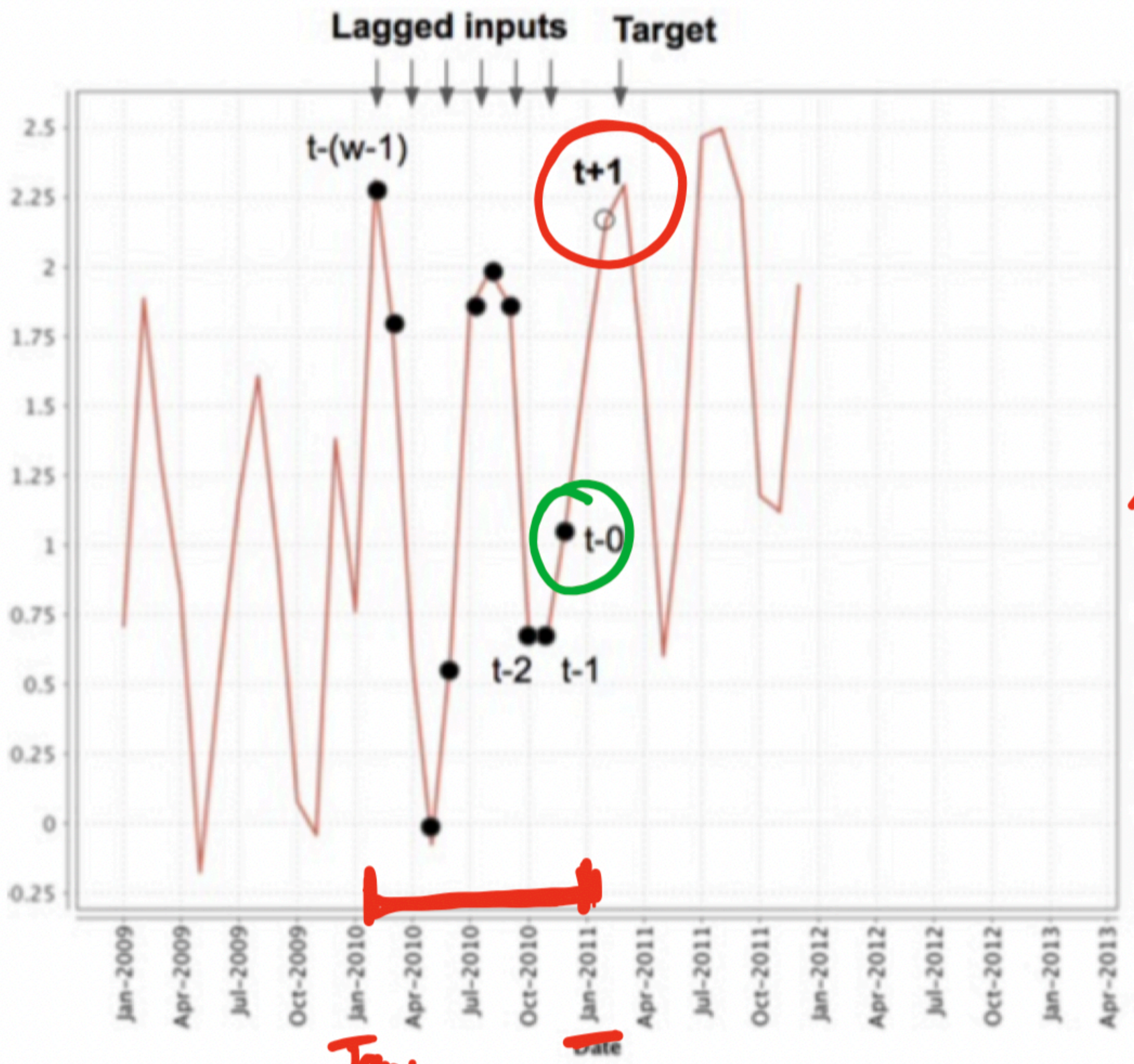
Hand-engineered.

Machine Learning Methods



t-(w-1)
t-0
t
t+1
window w.
Lagged inputs
t-(w-1)
...
t-3
t-2
t-1
t-0
Model
Forecast
t+1
w?
RNN / LSTMs.
O_t
O_{t+1}
h_t
t
t+1

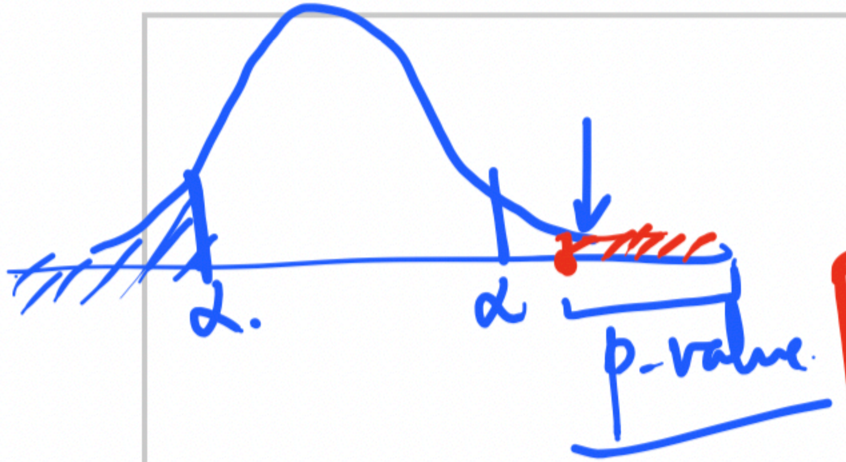


Jan 2010

Jan 2011

window size should be the seasonality period.

A single series can be used for training



Prediction can happen if a time series depicts stationarity.

↳ weak. (trend stationarity)

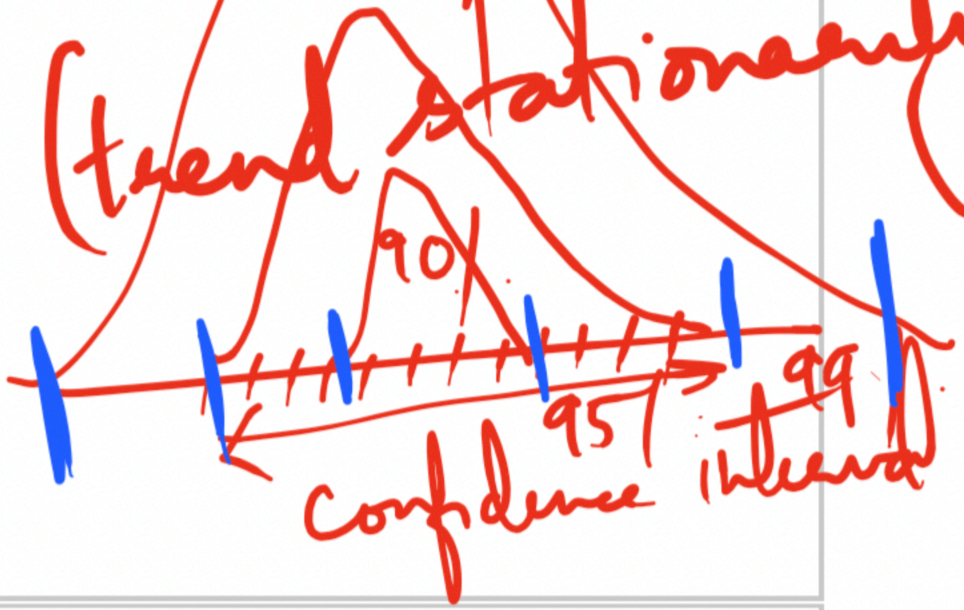
Dickey Fuller Test

H_0 Not stationary

Stationary

S

NS.



- Presence of a unit root implies non-stationarity
- Consider the Autoregressive Model

$$y_t = \rho y_{t-1} + \epsilon_t$$

A unit root $\rho = 1 \implies$ Non-stationarity

NS: Mean will drift

- Zero root $\rho = 0 \implies$ Stationarity

Stationarity implies $y_t = \epsilon_t$ i.e. changes will occur in a random walk

|| Presence the mean value of the series

- Presence of a unit root implies non-stationarity
- Consider the Autoregressive Model

$$y_t = \rho y_{t-1} + \epsilon_t$$

- Consider subtracting y_{t-1} from both sides

$$y_t - y_{t-1} = (\rho - 1)y_{t-1} + \epsilon_t$$

i.e. $\Delta y_t = \delta y_{t-1} + \epsilon_t$ where $\Delta y_t \equiv y_t - y_{t-1}$ and $\delta \equiv \rho - 1$

- Testing for unit root is equivalent to testing $\delta = 0$ $\rho = 1$ NS.

SP : The next change should be predictable from the current level (value) of the series.

- $\Delta y_t = \delta y_{t-1} + \epsilon_t$

  Testing for unit root is equivalent to testing for $\delta = 0$ (Non-stationarity)

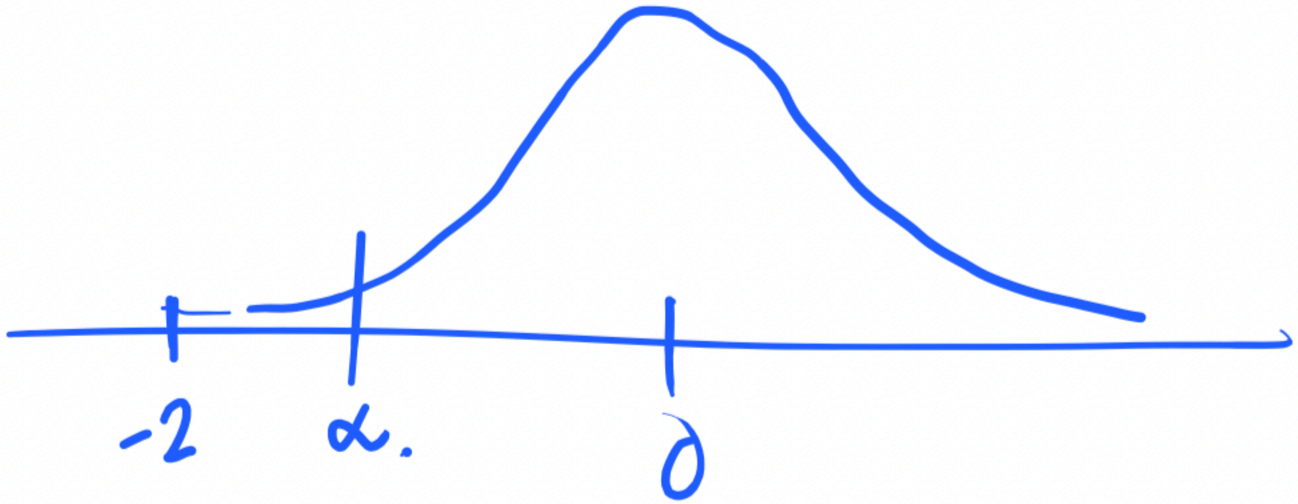
- If $\delta < 0$ (stationarity), it is possible to predict using y_{t-1} the change from the current value y_{t-1}
  - That is, the level of the series is a predictor for the next period's change

- The Dickey Fuller test provides the statistical significance of the difference between the processes having unit root $\delta = 0$ and processes having non-zero δ <0

NS S.

δ.   0

- Critical values for this test statistic are obtained form the Dickey-Fuller Table



Augmented Dickey Fuller (ADF) Test

- ADF is applied to the autoregressive process (which accounts for autocorrelations in the series).

Previous level

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t$$

lagged differences

- Null Hypothesis H_0: Unit root is present (Non-stationarity)

  Alternate Hypothesis H_A: Stationarity or Trend Stationarity

- The unit root test is carried out under the null hypothesis $\gamma = 0$ against the alternative hypothesis $\gamma < 0$.

- The test statistic is $DF = \dfrac{\hat{\gamma}}{SE(\hat{\gamma})}$ SE is the standard error

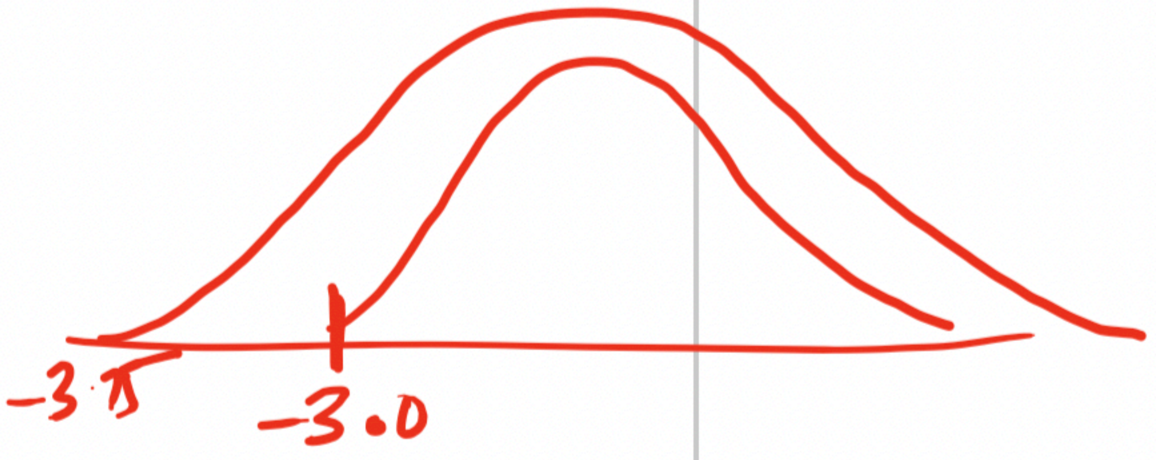
standard deviation

Augmented Dickey Fuller Test is Assymetric

critical values (α).

99% 95%

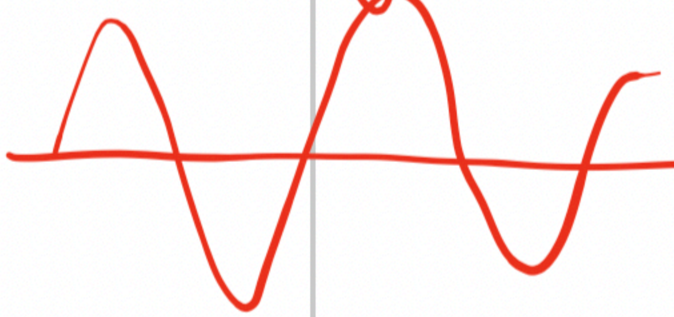
Critical values for Dickey–Fuller *t*-distribution.				
	Without trend		With trend	
Sample size	1%	5%	1%	5%
T = 25	−3.75	−3.00	−4.38	−3.60
T = 50	−3.58	−2.93	−4.15	−3.50
T = 100	−3.51	−2.89	−4.04	−3.45
T = 250	−3.46	−2.88	−3.99	−3.43
T = 500	−3.44	−2.87	−3.98	−3.42
T = ∞	−3.43	−2.86	−3.96	−3.41



- If the calculated test statistic is less (more negative) than the critical value, then the null hypothesis of is rejected and no unit root is present.

H. → − change

L → + change



- Stationarity would imply $\gamma < 0$, so that the process exhibits a reversion to the mean.
  - Thus, the lagged level (y_{t-1}) will provide relevant information in predicting the change of the series $\Longrightarrow$ the series is stationary $\Longrightarrow$ the null hypothesis is rejected.

Intuition behing ADF

- If the series is stationary (or trend-stationary), then it has a tendency to return to a constant (or deterministically trending) mean.

y_{t-1} Δy_t

- Therefore, large values will tend to be followed by smaller values (negative changes), and small values by larger values (positive changes).

- Accordingly, the level of the series will be a significant predictor of next period's change, and will have a negative coefficient.