SFU

Beedie School of Business

BUS 865 Market Risk Management

Back Testing:
VaR and ES Backtesting For Nintendo

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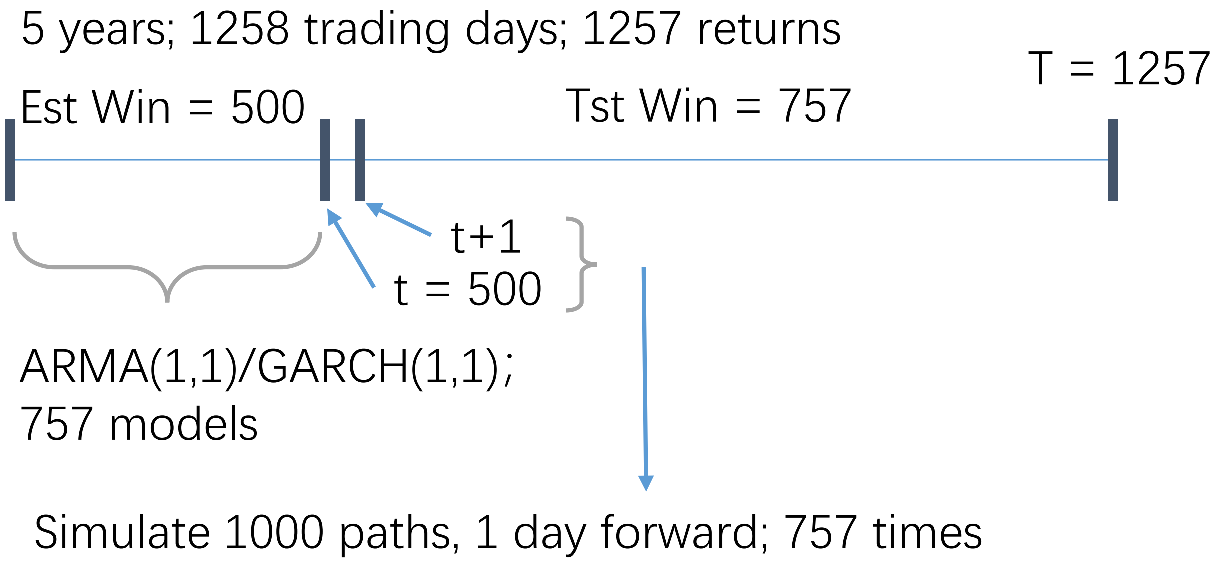
Company Introduction

- **34.858B MKT CAP**
- Multinational consumer electronics and video game company
- Switch; Zelda, Super Mario

Methodology For Backtest

1. Select Estimation/Test Window
2. Estimate ARMA/GARCH models
3. Simulate Paths for 1-day VaR for Each Test
4. Compute 95% VaR/ES for Each Test
5. Find Violations; Compute VR, Std ES, Ave Std ES
6. Test the Significance of VR



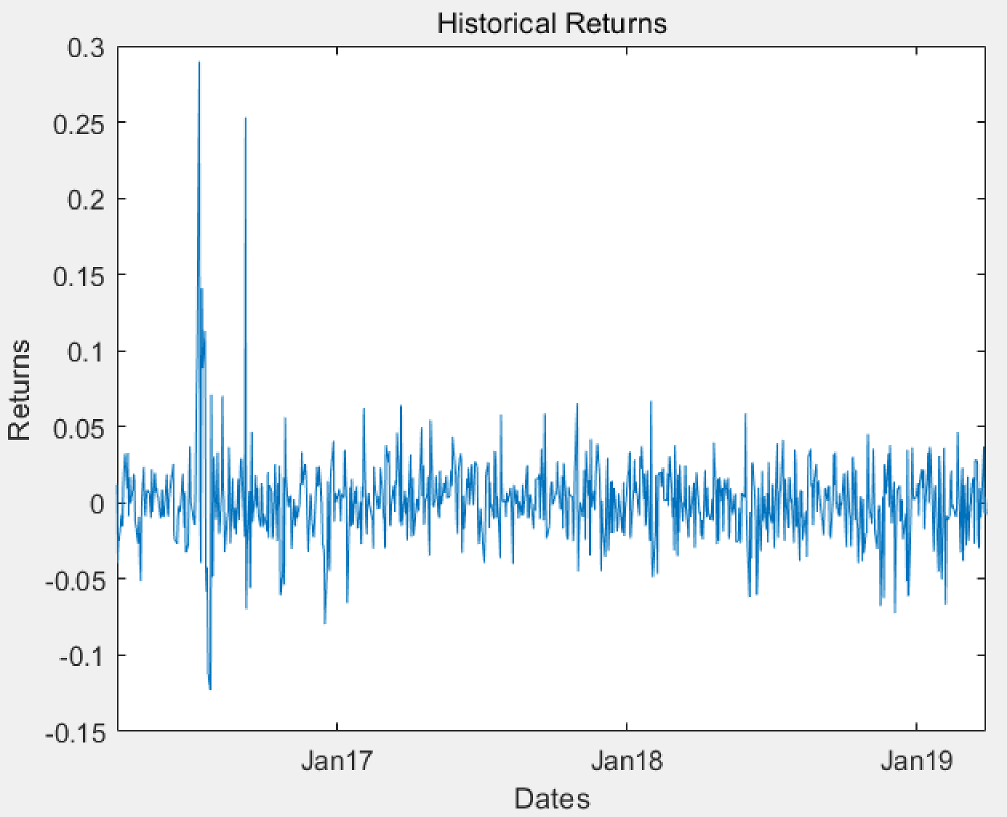
- Compute Violation Ratio/Standardized ES
- Mean of the Standardized ES
- Bernoulli coverage test/Independence of the Violations

Data Source/Processing

- Download & import 5-year historical daily data from Yahoo Finance.
- Convert adjusted closing price into returns.
- Plot the returns

```
data = readtable('NTDOY.csv');
ninR = price2ret(data.AdjClose);
%%
plot(data.Date(2:end),ninR);
xlabel('Dates');ylabel('Returns');title('Historical Returns');
datetick('x',12);xlim([dates(1) dates(end)]);
```

Date	Open	High	Low	Close	AdjClose	Volume
2014-04-02	14.6600	14.6600	14.5500	14.6100	13.8791	26400
2014-04-03	14.4900	14.5000	14.3600	14.3900	13.6701	41600
2014-04-04	14.4500	14.4500	14.2200	14.2500	13.5371	28800
2014-04-07	14.2500	14.3500	14.2500	14.2800	13.5656	15600
2014-04-08	13.9600	14.0900	13.9600	14.0400	13.3376	36700



Define Variables & Compute VaR/ES

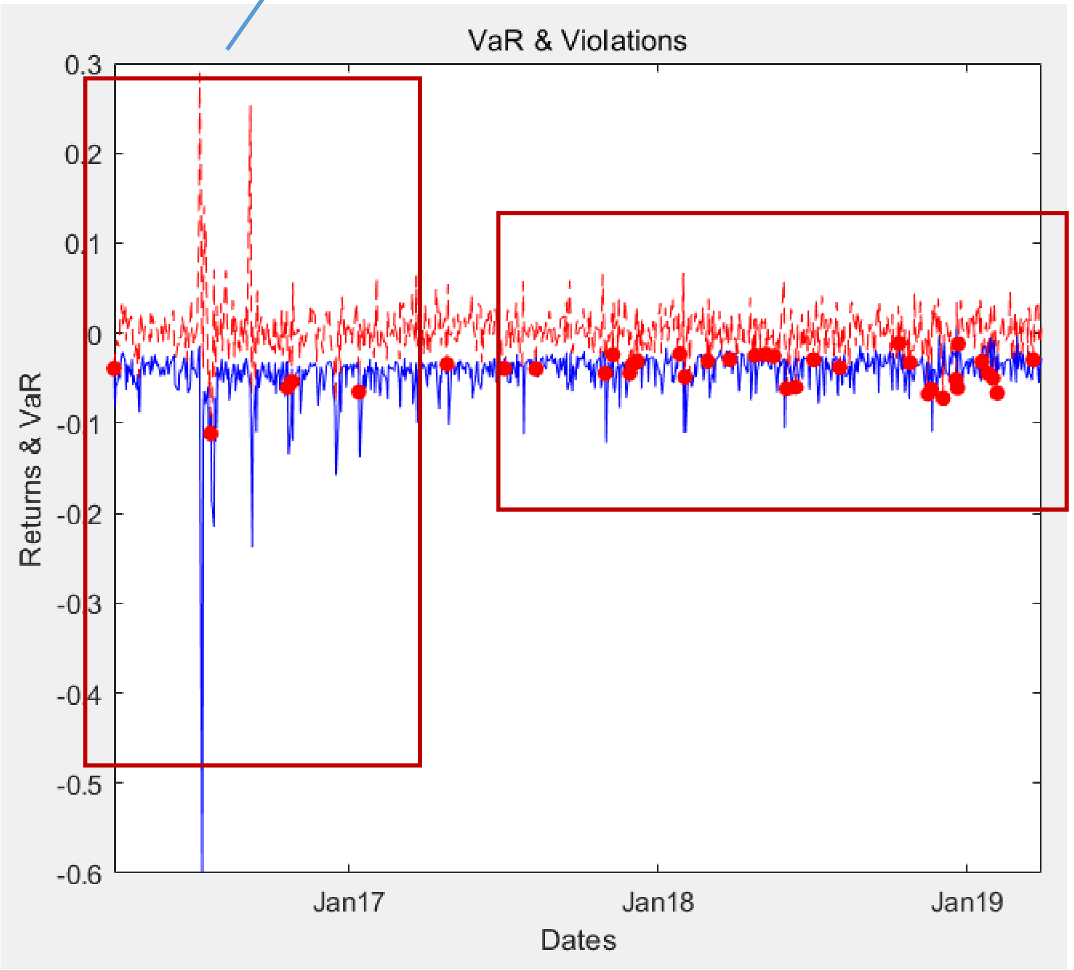
- **Set up ARMA(1,1)-GARCH(1,1) model; Define other variables**
- **For loop to estimate each estimation window and simulate 1-day forward returns**
- **Cal and record VaR&ES for each tests.**

```
%%
Mdl = arima('ARLags',1,'MALags',1,'Variance',garch(1,1));
T = length(ninR);
EstWin = 500;
p = 0.05;
NumObs = 1;
NumPaths = 1000;
VaR = NaN(T,1);
ES = NaN(T,1);
Simu = NaN(T,NumPaths);
```

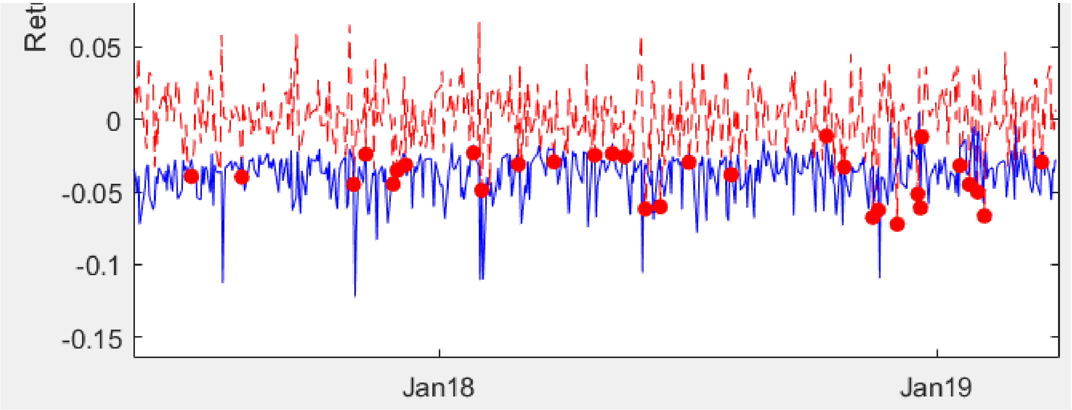
```
%%
for t = EstWin+1:T
    try
        EstMdl = estimate(Mdl,ninR(t-EstWin:t-1));
        [Innovations, Variances] = infer(EstMdl, ninR(t-EstWin:t-1));
        Simu(t,:) = simulate(EstMdl,NumObs,'NumPaths',NumPaths,...
            'E0',Innovations,'V0',Variances);
        VaR(t) = min(prctile(Simu(t,:), 5));
        ES(t) = mean(prctile(Simu(t,:),1:5));
    catch
        VaR(t) = min(prctile(ninR, 5));
        ES(t) = mean(prctile(ninR,1:5));
    end
end
```

Plot VaRs & Corresponding Violations

Conditional model reacts to the volatility quickly in light of higher volatility in returns.




```
%%
dates = data.Date(EstWin + 1:T);
figure(1)
plot(dates,ninR_TstWin,'r--', dates, VaR_TstWin,'b');
hold on
plot(dates(index),ninR_TstWin(index),'r.','markersize',20)
xlabel('Dates');ylabel('Returns & VaR');title('VaR &
Violations');
datetick('x',12);xlim([dates(1) dates(end)]);
```



Calculate Violation Ratio & Significance Test

```
VR = length(find(index))/(p *(T - EstWin));% Violation Ratio
s = std(VaR(EstWin + 1:T));% Volatility
ber = bern_test(p,v); % p is significant level,5%; v is 0-1ogical vector indicating violations
ind = ind_test(v);
```

- Violation Ratio is close to 1. This indicates the model performs well in capturing extreme outcomes.

Violaiton Ratio	***0.9775***
Volatility	*0.0298*

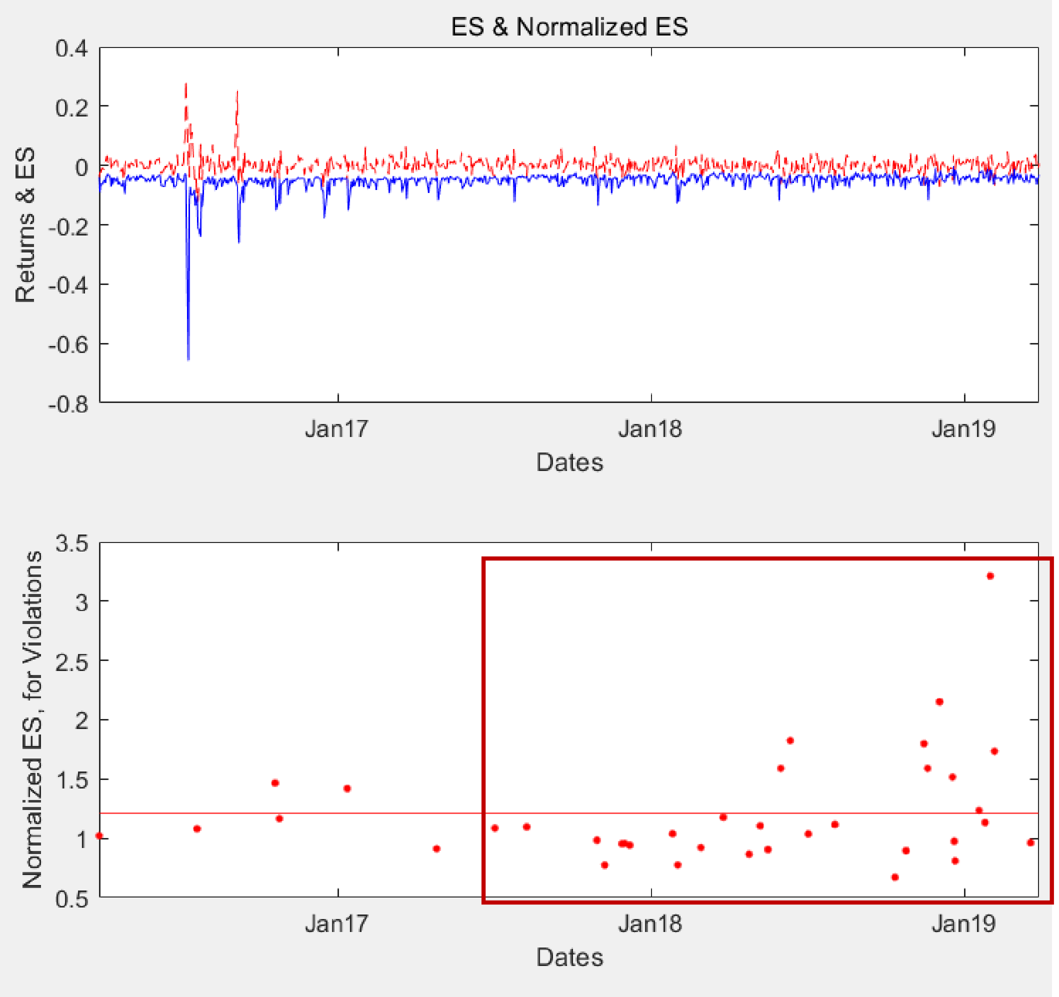
- With no comparison, we can not conclude if it is high or low. But from the previous plot, we can see a higher volatility in VaR corresponding to higher volatile returns.

	Coverage Test		*Independence Test*	
ARMA(1,1)-GARCH(1,1)	*Test Statistic*	*P-value*	*Test Statistic*	*P-value*
	0.0202	*0.8869*	*0.4251*	*0.5144*

- For a 95% significant level, the statistics should be greater than 3.84 based on a Chi^2(1)
- Bernoulli coverage test is not significant. We can not reject the hypothesis of VaR = 1 at 5% for this model.
- Independence test is not significant. We can not reject the hypothesis that VaR is dependent on the volatility of 1-day before for this model.

$$VR = \frac{\text{Observed number of violations}}{\text{Expected number of violations}} = \frac{v_1}{p \times W_T}.$$

Plot ESs & Standardized ESs for Violations



$$NS_t = \frac{y_t}{\mathrm{ES}_t}$$

Average Standardized ES = 1.2139

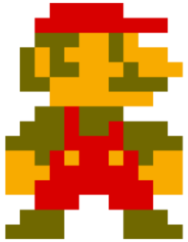
- This model slightly underestimate the ES for violations, which in hypothethis should have an expectation of 1.

- The Standardized ES for violations are more clustered in recent years.
- It also shows a wider range.

Conclusions & Improvements

- ARMA(1,1)-GARCH(1,1) model captures extreme results quite well as indicated by the 0.9775 VR.
- By testing, we can not reject VR = 1.
- More violations clusters in recent years.
- VaRs calculated from conditional model show a simultaneous volatility with the returns.
- There is a slightly underestimation for ES as shown in Ave Std ES > 1.

- The returns of Nintendo is relatively steady without many breaks. It remains unknown if this model applicable for other assets.
- There are more violations clustering in recent years. We can choose these years as a separate back testing dataset to see if this model still works well.



Thank you!

Q & A