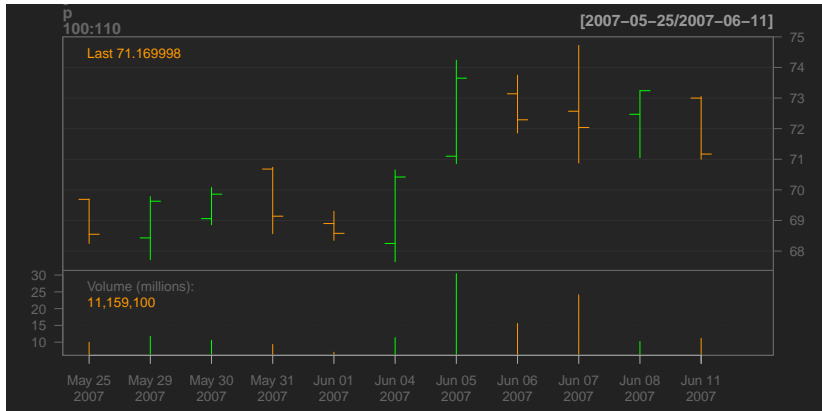


# Financial Time Series

P. Hénaff

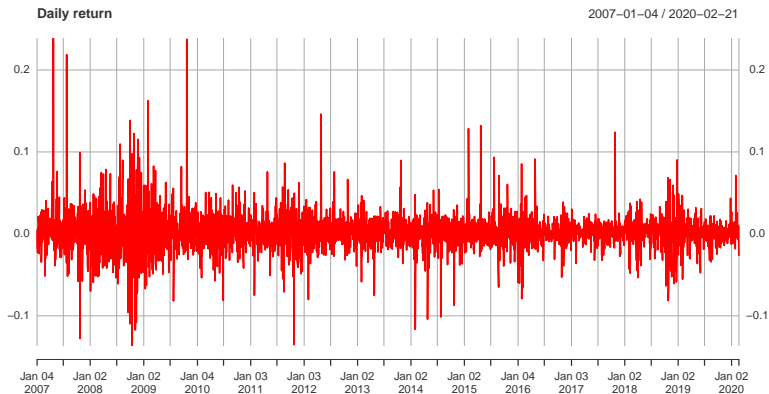
Version: 17 Dec 2024

# Financial Time Series (daily OHLC)

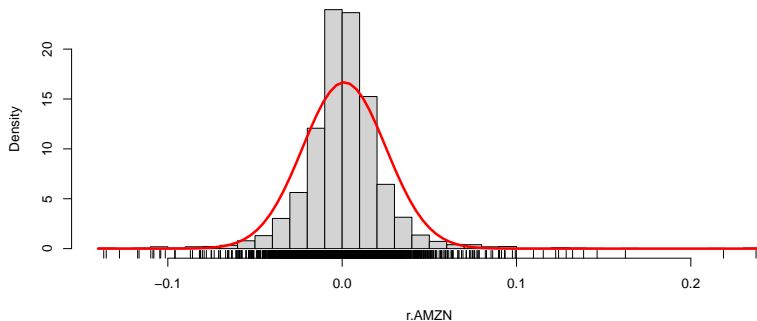


# Daily Return - AMZN

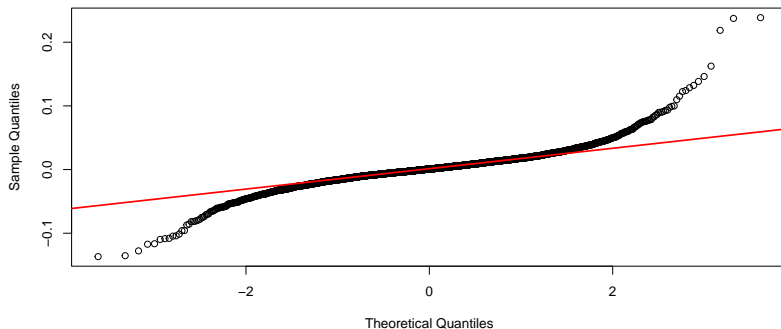
$$r_t = \log \left( \frac{P_t}{P_{t-1}} \right)$$



## Histogram of daily return - AMZN



## Analysis of return distribution - AMZN

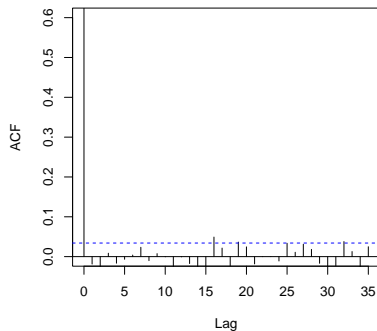


## Moments of daily returns

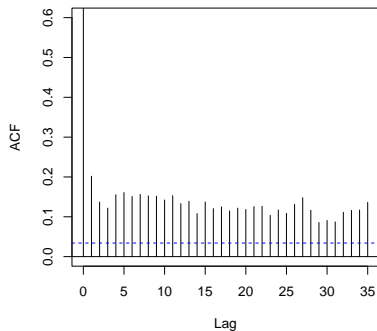
	mean	std dev	skewness	kurtosis
AMZN	0.0012075	0.0239215	0.9530444	12.859279
GOOG	0.0005604	0.0178051	0.5011199	11.504737
AAPL	0.0010301	0.0196726	-0.4681109	7.182435
QQQ	0.0005412	0.0130159	-0.1804299	6.992014
DIA	0.0003516	0.0114022	0.2151165	15.408315
SPY	0.0003397	0.0121101	-0.1558448	14.120228
PG	0.0003238	0.0109203	-0.1052706	7.853350
KO	0.0004433	0.0112445	0.2437227	12.933217

# Autocorrelation of Returns (AMZN)

autocorrelation of  $r(t)$



autocorrelation of  $|r(t)|$



## Rescaling daily return by $\sigma(r_{t-1})$ (Chen, Jayaprakash, and Yuan 2008)

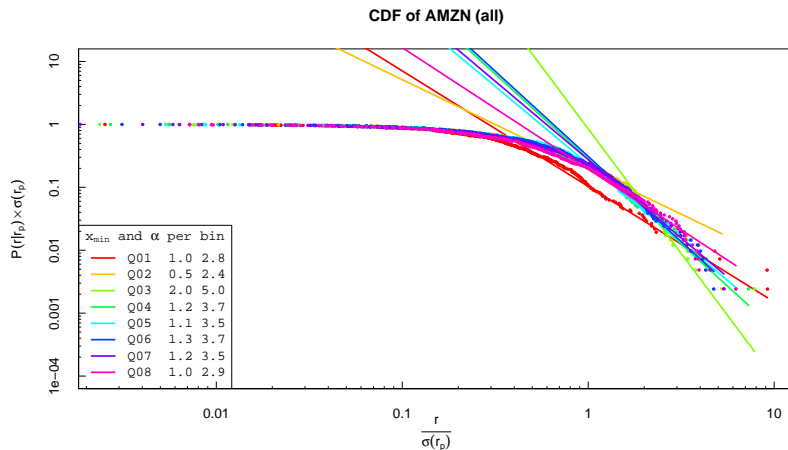
$$z_t = \frac{r_t}{\sigma(|r_{t-1}|)}$$

The density of  $z_t$  can be approximated by a power law. See paper for details of calculation.

$$\left. \begin{aligned} p(z_t) &= \frac{\alpha - 1}{z_{min}} \left( \frac{z_t}{z_{min}} \right)^{-\alpha} \\ Pr(z_t > x) &= \left( \frac{x}{z_{min}} \right)^{-\alpha+1} \end{aligned} \right\} z_t > z_{min}$$



# Rescaling of daily return by $\sigma(|r_{t-1}|)$



## Unconditional distribution of return

The Johnson family of distributions is formed by various transformations of the normal density. Let  $X$  be the observed data, and define  $Z$  by:

$$Z = \gamma + \delta \ln \left( g \left( \frac{X - \xi}{\lambda} \right) \right)$$

where:

$$g(u) = \begin{cases} u & SL \\ u + \sqrt{1 + u^2} & SU \\ \frac{u}{1-u} & SB \\ e^u & SN \end{cases}$$

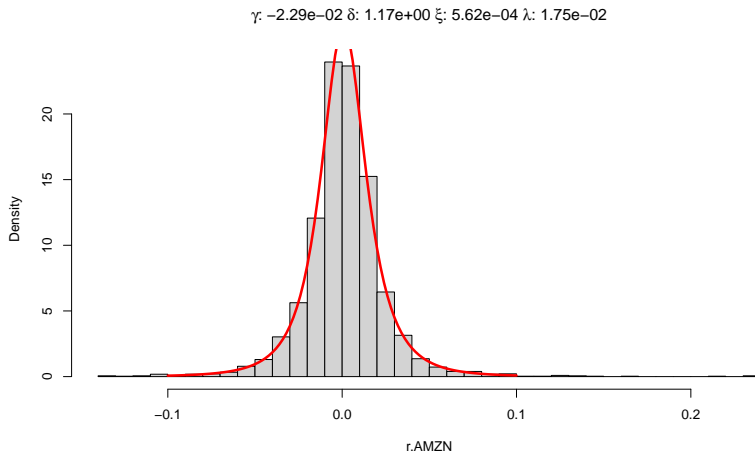
$X$  follows a Johnson distribution if  $Z$  is normal.

## Fitted Johnson SU distribution - AMZN (1)

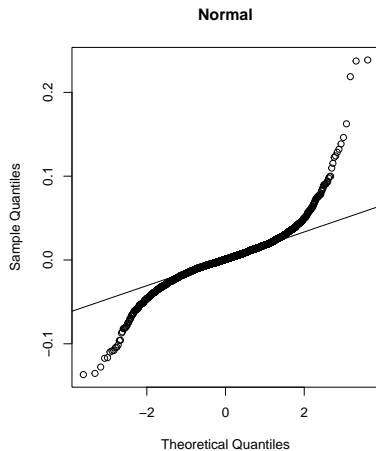
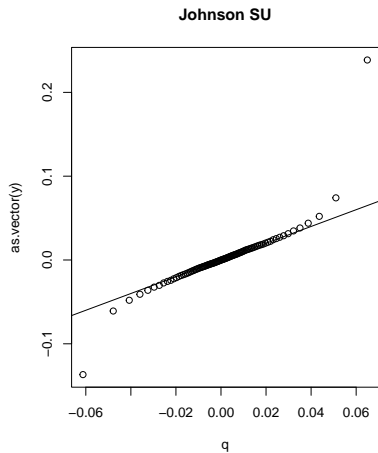
gamma	delta	xi	lambda	type
-0.0228945	1.16685	0.0005621	0.0174527	SU

	sample	johnson
mean	0.0012075	0.0010565
sigma	0.0239179	0.0225752
skew	0.9530444	-0.1098671
kurt	12.8592791	12.3022551

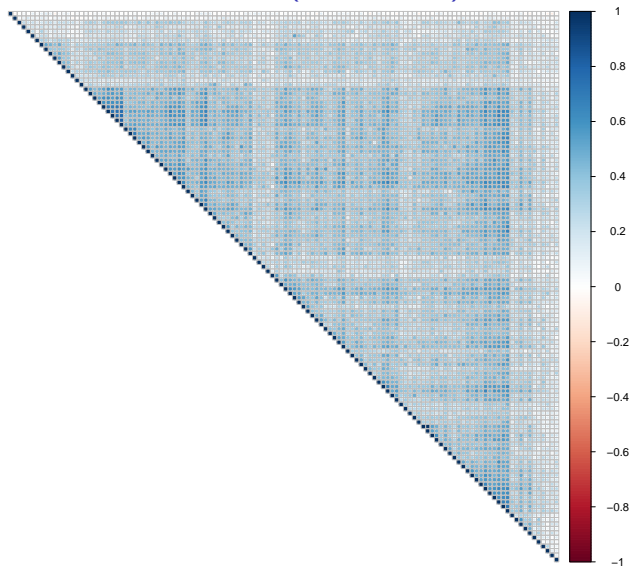
## Fitted Johnson SU distribution - AMZN (2)



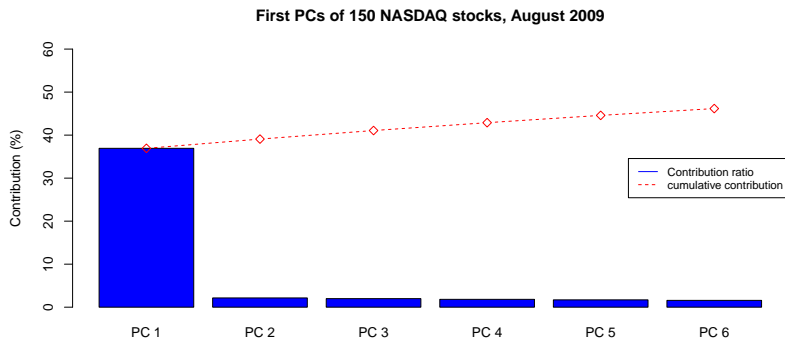
# Fitted Johnson SU distribution - AMZN (3)



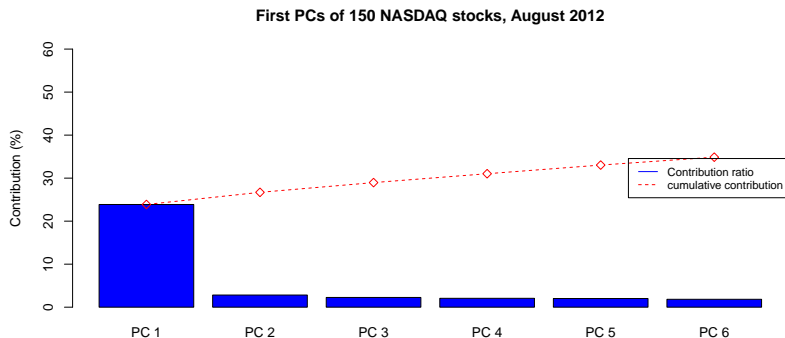
## Correlation between assets (NASDAQ)



# Correlation between assets



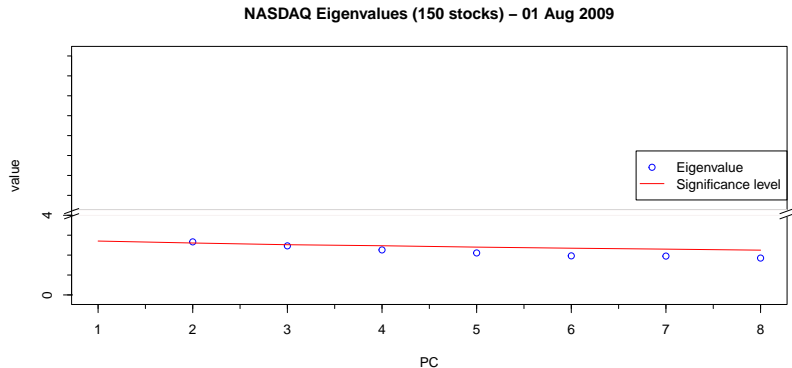
# Correlation between assets



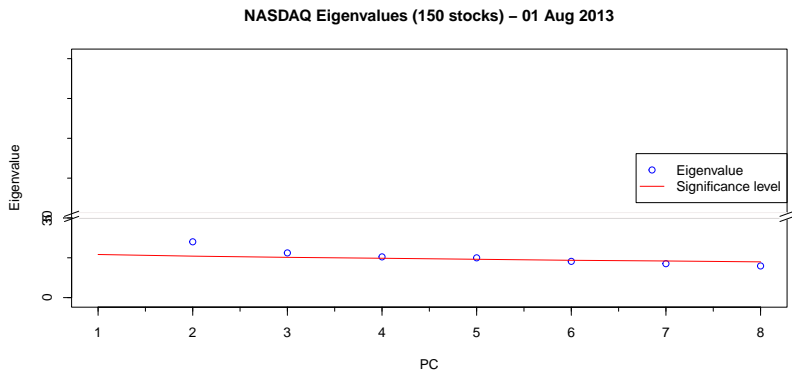


## How many dimensions in a market?

Significance level (95%) for eigenvalues (252 observations, 127 variables):



# How many dimensions in a market?



## Summary

To summarize, empirical observations show that the distribution of returns exhibit features that strongly depart from the classical hypothesis of independence and normality. We find:

1. no evidence of linear autocorrelation of return, however,
2. there is an observable autocorrelation of  $|r_t|$  and  $r_t^2$ , suggesting autocorrelation in the volatility of return,
3. we also observe large excess kurtosis, which is incompatible with normal density,
4. The rank of a broad stock market such as the NASDAQ is probably much lower than the number of stocks.

## Bibliography

Chen, Kan, C Jayaprakash, and Baosheng Yuan. 2008.  
“Conditional Probability as a Measure of Volatility Clustering in  
Financial Time Series.” *Physica A*, 1–5.  
<https://arxiv.org/abs/0503157v2>.