A Study on the Foreign Exchange Market

Chonkit Pun

Tianchi Chen

Outline

- Intro to foreign exchange
- Time series analysis
  - Exchange rate and correlation of return
  - Arbitrage of return and bid-ask spread

Introduction:
Foreign Exchange(Forex)

- Decentralized (as oppose to stock exchange)
- Trade 24 hours a day, 5 days a week
- High liquidity
- Spot market
- Future/forward market

Mechanism

- USD/EUR: how much EUR does 1 USD buy
- Ask: price to buy the base currency
- Bid: Selling price of the base currency
- Bid-ask spread: difference between bid and ask

USD/CAD = 1.2000/05

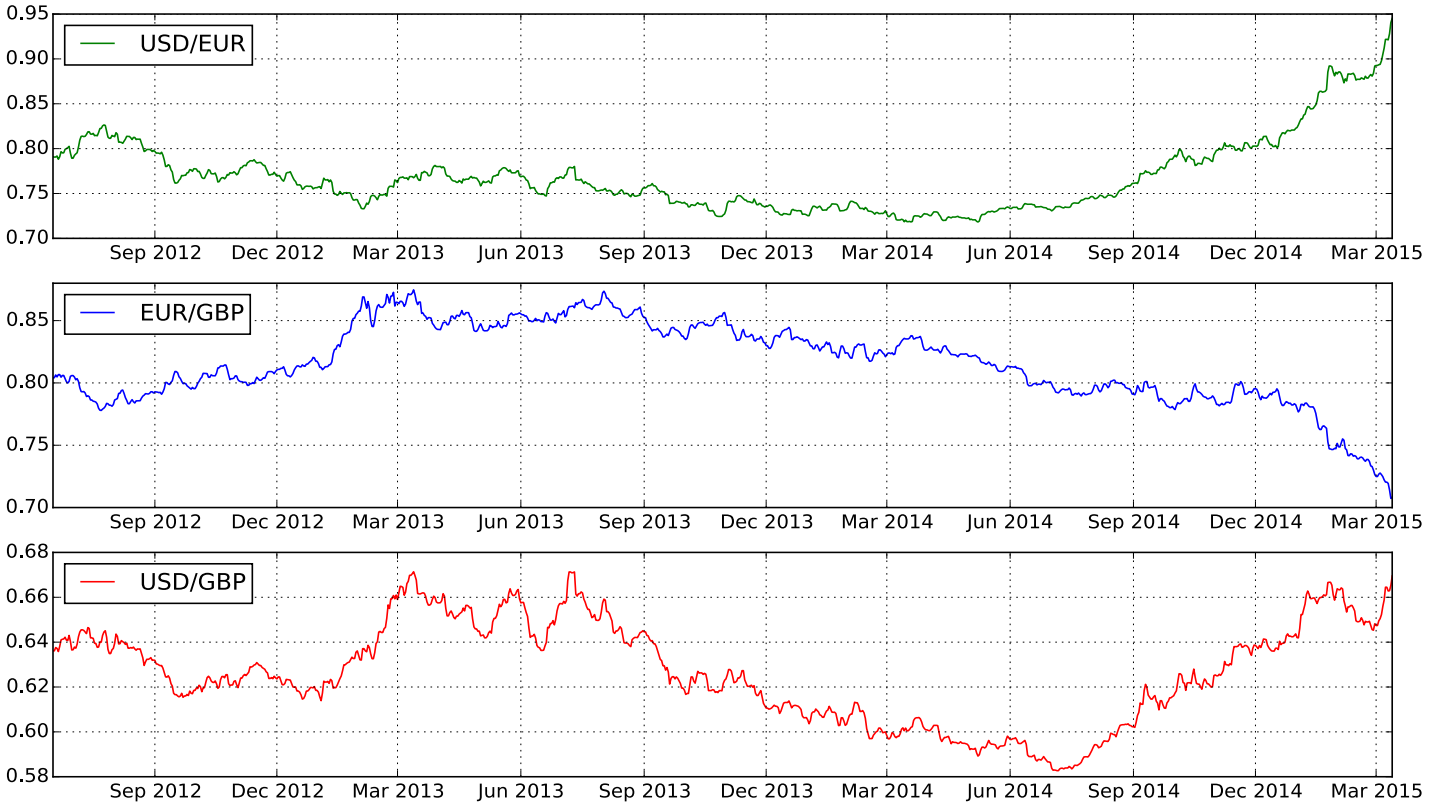
Bid = 1.2000

Ask= 1.2005

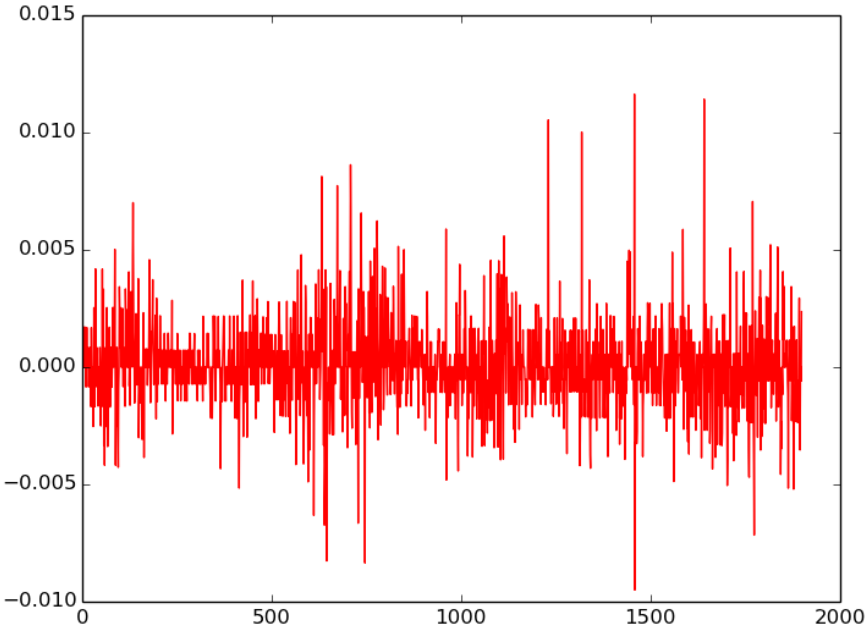
Spot market

- Exchange rate depends on supply and demand
- Factors:
  - Inflation rate: high inflation=>lower money value
  - Interest rate: high interest rate=>higher money value
  - Terms of trade: import > export => lower money value

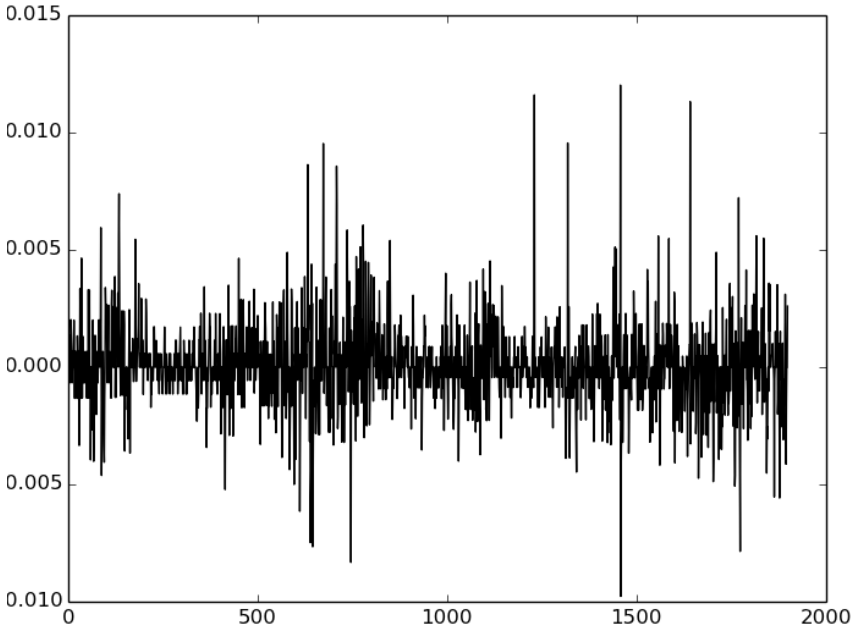
Time series analysis I: return of exchange rate and correlation



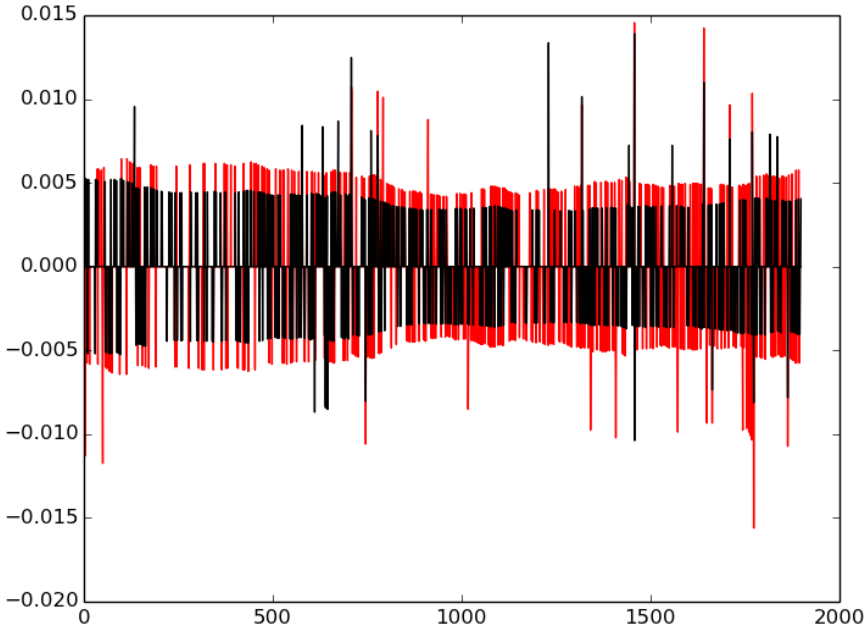
Return of exchange rate



JPY/CNY

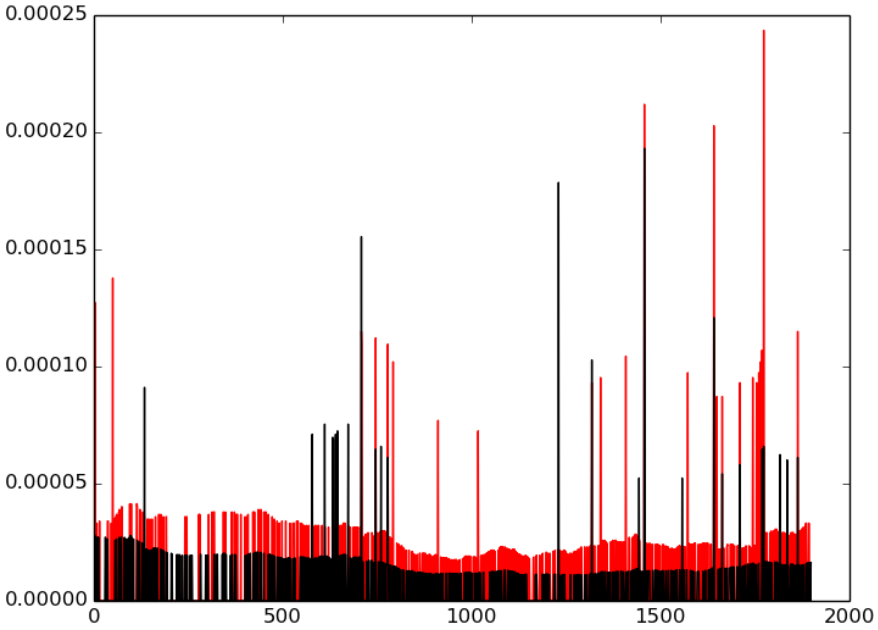


JPY/HKD



Time series of log return of JPY/EUR (black) and JPY/USD (red)

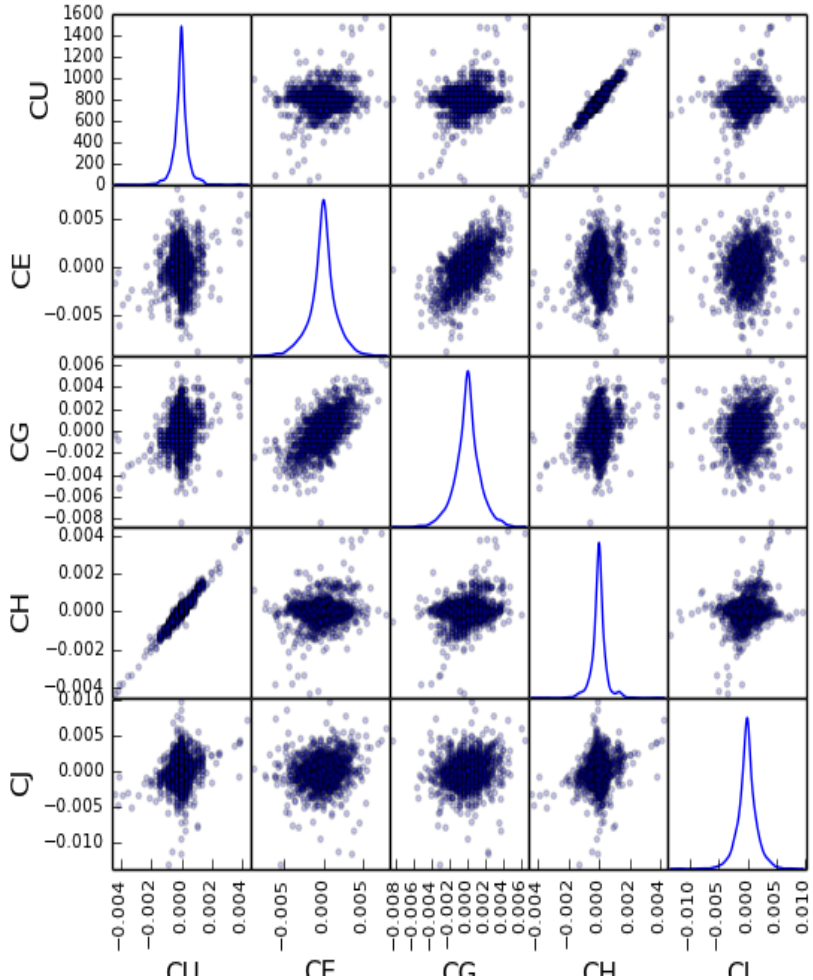
R=Log return plot

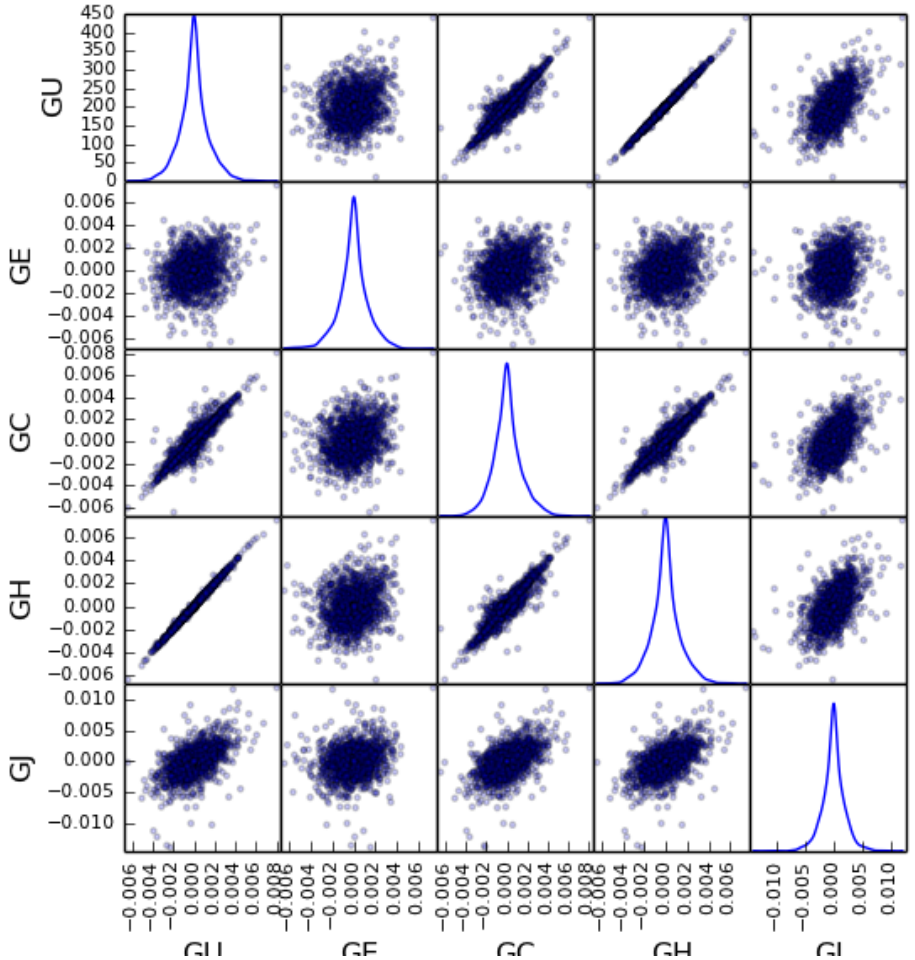


Volatility=R^2

2-d scatter plot could give us more information of how two currency correlate

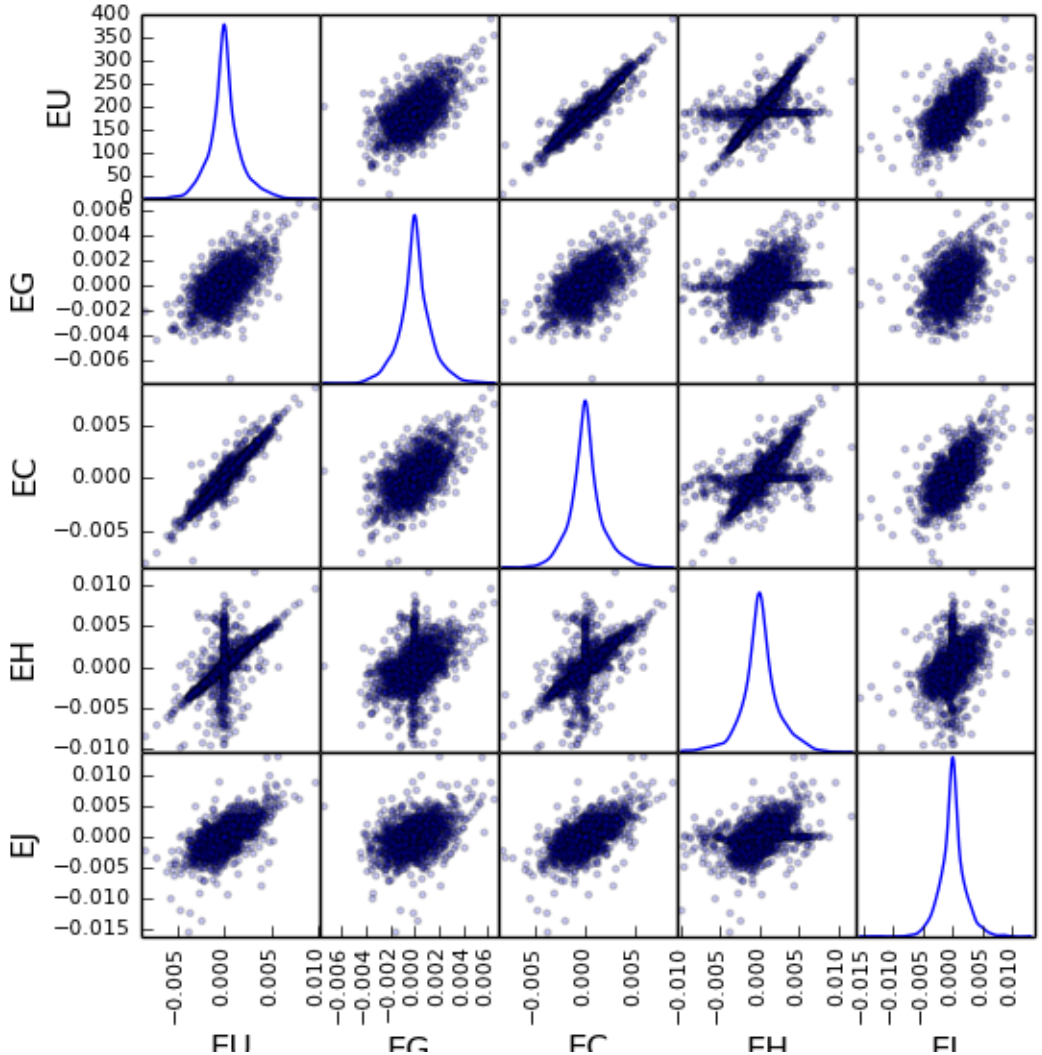
Four categories





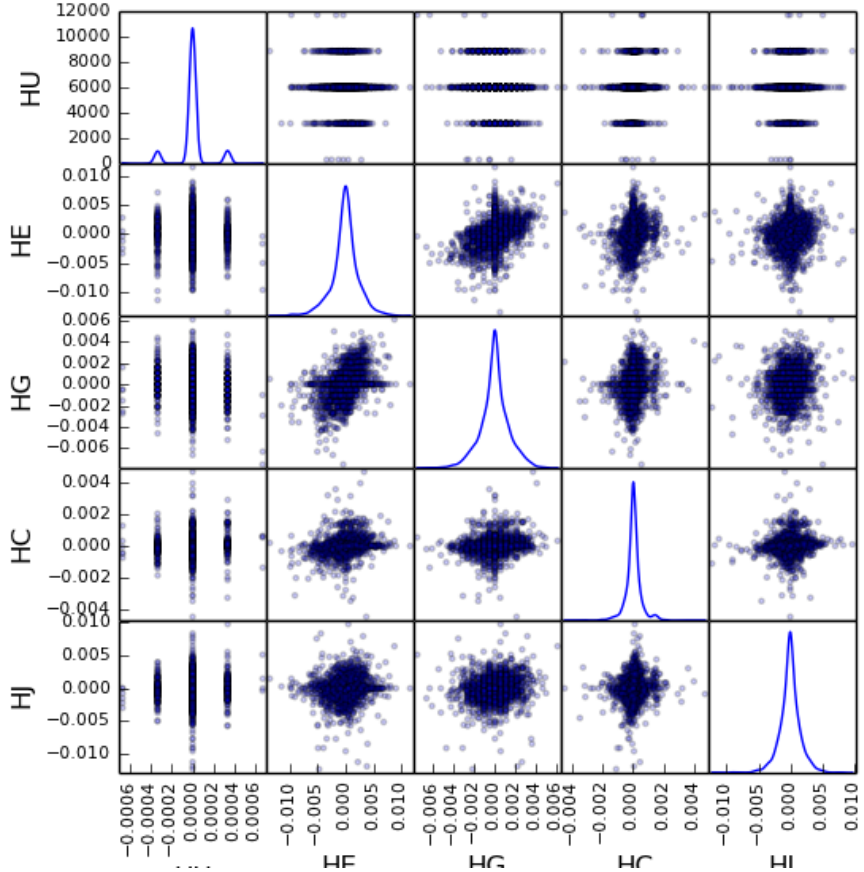
C and G shows more fuzziness

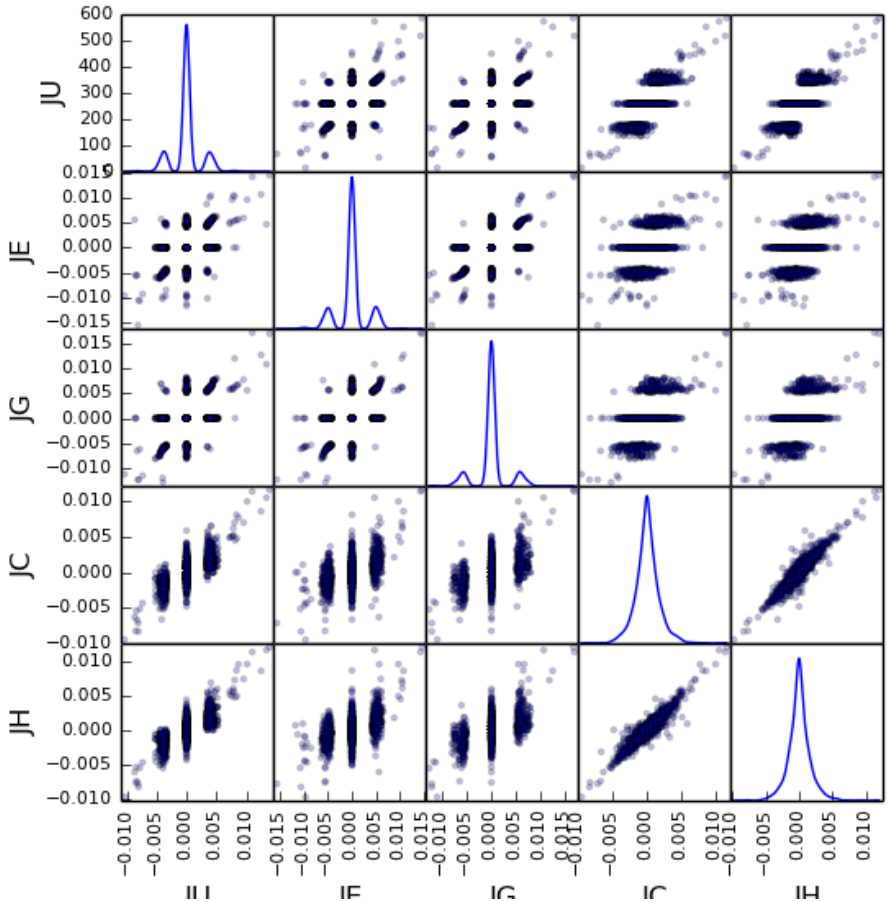
EUR shows some uncertain correlation



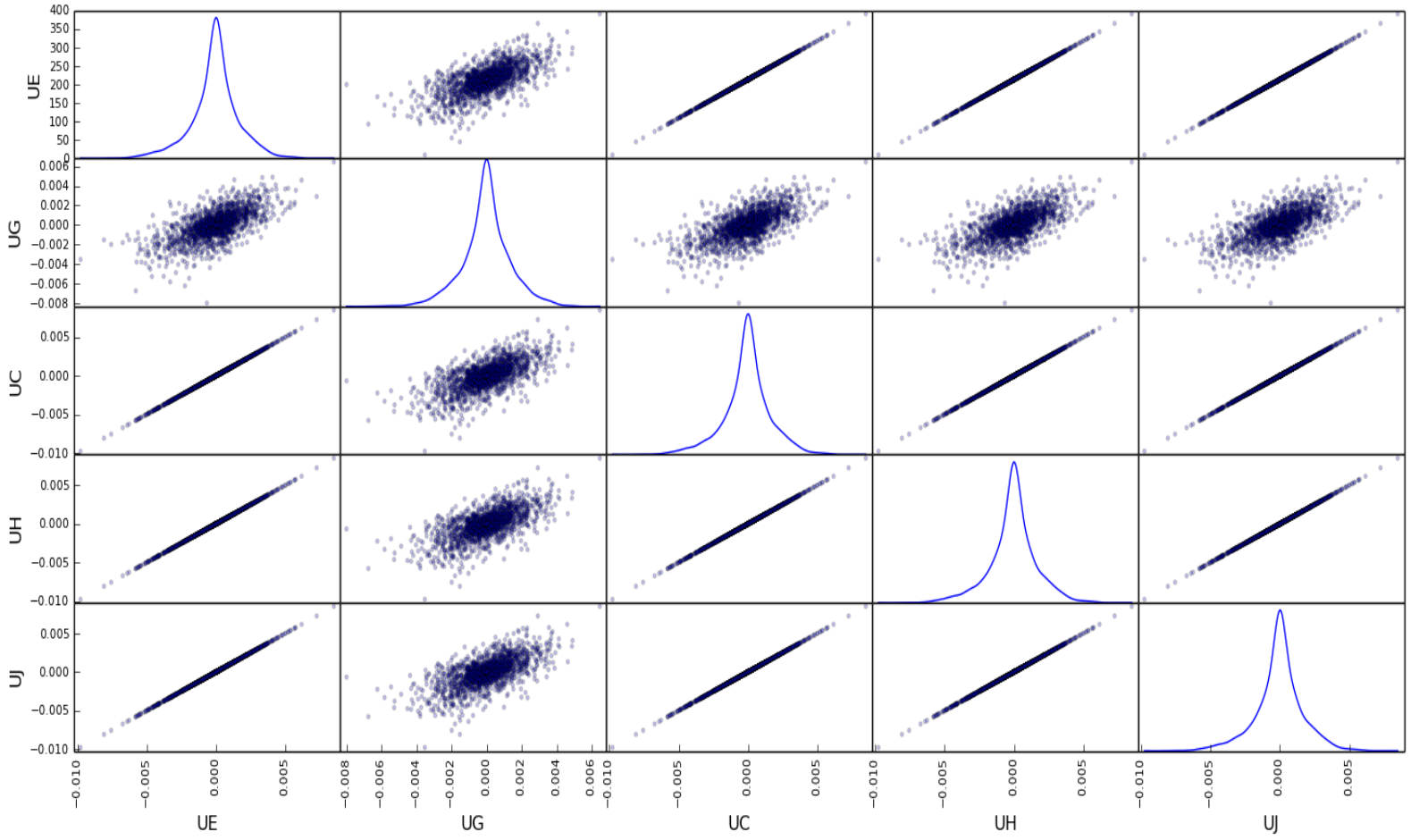
H and J shows “Discreteness “ along with correlation

2-d scatter plot can tell us more about how two currency correlate via a third currency

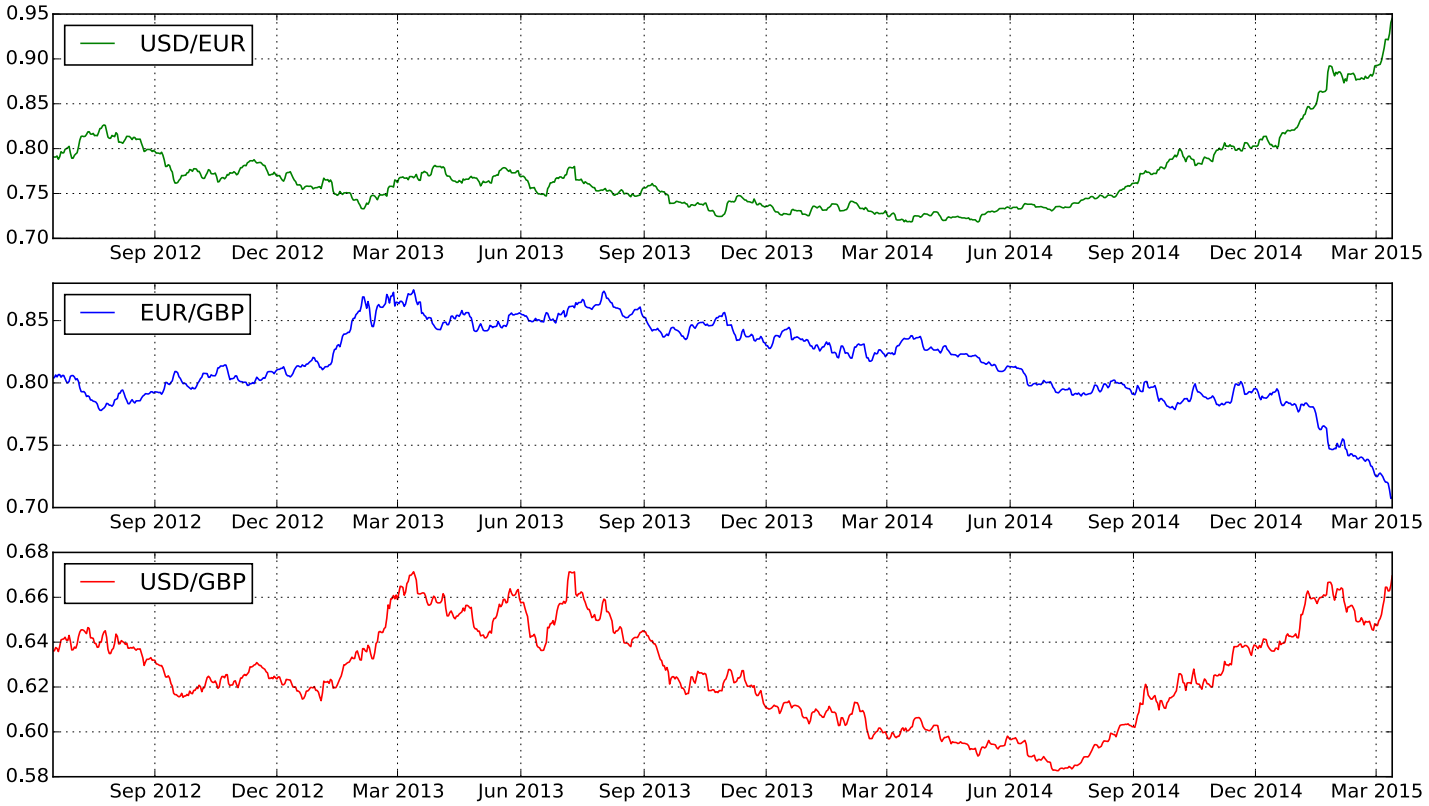




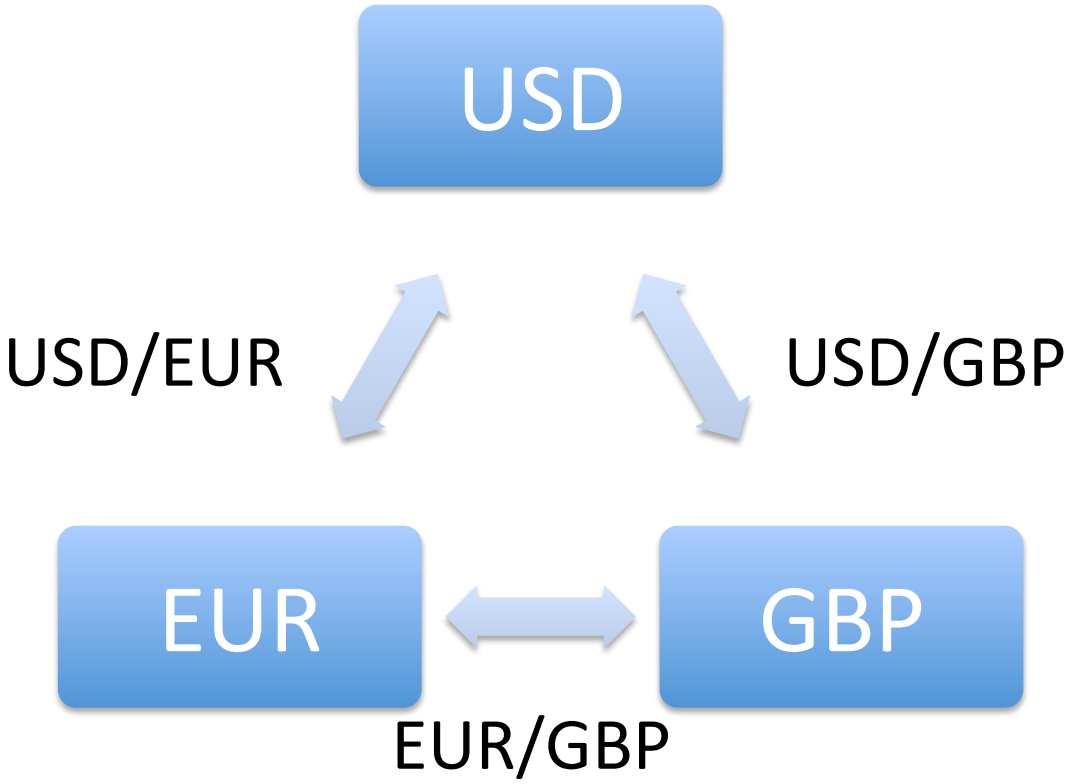
Most stable one if USD



Time series analysis II: arbitrage of return and bid ask spread



The triangle arbitrage



At particular moment, if (USD/EUR)b*(EUR/GBP)b*(GBP/USD)b =/= 1
, an arbitrage opportunity exist

The triangle arbitrage

- Our data: daily average exchange rate
- Not high frequency data (of order ms→s)
- Arbitrage does exist, but dissipates very quickly ,of order of 10s (Danial Fenn, University of Oxford)
- Look at 'arbitrage' of return instead:

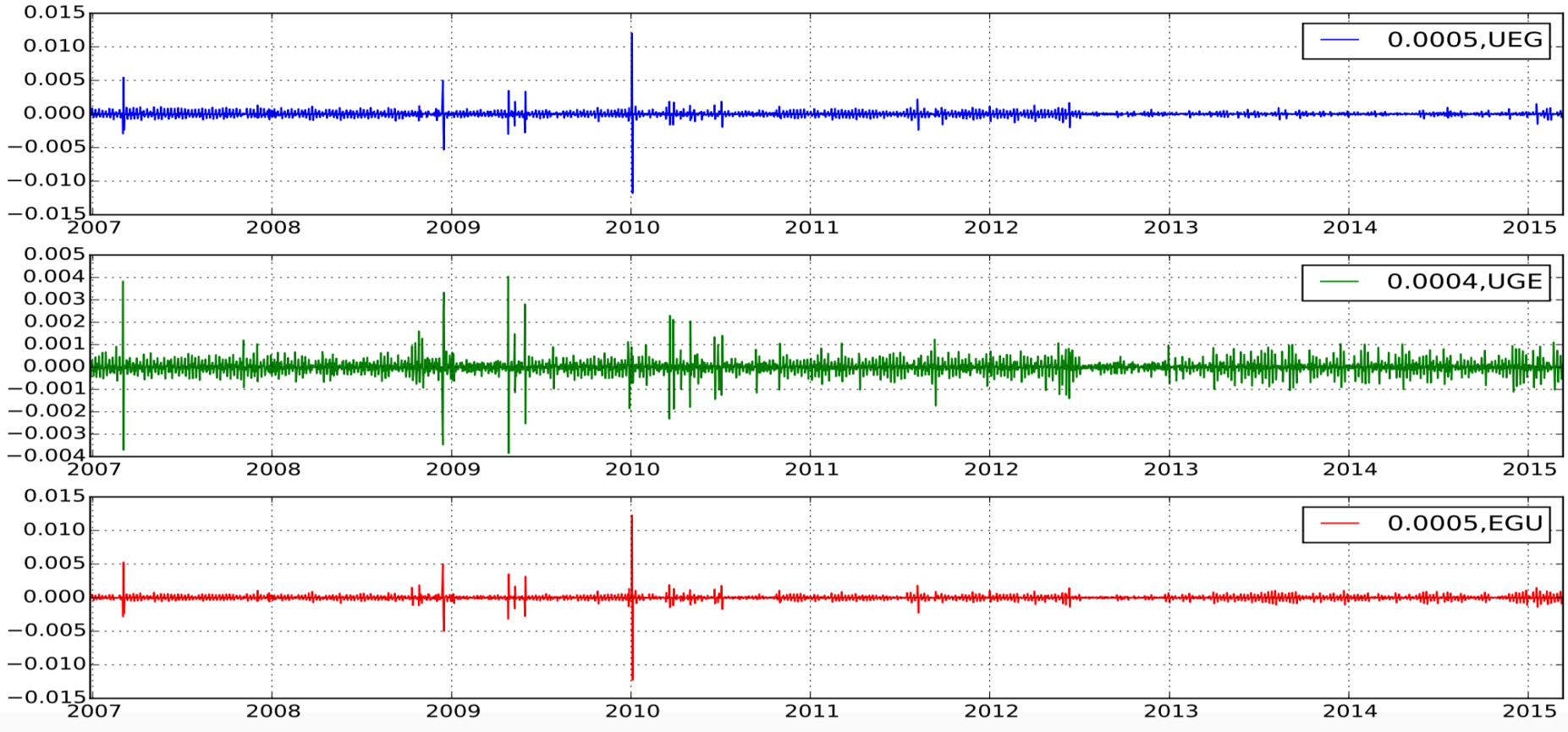
$$\text{Arbitrage} = R(\text{USD/EUR})_t * R(\text{EUR/GBP})_t - R(\text{USD/GBP})_t$$

Where $R(x)_t = \ln(x(t+1)) - \ln(x(t))$

Time series of (return) arbitrage

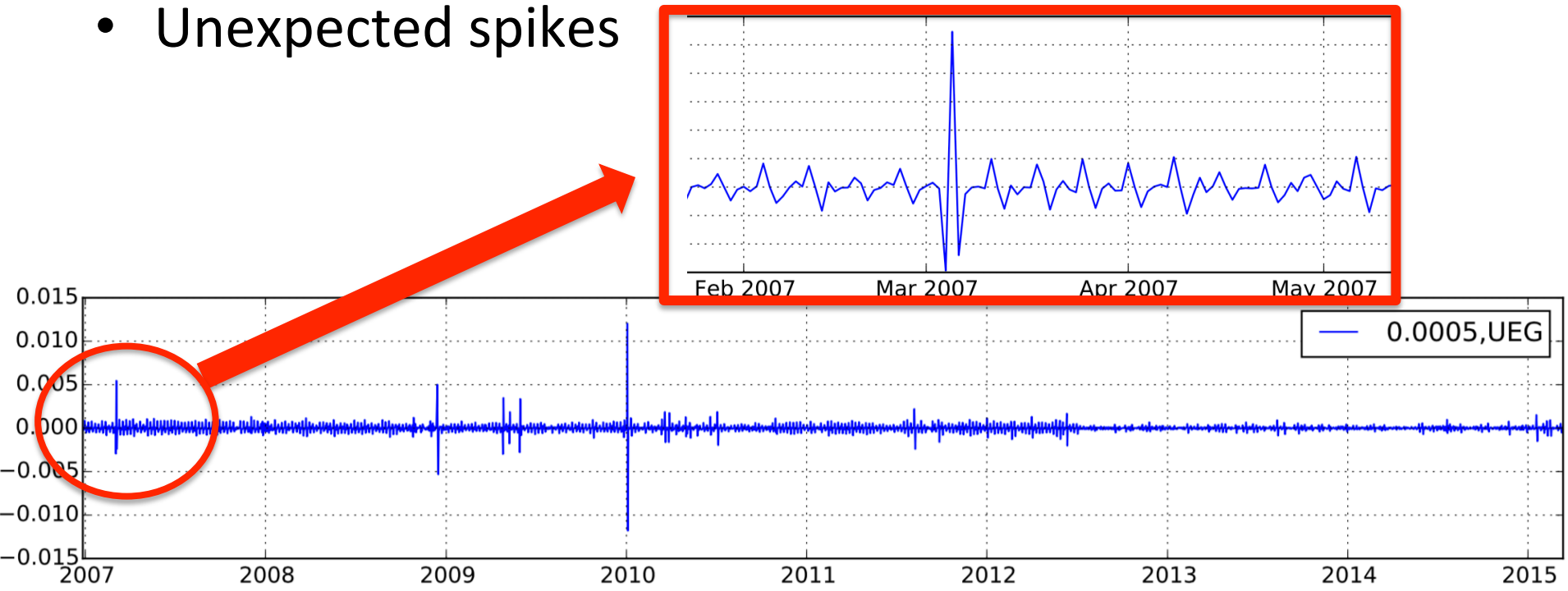
- notation: USD=U, EUR=E, GBP=G

$$UEG = R(USD/EUR)_t * R(EUR/GBP)_t - R(USD/GBP)_t$$



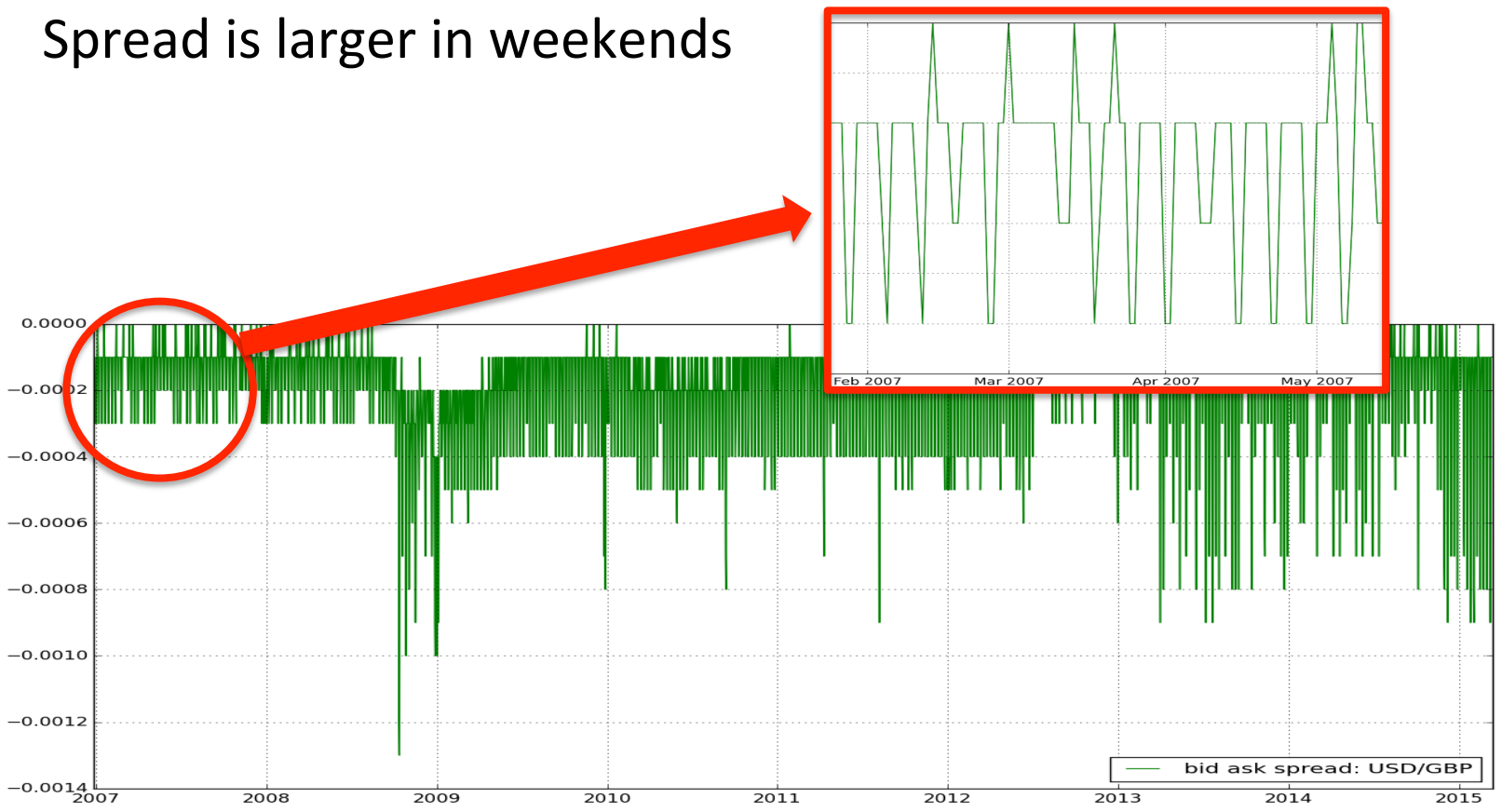
Time series of (return) arbitrage

- Periodic feature (period = 7 days/1week)
- Mean of arbitrage ~ 10^{-8} → 10^{-7} ~ 0
- Unexpected spikes



Time series of bid ask spread(BAS)

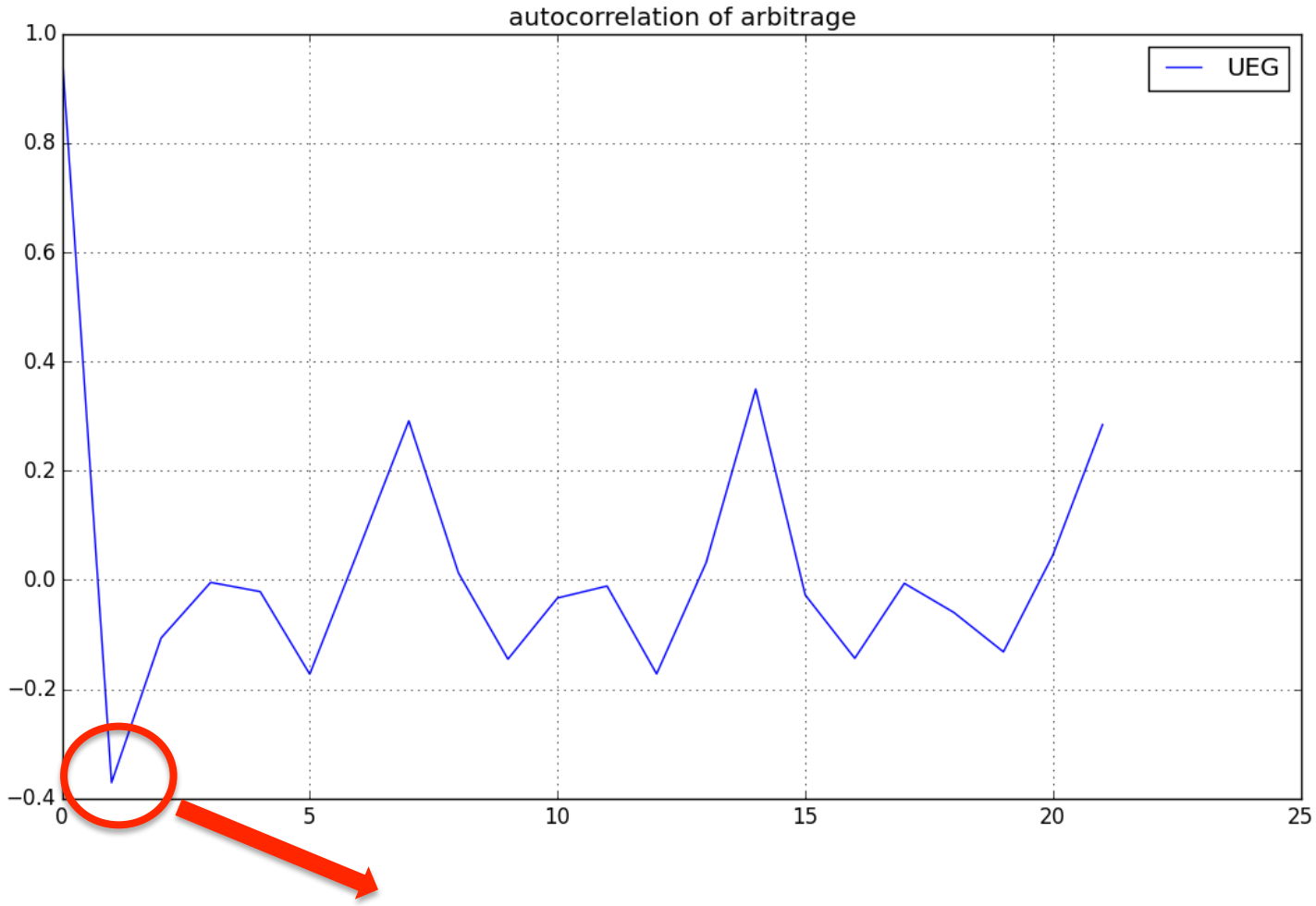
- Bid price – ask price ≤ 0 (always)
- Also exhibit period behavior (period = 7 days)
- Spread is larger in weekends



Arbitrage and BAS

- Comparing the time series of BAS (of UE, EG, UG) and arbitrage of UEG
- Similar pattern: periodic, some spikes in the BAS time series coincide with those in the arbitrage time series

Autocorrelation of arbitrage



Negative autocorrelation at lag-1 (day)

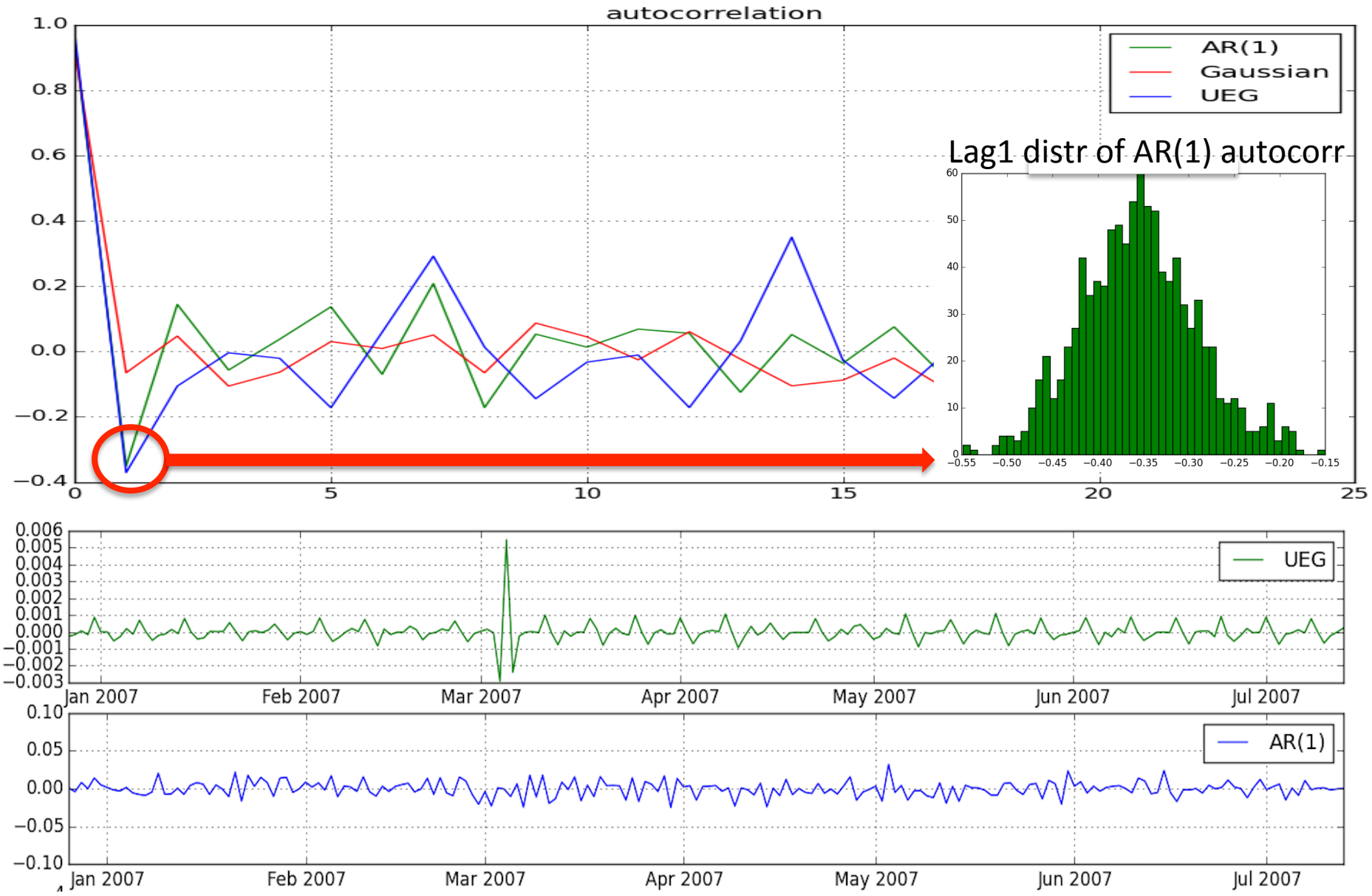
Autoregressive (AR) model

- Negative lag-1 autocorrelation of arbitrage:

→Arbitrage change is negatively related to today's arbitrage

- $R(t+1)-R(t) = -\alpha R(t) + \beta\, \varepsilon(t)$ ← noise term
- $R(t+1) = (1-\alpha)R(t) + \beta\varepsilon(t)$ ←AR(1)
- Can explain the dynamics of the arbitrage time series only in a short observation window (several days)

AR(1) model

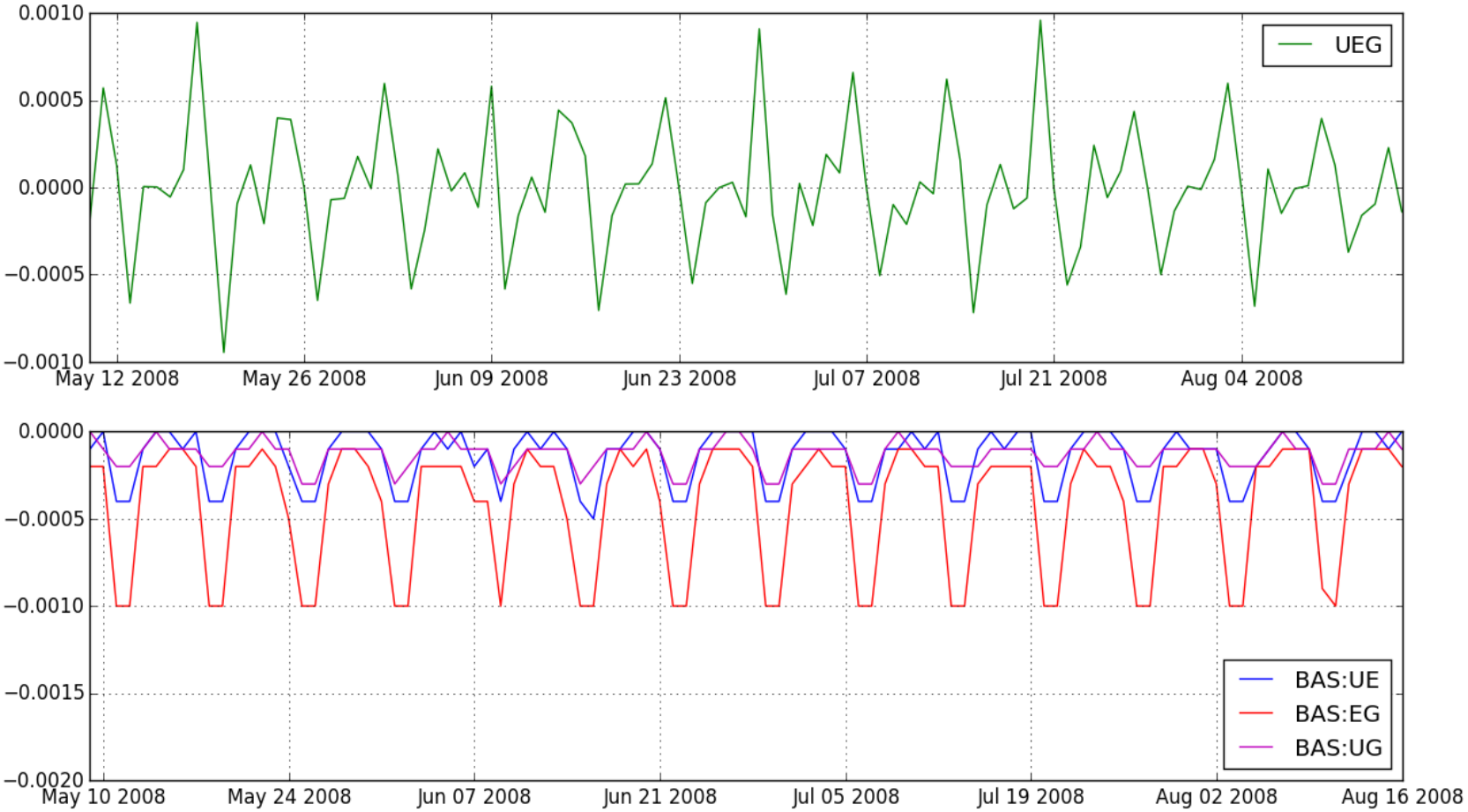

autocorrelation
AR(1)
Gaussian
UEG
Lag1 distr of AR(1) autocorr
UEG
AR(1)
Jan 2007
Feb 2007
Mar 2007
Apr 2007
May 2007
Jun 2007
Jul 2007

AR(1) model

- Can only explain data up to lag 1
- Still cannot explain the periodic behavior of the arbitrage time series and the existence of sudden spikes
- Due to the similarities between the BAS time series and the arbitrage time series, we attempt to model these other features using the BAS time series

BAS vs arbitrage

- Both are periodic with period of 1 week
- Both deviate from zero significantly around weekends

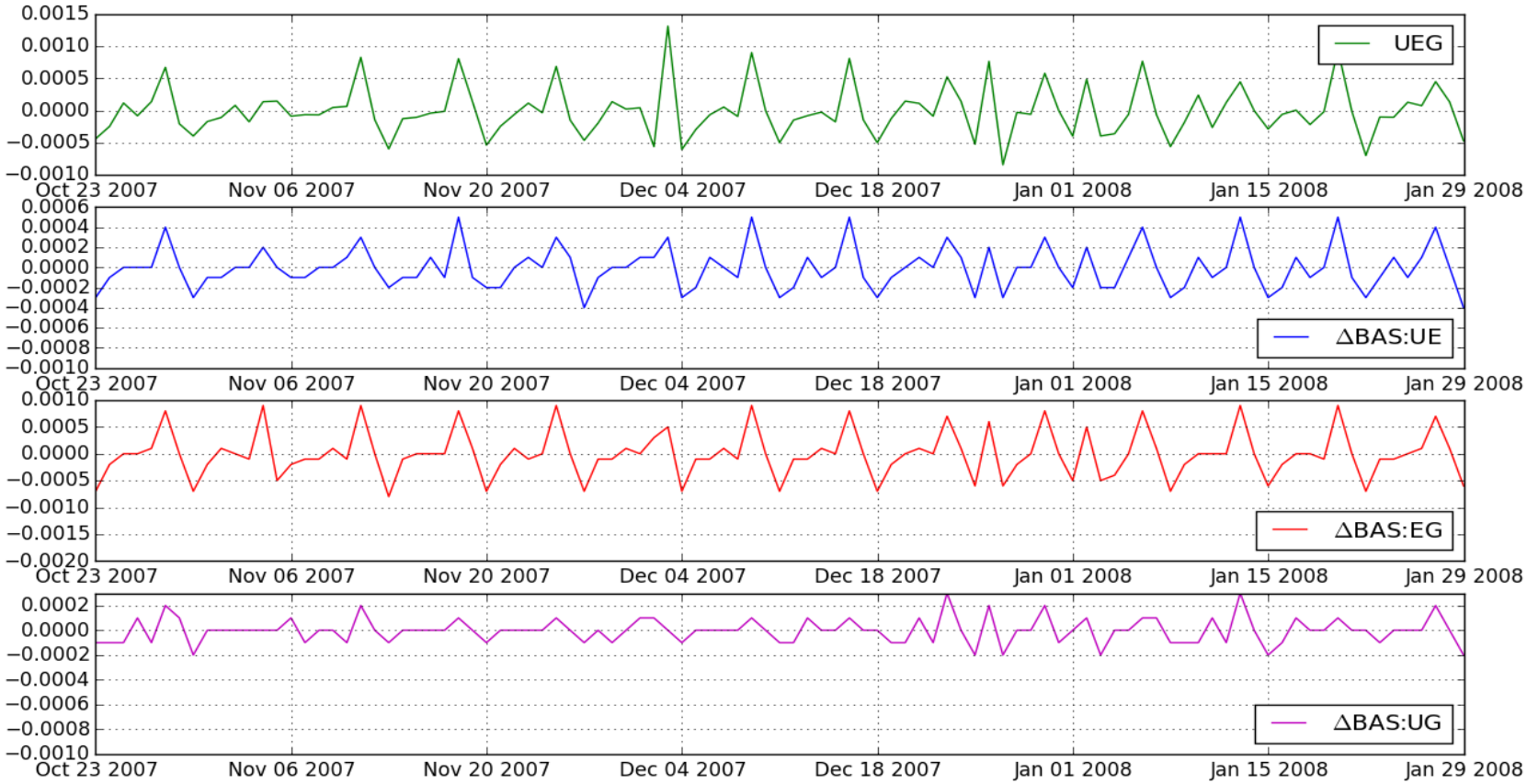


BAS vs arbitrage

- some huge spikes (>0.005) in the arbitrage coincide with those in BAS. The reverse are seen not to be necessarily true

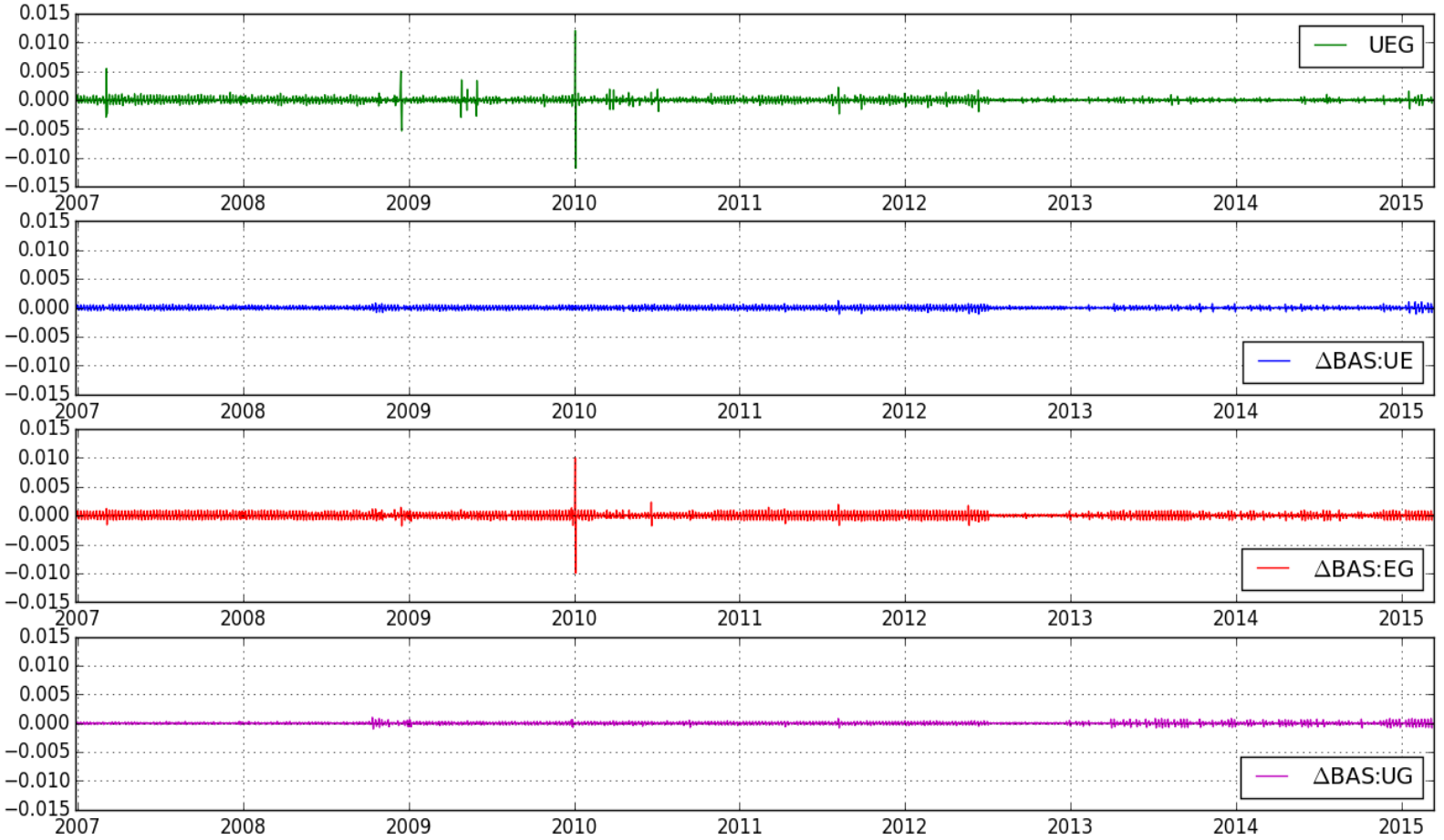
‘return’/change of BAS vs arbitrage(UEG)

- We now look at the change (return) of BAS
- Both has a periodic behavior
- Micro-profile (weekend oscillations) are also quite similar



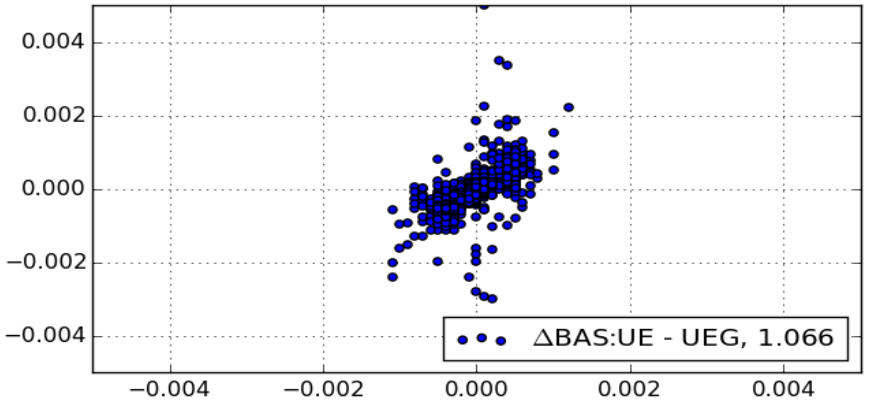
‘return’/change of BAS vs arbitrage(UEG)

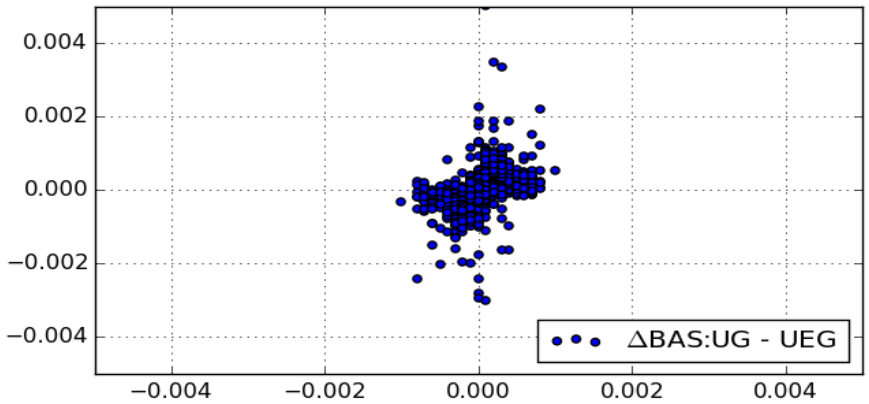
- The macro-profile (spikes) are also similar, but magnitude does not have a right scale

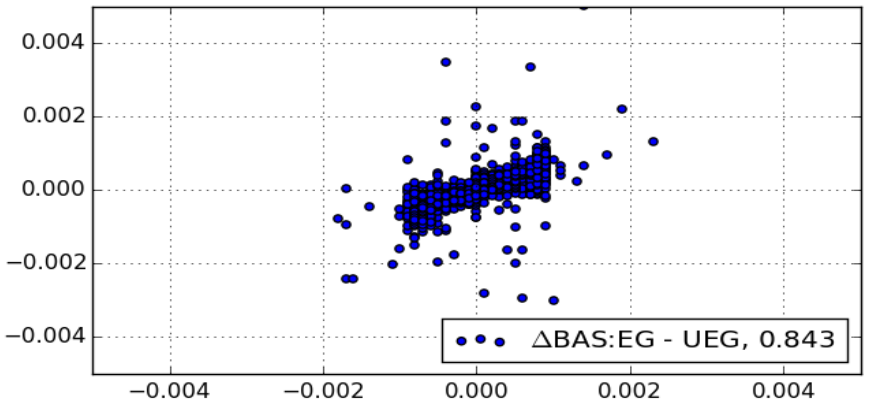


Correlation of ΔBAS and arbitrage (UEG)

- Correlation are strong for UE and EG, not so for UG (2007-2015)

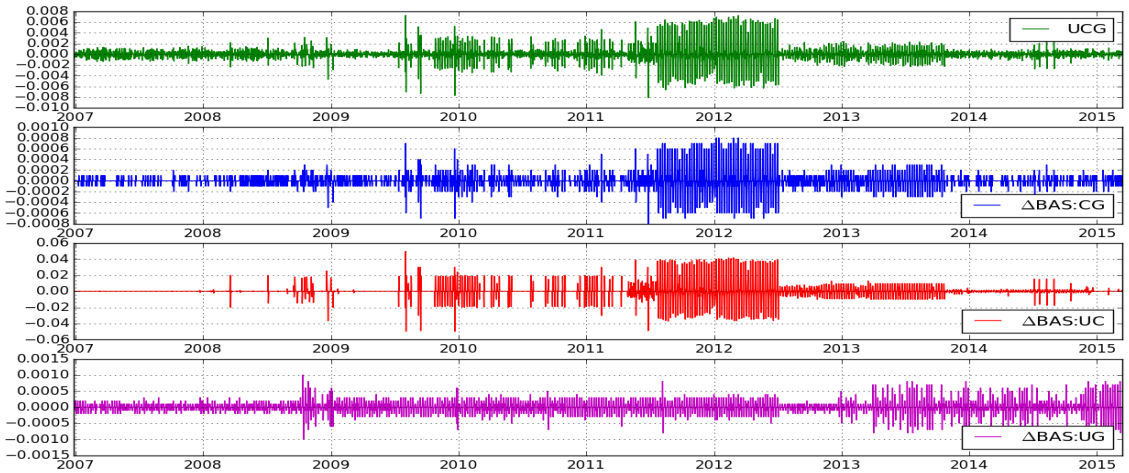


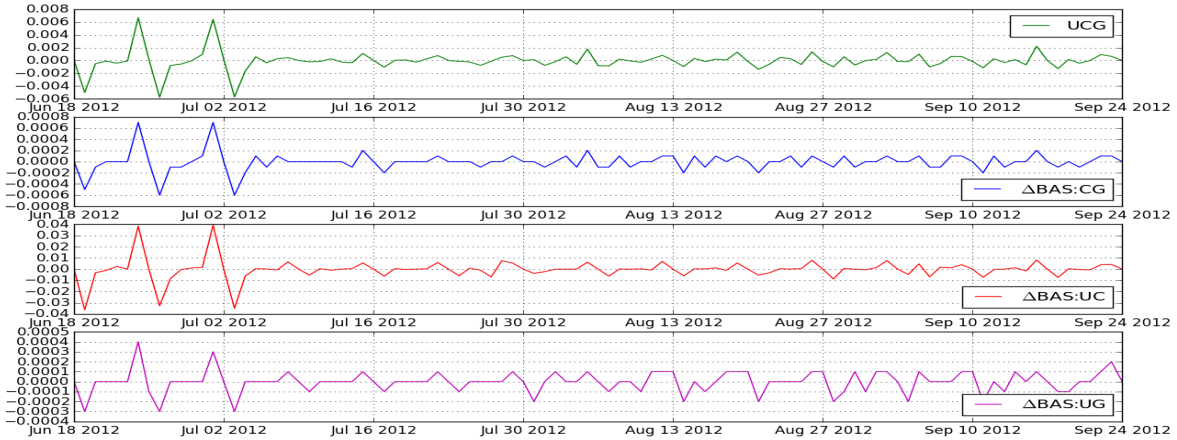




ΔBAS vs arbitrage (UCG)

- R(USD/CNY)*R(CNY/GBP)-R(USD/GBP)
- ΔBAS(UC)
- ΔBAS(CG)
- ΔBAS(UG)





Discussion

- Possible that both ΔBAS and arbitrage are driven by the same underlying factor(s) (e.g. trading volume) which might affect both time series in similar fashion
- Underlying factors that affect the arbitrage might affect the BAS with a different magnitude
- The resolution of our data (daily average) covers up features which might otherwise be visible in high frequency data

Conclusion

- Both arbitrage and BAS deviate from zero largely during weekends
- Macro-profile (huge spikes) are seen to be related in both arbitrage and BAS time series
- Micro-profile (weekly oscillation) are also seen to be related in the two time series
- Other factors are also needed to be consider to understand the arbitrage time series

Reference

- Investopedia
- *Network communities and the Foreign exchange market*- Daniel Fenn, University of Oxford