

Long memory motifs persistence in market structure dynamics

Jeremy Turiel, Tomaso Aste

University College London

Outline

- ▶ Temporal network from exponential smoothened weighted correlations
- ▶ Filter correlation matrices with TMFG
- ▶ Check for soft persistence of TMFG motifs in time
- ▶ Identify motif properties in identifying structures
- ▶ Apply motif findings to portfolio construction

Market, Systemic Sector Risk

- ▶ Not all sectors are persistently correlated
- ▶ Strong correlations do not imply persistent correlations in time
 - important to diversify future risk
- ▶ Motifs identify more persistent correlation structures
- ▶ Identify country market stability and structure from decay law
- ▶ Motifs identify persistently correlated sectors - diversify sector risk
- ▶ Large persistent motif components (motif chains) indicate potential for systemic risk

Power Law Decay Regimes

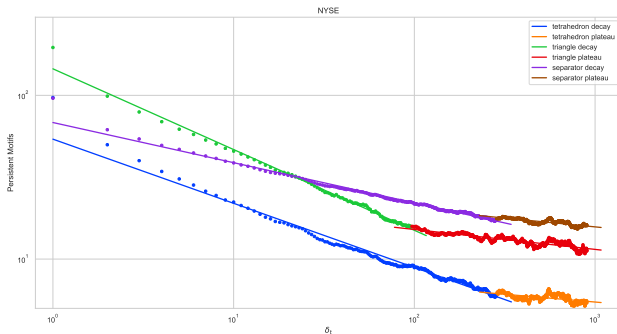


Figure 1: Decay of triangular clique faces, separators and clique motifs overlap between layers for 100 NYSE stocks, as a function of time shift $\tau = [0, 900]$ (average over 200 values of t). The two power-law regimes are identified by the minimum MSE sum of the fits.

Normalised Power Law Decay Regimes

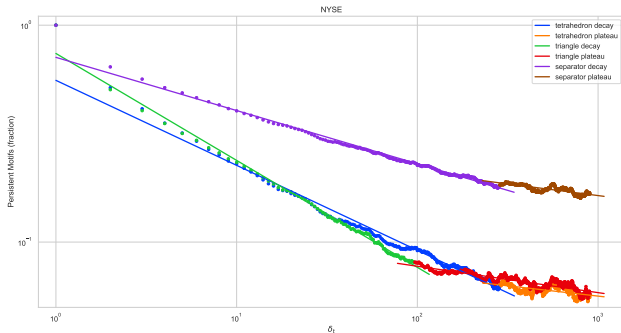


Figure 2: Decay of triangular clique faces, separators and clique motifs overlap between layers for 100 NYSE stocks, as a function of time interval $\delta_t = [0, 900]$ (average over 200 simulations). The two power-law regimes are identified by the minimum MSE sum of the fits.

Motif Persistence Decay Exponents - Market Stability

Table 1: Exponents for the decay power law regime identified by MSE in different sample markets. The analysis refers to 100 randomly selected stocks amongst the 500 most capitalised, over time intervals $\tau = [0, 900[$ and $t = [0, \dots, 200[$ different initial temporal network layers.

Market	Clique Exponent	Triangular Motif Exponent	Clique Separator Exponent
NYSE	-0.392	-0.493	-0.245
Germany	-0.792	-0.598	-0.381
Italy	-0.785	-0.811	-0.174*
Israel	-1.024	-0.866	-0.728

* Result compromised by regimes not well identified for edge decay in large systems (≈ 100 stocks)

Edge vs. Motif Persistence - Adjusted Decay Exponents

Table 2: Exponent for the power law decay regime identified by MSE in different sample markets. The analysis refers to 100 randomly selected stocks amongst the 500 most capitalised, over time intervals $\tau = [0, 900[$ and $t = [0, \dots, 200[$ different initial temporal network layers.

Market	Edge Exponent	Triangular Motif Exponent	Triangular Motif Exponent**
NYSE	-0.164	-0.398	-0.133
Germany	-0.265	-0.471	-0.157
Italy	-0.144*	-0.458	-0.153
Israel	-0.397	-0.830	-0.277

* Result compromised by regimes not well identified for edge decay in large systems (≈ 100 stocks)

** Motif exponent adjusted by the probability of simultaneous edge persistence in the motif

Motif - Sector Correspondence

Table 3: Motif components and Financial Times sector affiliation for the ten most persistent motifs in the NYSE's 100 most capitalised stocks.

Security 1	Security 2	Security 3	FT Sector
Biogen Inc	Gilead Sciences Inc	Celgene Corp	Biopharmaceutical
UnitedHealth Group Inc	Cigna Corp	Anthem Inc	Health Care
Biogen Inc	Gilead Sciences Inc	Amgen Inc	Biopharmaceutical/Biotechnology
Bank of America Corp	JPMorgan Chase & Co	Morgan Stanley	Financials-Banks
Vanguard FTSE ETF**	MSCI EAFE ETF	Vanguard FTSE EFT***	Index ETFs
Invesco QQQ Trust	Amazon.com Inc	Alphabet Inc	Tech/ETF on NAS-DAQ*
ConocoPhillips	Schlumberger NV	Exxon Mobil Corp	Oil & Gas
NVIDIA Corp	Texas Instruments Inc	Broadcom Inc	Technology Hardware & Equipment
Chevron Corp	Schlumberger NV	Exxon Mobil Corp	Oil & Gas
Chevron Corp	ConocoPhillips	Schlumberger NV	Oil & Gas

* Top Holdings include Amazon, Facebook, Apple, Alphabet

** Vanguard FTSE Developed Markets Index Fund ETF Shares

*** Vanguard FTSE Emerging Markets Index Fund ETF Shares

Motif - Sector Correspondence

Table 4: Motif components and Financial Times sector affiliation for the ten most persistent motifs in the NYSE's 100 most capitalised stocks.

Security 1	FT Sector	Security 2	FT Sector	Security 3	FT Sector
Biogen Inc	Biopharmaceutical	Gilead Sciences Inc	Biopharmaceutical	Celgene Corp	Biopharmaceutical
UnitedHealth Group Inc	Health Care	Cigna Corp	Health Care	Anthem Inc	Health Care
Biogen Inc	Biopharmaceutical	Gilead Sciences Inc	Biopharmaceutical	Amgen Inc	Biotechnology
Bank of America Corp	Financials-Banks	JPMorgan Chase & Co	Financials-Banks	Morgan Stanley	Financials-Banks
Vanguard FTSE ETF**	Index ETFs	MSCI EAFE ETF	Index ETFs	Vanguard FTSE EFT***	Index ETFs
Invesco QQQ Trust	ETF on NASDAQ*	Amazon.com Inc	Tech	Alphabet Inc	Tech
ConocoPhillips	Oil & Gas	Schlumberger NV	Oil & Gas	Exxon Mobil Corp	Oil & Gas
NVIDIA Corp	Tech Hardware	Texas Instruments Inc	Tech Hardware	Broadcom Inc	Tech Hardware
Chevron Corp	Oil & Gas	Schlumberger NV	Oil & Gas	Exxon Mobil Corp	Oil & Gas
Chevron Corp	Oil & Gas	ConocoPhillips	Oil & Gas	Schlumberger NV	Oil & Gas

* Top Holdings include Amazon, Facebook, Apple, Alphabet

** Vanguard FTSE Developed Markets Index Fund ETF Shares

*** Vanguard FTSE Emerging Markets Index Fund ETF Shares

Persistent Motifs Visualisation

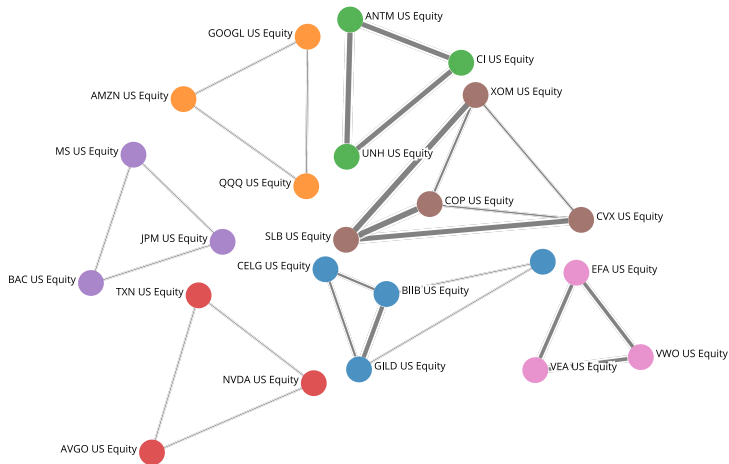


Figure 3: Network representation of the ten most persistent triangular motifs in the TMFG layers for the 100 most capitalised stocks of the NYSE.

Application to portfolio construction - Random Portfolios

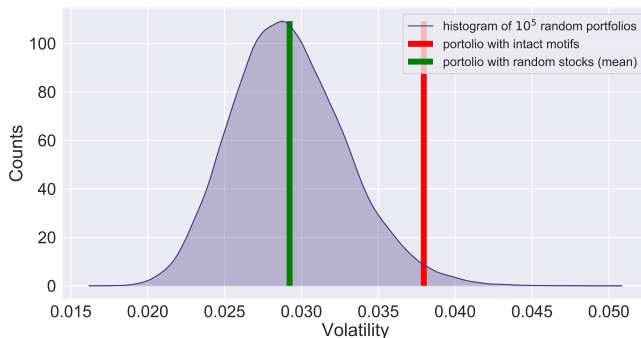


Figure 4: Portfolio volatility distribution for the 100 most capitalised stocks in the NYSE. The reference portfolio (red bar) contains all stocks in the 10 most persistent triangles and distribution portfolios are formed from a random selection of stocks (mean distribution volatility represented by the green bar).

Application to portfolio construction - Persistent Motifs

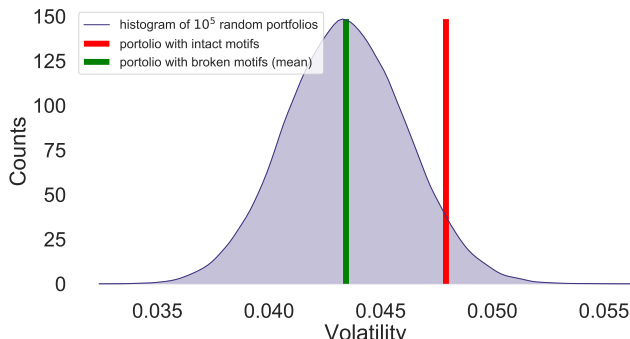


Figure 5: Portfolio volatility distribution for the 100 most capitalised stocks in the NYSE. The reference portfolio (red bar) contains all stocks in the 10 most persistent triangles and distribution portfolios have one motif element replaced by a random selection of stocks (mean distribution volatility represented by the green bar).

Application to portfolio construction - Vol or Persistence Weighting

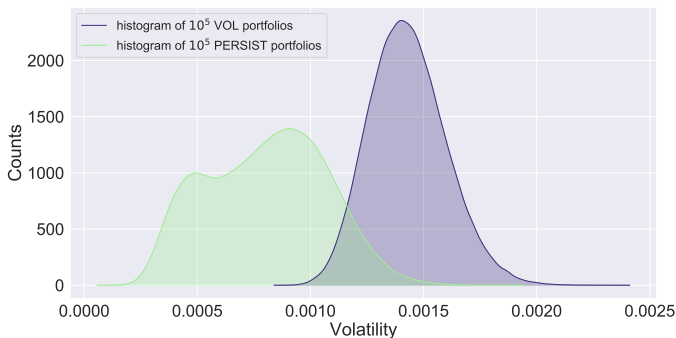


Figure 6: Portfolio volatility distribution for the 100 most capitalised stocks in the NYSE. The vol portfolios are formed by weighting a random selection of assets by $1/\text{vol}$ while the persist portfolios are formed weighting assets by $1/\text{persistence}$.

Conclusion

- ▶ Motifs are more persistent (adjusted by edge probability) than individual edges
- ▶ Motif decay presents a plateau region where stable motifs are present for a long time
- ▶ Most persistent motifs represent sectors with strong common drivers
- ▶ Excluding the most persistent motif structures from portfolios allows to significantly reduce portfolio volatility