

STOCK QUOTE CORRELATIONS

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ABSTRACT

The aim of this analysis is to determine correlations between different traded stocks and attempt to establish categories of stocks behaving in a similar fashion. All the numerical calculations have been performed using Octave 3.8.0.

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1 CORRELATION OF STOCK QUOTES

1.1 Data preparation

The data basis consists of daily quotes of stocks which have been publicly traded between August 29th 2014 and August 28th 2015.

For a stock i , the quote on the j^{th} day of the analysed period is denoted as $q_j^{(i)}$. Quotes from successive trading days form time series where the quote $q_j^{(i)}$ comes from a later date than $q_j^{(i-1)}$.

As no trading takes place on weekends and bank holidays (Christmas, Easter) subsequent quotes might be separated by several days. I.e. even though two quotes $q_j^{(i-1)}$ and $q_j^{(i)}$ are subsequent in the analysed time series, they don't necessarily result from subsequent dates.

The analysis has been performed on a normalized data set $\{\delta_i^{(j)}\}$ of daily quote changes between subsequent time series elements (e.g. trading days):

$$\delta_i^{(j)} \equiv \log \frac{q_i^{(j)}}{q_{i-1}^{(j)}} \quad (1.1.1)$$

Stocks which haven't been traded continuously during the analysed time interval have been removed from the data set. If a stock hasn't been traded on a certain date, the previous day's quote has been assumed.

The whole data set consists of quote data from 264 trading days for 164 different stocks.

1.2 Same-day correlation

The correlation coefficient C_{jk} is a measure for how similar the daily quote changes of stocks j and k fare. The correlation between the quote time series for the same trading day is

$$C_{jk} \equiv \frac{\sum_{i=1}^N (q_i^{(j)} - \langle q^{(j)} \rangle) (q_i^{(k)} - \langle q^{(k)} \rangle)}{\sqrt{\sum_{i=1}^N (q_i^{(j)} - \langle q^{(j)} \rangle)^2} \sqrt{\sum_{i=1}^N (q_i^{(k)} - \langle q^{(k)} \rangle)^2}} \quad (1.2.1)$$

The resulting correlation coefficients are visualized in figure 2. Since each time series has a self-correlation of 1, the diagonal shows up very prominently but carries no information.

1.3 Temporal correlation

Knowing the the quote changes of a stock in advance is the dream of every stock trader. If a stock could be found whose price changes echo the evolution of another stocks prices with some days T delay, this information could be exploited. By evaluating the temporal correlation between all stock quotes during the analysed period verifies that no such price echoes exist.

The temporal correlation between two stocks is determined by

$$C_{jk}^{(T)} \equiv \frac{\sum_{i=1}^{N-T} (q_i^{(j)} - \langle q^{(j)} \rangle) (q_{i+T}^{(k)} - \langle q^{(k)} \rangle)}{\sqrt{\sum_{i=1}^{N-T} (q_i^{(j)} - \langle q^{(j)} \rangle)^2} \sqrt{\sum_{i=1}^{N-T} (q_{i+T}^{(k)} - \langle q^{(k)} \rangle)^2}} \quad (1.3.1)$$

For $T = 0$ the temporal correlations are reduced to the already discussed same-day correlation 1.2.1.

Day close quote

1.4 Market momentum

Securities whose stock quote evolution are highly correlated or anti-correlated influence the evolution of the market as a whole. The quantity momentum p is introduced in order to quantify the influence of the different correlation domains on the market:

$$p \equiv \sqrt{\langle C \circ C \rangle} \quad (1.4.1)$$

whereas \circ represents the Hadamard product. The higher the value of p is, the more securities evolve correlated and/or anti-correlated.

2 RESULTS

2.1 SIX stock exchange SWX

2.1.1 Market dynamics

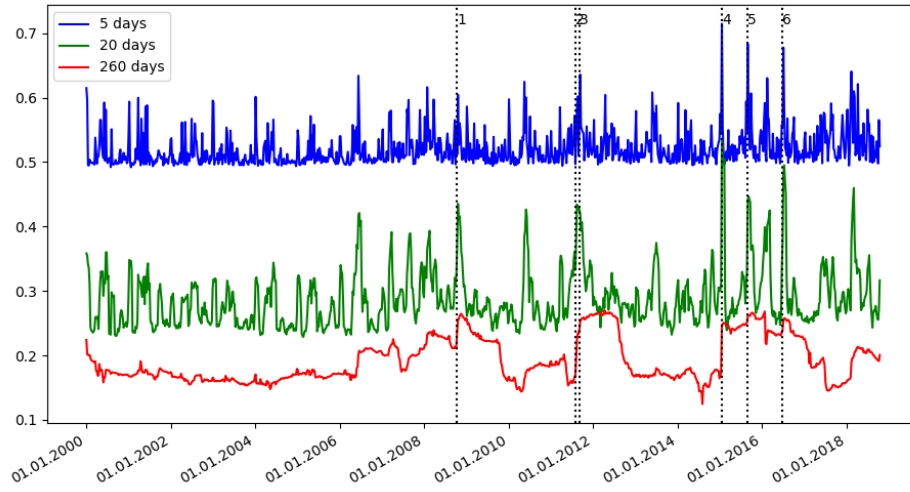


Figure 1: Evolution of stock quote correlations over various time scales. Possible trigger events for peaks in the 28-day correlation are marked by vertical lines. See table 1.

#	Date	Event
1	08.10.2008	EU 750 bEUR bail-out funds
2	04.08.2011	EZB starts buying of government bonds
3	06.09.2011	start of EUR:CHF ceiling
4	15.01.2015	end of EUR:CHF ceiling
5	24.08.2015	Mini-crash "black monday"
6	24.06.2016	Brexit referendum

Table 1: Possible trigger events for peaks in the 28-day market correlation. See figure 1.

2.2 External trigger events

2.2.1 EU 750 bEUR bail-out funds

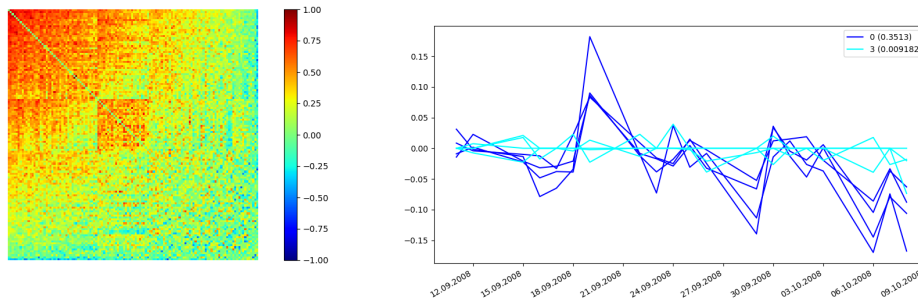


Figure 2: Left: Correlations between quotes of 126 securities over 28 days (20 trading days) up to 08.10.2008. Right: Security quote samples from this period.

Cluster	Norm	ISIN	Issuer
0	0.444	CH0000816824	OC Oerlikon Corporation AG
0	0.438	CH0012221716	ABB Ltd
0	0.428	CH0012453913	Temenos Group AG
0	0.424	CH0012410517	Bâloise Holding AG
1	0.371	CH0008012236	Gurit Holding AG
1	0.355	CH0100837282	Kardex AG
1	0.333	CH0208062627	Meier Tobler AG
1	0.322	CH0023405456	Dufry AG
2	0.237	CH0010754924	Schweiter Technologies AG
2	0.231	CH0110240600	AFG Arbonia-Forster-Holding AG
2	0.229	CH0005795668	SCHMOLZ+BICKENBACH AG
2	0.224	CH0011795959	dorma+kaba Holding AG
3	0.090	CH0214706357	Bergbahnen Engelberg-Trübsee-Titlis AG
3	0.063	CH0003583256	Highlight Event and Entertainment AG
3	0.062	CH0002609656	Villars Holding S.A.
3	0.051	CH0020739006	Dottikon ES Holding AG

2.2.2 EZB starts buying of government bonds

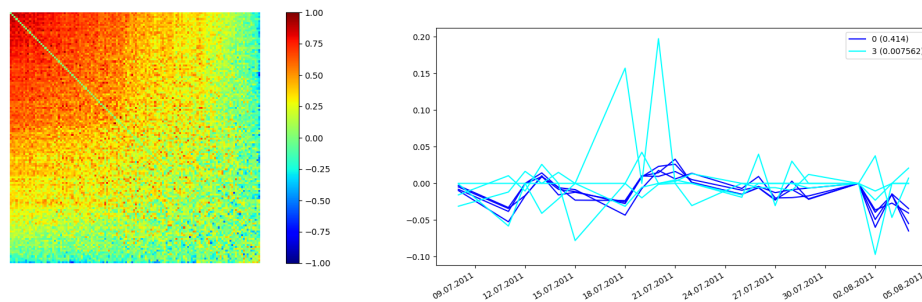


Figure 3: Left: Correlations between quotes of 130 securities over 28 days (20 trading days) up to 04.08.2011. Right: Security quote samples from this period.

Cluster	Norm	ISIN	Issuer
0	0.495	CH0030170408	Geberit AG
0	0.488	CH0011075394	Zurich Insurance Group AG
0	0.477	CH0012271687	Helvetia Holding AG
0	0.475	CH0025238863	Kühne + Nagel International AG
1	0.328	CH0011432447	Basilea Pharmaceutica AG
1	0.324	CH0008742519	Swisscom AG
1	0.310	CH0208062627	Meier Tobler AG
1	0.307	CH0212255803	Burkhalter Holding AG
2	0.226	CH0004870942	Goldbach Group AG
2	0.216	CH0005319162	Elma Electronic AG
2	0.193	CH0002361068	Starrag Group Holding AG
2	0.185	CH0012100191	Tecan Group AG
3	0.096	CH0002661731	Zwahlen & Mayr SA
3	0.090	CH0242606942	Airopack Technology Group AG
3	0.089	CH0024736404	Edisun Power Europe AG
3	0.077	CH0001931853	Cham Paper Group Holding AG

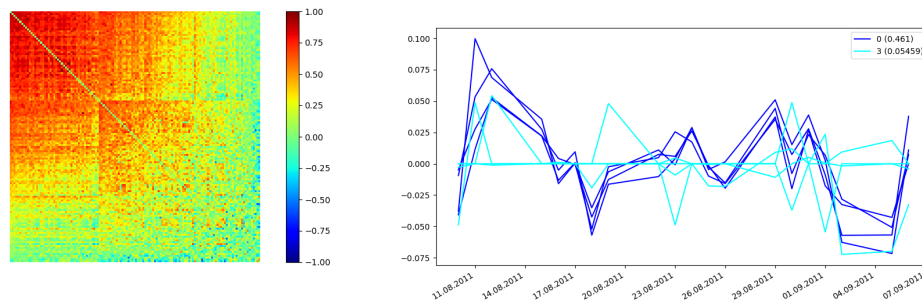


Figure 4: Left: Correlations between quotes of 132 securities over 28 days (20 trading days) up to 06.09.2011. Right: Security quote samples from this period.

2.2.3 start of EUR:CHF ceiling

Cluster	Norm	ISIN	Issuer
0	0.533	CH0012271687	Helvetia Holding AG
0	0.522	CH0001752309	Georg Fischer AG
0	0.519	CH0012410517	Bâloise Holding AG
0	0.506	CH0011075394	Zurich Insurance Group AG
1	0.477	CH0009002962	Barry Callebaut AG
1	0.472	CH0016440353	Ems-Chemie Holding AG
1	0.458	CH0039821084	METALL ZUG AG
1	0.453	CH0127480363	Autoneum Holding AG
2	0.320	CH0010675863	Swissquote Group Holding Ltd
2	0.303	CH0023868554	Implen AG
2	0.303	CH0011178255	Tamedia AG
2	0.289	CH0030380734	Huber+Suhner AG
3	0.135	CH0187624256	IVF HARTMANN Holding AG
3	0.119	CH0003583256	Highlight Event and Entertainment AG
3	0.113	CH0012488190	AEVIS Victoria SA
3	0.106	CH0002609656	Villars Holding S.A.

2.2.4 end of EUR:CHF ceiling

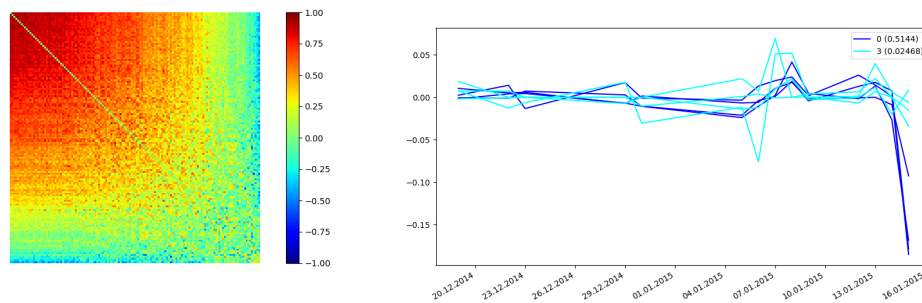


Figure 5: Left: Correlations between quotes of 139 securities over 28 days (14 trading days) up to 15.01.2015. Right: Security quote samples from this period.

Cluster	Norm	ISIN	Issuer
0	0.556	CH0210483332	Compagnie Financière Richemont SA
0	0.544	CH0025238863	Kühne + Nagel International AG
0	0.542	CH0012280076	Straumann Holding AG
0	0.540	CH0012255151	The Swatch Group AG
1	0.476	CH0001752309	Georg Fischer AG
1	0.463	CH0030380734	Huber+Suhner AG
1	0.462	CH0016440353	Ems-Chemie Holding AG
1	0.459	CH0009002962	Barry Callebaut AG
2	0.364	CH0010570759	Chocoladefabriken Lindt & Sprüngli AG
2	0.362	CH0006372897	Interroll Holding AG
2	0.354	CH0021545667	Vaudoise Assurances Holding SA
2	0.348	CH0319416936	Flughafen Zürich AG
3	0.157	CH0189177055	Adecco SA
3	0.151	CH0242606942	Airopack Technology Group AG
3	0.149	CH0003245351	Von Roll Holding AG
3	0.145	CH0008207356	BVZ Holding AG

2.2.5 Mini-crash "black monday"

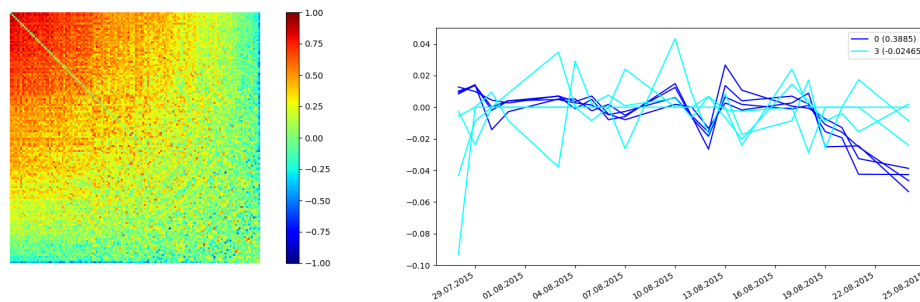


Figure 6: Left: Correlations between quotes of 140 securities over 28 days (20 trading days) up to 24.08.2015. Right: Security quote samples from this period.

Cluster	Norm	ISIN	Issuer
0	0.452	CH0038863350	Nestlé AG
0	0.452	CH0012005267	Novartis AG
0	0.441	CH0126881561	Swiss Re AG
0	0.440	CH0008742519	Swisscom AG
1	0.343	CH0012268360	Kudelski S.A.
1	0.338	CH0012530207	Bachem Holding AG
1	0.327	CH0002088976	Valora Holding AG
1	0.318	CH0212255803	Burkhalter Holding AG
2	0.206	CH0022427626	LEM Holding SA
2	0.202	CH0030380734	Huber+Suhner AG
2	0.196	CH0024590272	ALSO Holding AG
2	0.194	CH0021545667	Vaudoise Assurances Holding SA
3	0.051	CH0008531045	Datacolor AG
3	0.046	CH0010947627	Airesis SA
3	0.046	CH0008012236	Gurit Holding AG
3	0.029	CH0002661731	Zwahlen & Mayr SA

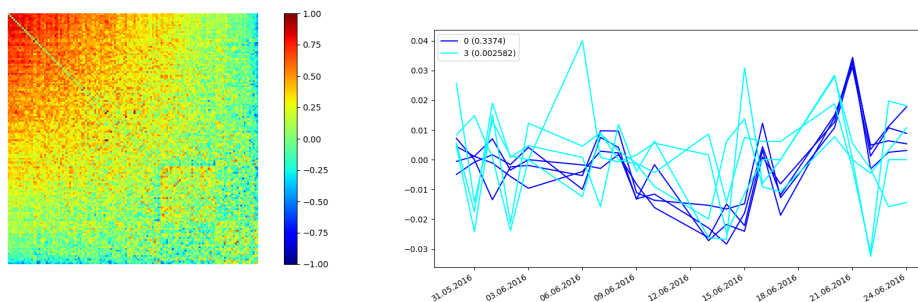


Figure 7: Left: Correlations between quotes of 139 securities over 28 days (20 trading days) up to 24.06.2016. Right: Security quote samples from this period.

2.2.6 Brexit referendum

Cluster	Norm	ISIN	Issuer
0	0.399	CH0012221716	ABB Ltd
0	0.395	CH0013841017	Lonza Group AG
0	0.388	CH0126881561	Swiss Re AG
0	0.386	CH0012138605	Adecco SA
1	0.308	CH0003671440	Rieter Holding AG
1	0.294	CH0002088976	Valora Holding AG
1	0.277	CH0009002962	Barry Callebaut AG
1	0.276	CH0012268360	Kudelski S.A.
2	0.230	CH0039821084	METALL ZUG AG
2	0.207	CH0002187810	Phoenix Mecano AG
2	0.194	CH0110303119	Leclanché S.A.
2	0.186	CH0010675863	Swissquote Group Holding Ltd
3	0.108	CH0244017502	Conzzeta AG
3	0.094	CH0208062627	Meier Tobler AG
3	0.073	CH0011178255	Tamedia AG
3	0.071	CH0003420806	Orell Füssli Holding AG

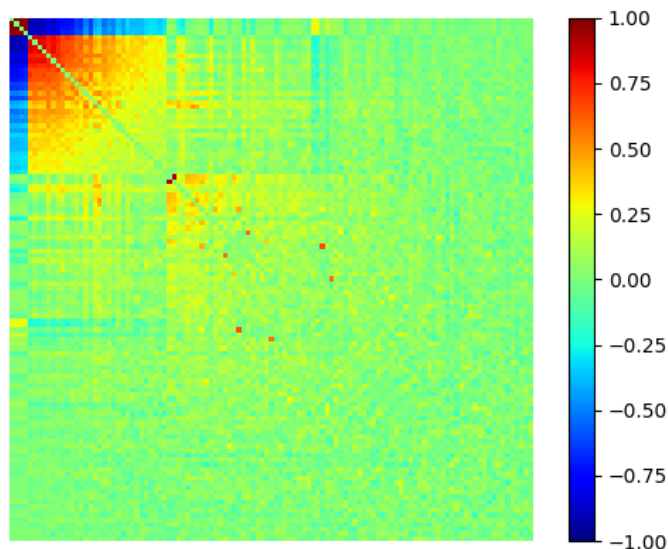


Figure 8: Quote correlation matrix of 139 traded stocks on the same trading day. Axis indicate the correlated stocks.

Table 2 compares the statistical properties of the five correlation clusters. The general conclusion from this comparison is that clusters with high correlation coefficients C_{jk} contain stocks with small daily quote change fluctuations (small $\sigma(\delta)$).

Figure 3 shows a logarithmic plot of the daily quote changes for clusters A,B,D and E. Cluster C has been omitted for layout reasons. As per definition of cluster A, its stock quotes tend to move in parallel, the low fluctuation compared to the other clusters can easily be deduced from the small band the daily quote changes inhabit. Furthermore, cluster A stock quotes seem to be strongest affected by systemic influences the SNB's decision on January 15th 2015 to disband the strict coupling of the Swiss Franc to the Euro. This information is imprinted as a negative peak at trading day 88.

In contrast, stocks in cluster E give no indication that January 15th was anything other than an ordinary trading day. Any effect the SNB's decision might have had is hidden by the regular highly fluctuating quote changes.

Cluster	Stocks	Gain	$\langle \delta \rangle$	$\langle \sigma(\delta) \rangle$	$\langle C \rangle$
A	33	-3.34%	-0.014%	0.016	0.618
B	34	2.03%	0.008%	0.017	0.387
C	39	-6.18%	-0.026%	0.018	0.196
D	30	-12.53%	-0.054%	0.020	0.112
E	28	-12.44%	-0.054%	0.032	0.048

Table 2: Averaged statistical characteristics over the analysed period for each correlation cluster.

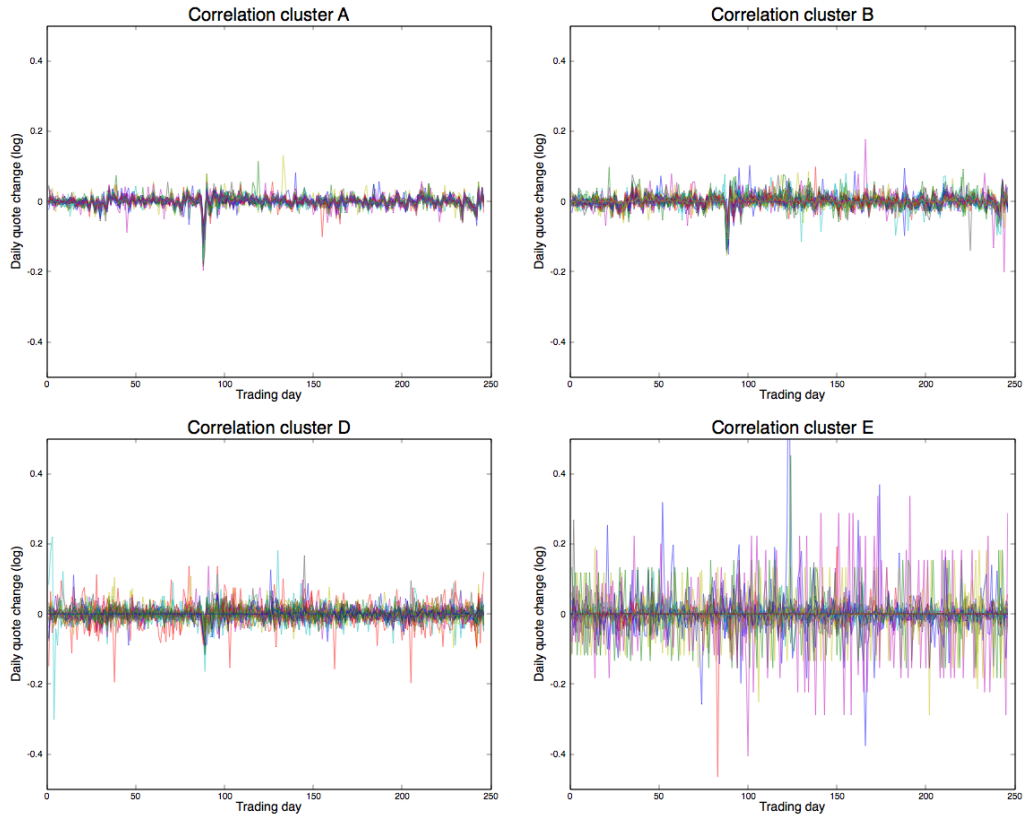


Figure 9: Logarithm of daily quote changes for stocks within the same correlation cluster during the analysed period.

The explicit assignment of stocks to correlation clusters is shown in appendix A.

Figure 4 shows the temporal correlations for $T = 1, 2, 3, 4$. Interestingly enough, there seem to exist correlations between stock prices with a

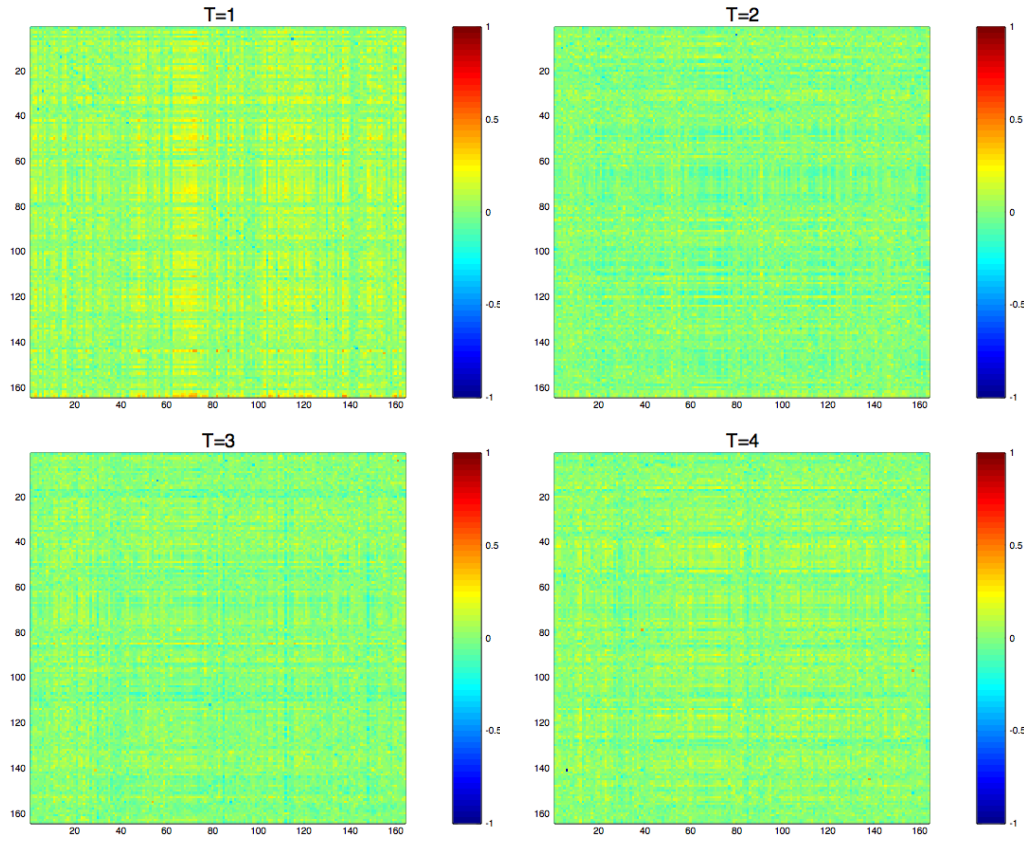


Figure 10: Quote correlation matrix of 164 traded stocks between different trading days.

delay of one day for $T = 1$ which decay fast for higher delay times ($T > 1$). However, by inspection of the respective price evolutions it seems that this effect mostly arises because some few stocks, especially 3M Company (US88579Y1010), but also Adecco SA (CH0189177055) only reacted with one day delay to the CHF/EUR decoupling on January 15th than others. It is highly doubtful whether without the massive effect of the CHF/EUR decoupling a significant correlation could have been found after one day.

Figure 5 shows some examples.

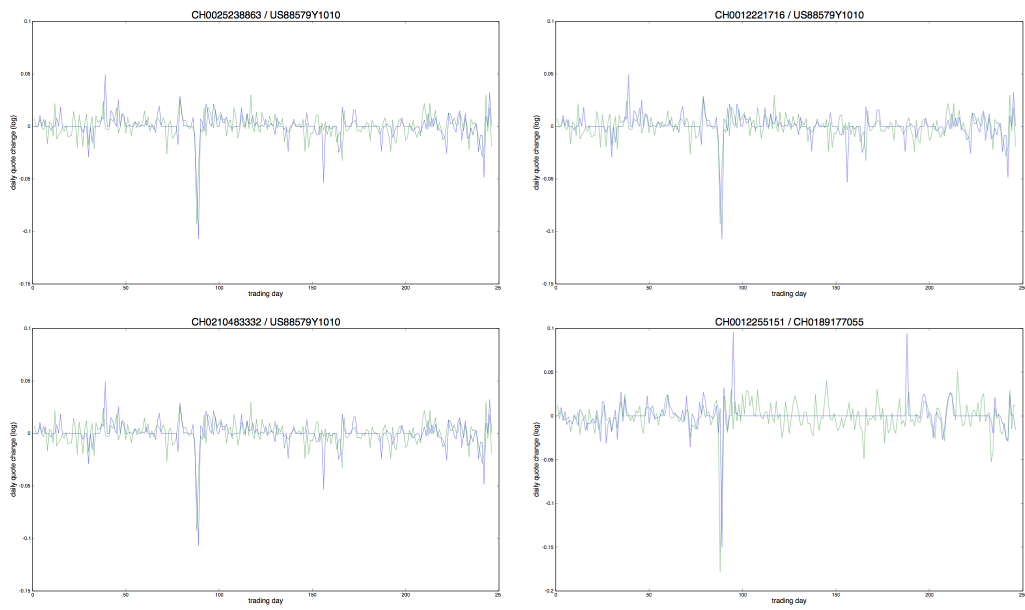


Figure 11: Stock prices evolutions with a temporal correlation > 0.40 for $T = 1$. The delayed stock is drawn in blue.

A CLUSTER ASSIGNMENT

Cluster	Company	ISIN
A	CH0012221716	ABB Ltd
A	CH0012138605	Adecco SA
A	CH0012410517	Bâloise Holding AG
A	DE000BASF111	BASF SE
A	CH0010570767	Chocoladefabriken Lindt & Sprüngli AG
A	CH0210483332	Compagnie Financière Richemont SA
A	CH0126673539	DKSH Holding AG
A	CH0023405456	Dufry AG
A	CH0016440353	Ems-Chemie Holding AG
A	CH0030170408	Geberit AG
A	CH0001752309	Georg Fischer AG
A	CH0010645932	Givaudan SA
A	CH0012271687	Helvetia Holding AG
A	CH0012214059	Holcim Ltd
A	CH0025238863	Kühne + Nagel International AG
A	CH0013841017	Lonza Group AG
A	CH0038863350	Nestlé AG
A	CH0012005267	Novartis AG
A	CH0038459415	Novartis AG
A	CH0000816824	OC Oerlikon Corporation AG
A	CH0012032048	Roche Holding AG
A	CH0012032113	Roche Holding AG
A	CH0024638196	Schindler Holding AG
A	CH0024638212	Schindler Holding AG
A	CH0002497458	SGS AG
A	CH0012549785	Sonova Holding AG
A	CH0012280076	Straumann Holding AG
A	CH0014852781	Swiss Life Holding AG
A	CH0126881561	Swiss Re AG
A	CH0012255144	The Swatch Group AG
A	CH0012255151	The Swatch Group AG
A	CH0033361673	u-blox Holding AG
A	CH0011075394	Zurich Insurance Group AG

Table 3: Cluster A stocks.

Cluster	Company	ISIN
B	US88579Y1010	3M Company
B	CH0189177055	Adecco SA
B	CH0043238366	ARYZTA AG
B	CH0011339204	Ascom Holding AG
B	CH0127480363	Autoneum Holding AG
B	CH0009002962	Barry Callebaut AG
B	CH0011432447	Basilea Pharmaceutica AG
B	CH0238627142	Bossard Holding AG
B	CH0002432174	Bucher Industries AG
B	CH0025536027	Burckhardt Compression Holding AG
B	US1491231015	Caterpillar Inc.
B	CH0010570759	Chocoladefabriken Lindt & Sprüngli AG
B	CH0012142631	Clariant AG
B	CH0003825756	Comet Holding AG
B	CH0030486770	Dätwyler Holding AG
B	CH0021218067	Evolva Holding SA
B	CH0010567961	Flughafen Zürich AG
B	CH0003541510	Forbo Holding AG
B	CH0015536466	Galenica AG
B	CH0100185955	gategroup Holding AG
B	CH0023868554	Implenia AG
B	CH0011795959	Kaba Holding AG
B	CH0100837282	Kardex AG
B	CH0010702154	Komax Holding AG
B	CH0012268360	Kudelski S.A.
B	CH0003504856	Kuoni Reisen Holding AG
B	CH0190891181	Leonteq AG
B	CH0025751329	Logitech International S.A.
B	CH0002168083	Panalpina Welttransport (Holding) AG
B	CH0003671440	Rieter Holding AG
B	CH0239229302	SFS Group AG
B	CH0011037469	Syngenta AG
B	CH0012100191	Tecan Group AG
B	CH0002088976	Valora Holding AG

Table 4: Cluster B stocks.

Cluster	Company	ISIN
C	CH0110240600	AFG Arbonia-Forster-Holding AG
C	CH0019107025	APG SGA SA
C	CH0012530207	Bachem Holding AG
C	US0572241075	Baker Hughes Incorporated
C	CH0001503199	BELIMO Holding AG
C	CH0004410418	Bell AG
C	CH0130293662	BKW AG
C	CH0012684657	Bobst Group SA
C	CH0212255803	Burkhalter Holding AG
C	CH0011003594	Carlo Gavazzi Holding AG
C	CH0225173167	Cembra Money Bank AG
C	CH0006937772	Charles Vögele Holding AG
C	CH0008702190	Cicor Technologies Ltd.
C	CH0025343259	COLTENE Holding AG
C	CH0244017502	Conzzeta AG
C	FR0000120644	Danone
C	CH0012829898	Emmi AG
C	CH0039651184	Energiedienst Holding AG
C	CH0009320091	Feintool International Holding AG
C	CH0008012236	Gurit Holding AG
C	CH0024666528	HOCHDORF Holding AG
C	CH0030380734	Huber+Suhner AG
C	CH0011029946	INFICON Holding AG
C	CH0006372897	Interroll Holding AG
C	CH0022427626	LEM Holding SA
C	CH0039821084	METALL ZUG AG
C	CH0108503795	Meyer Burger Technology AG
C	CH0009062099	Schaffner Holding AG
C	CH0198415058	Schindler Holding AG
C	CH0198415066	Schindler Holding AG
C	CH0005795668	SCHMOLZ+BICKENBACH AG
C	CH0010754924	Schweiter Technologies AG
C	CH0014284498	Siegfried Holding AG
C	CH0000587979	Sika AG
C	CH0038388911	Sulzer AG
C	CH0008742519	Swisscom AG
C	CH0010675863	Swissquote Group Holding Ltd
C	CH0021545667	Vaudoise Assurances Holding SA
C	CH0208062627	Walter Meier AG

Table 5: Cluster C stocks.

Cluster	Company	ISIN
D	CH0242606942	Airopack Technology Group AG
D	CH0034389707	Alpiq Holding AG
D	CH0024590272	ALSO Holding AG
D	CH0214706357	Bergbahnen Engelberg-Trübsee-Titlis AG
D	CH0126639464	Calida Holding AG
D	CH0001624714	CPH Chemie + Papier Holding AG
D	CH0020739006	Dottikon ES Holding AG
D	CH0239714907	Geberit AG
D	CH0004870942	Goldbach Group AG
D	CH0004647951	Hügli Holding AG
D	CH0017875789	Jungfraubahn Holding AG
D	CH0110303119	Leclanché S.A.
D	CH0012815459	LifeWatch AG
D	CH0026205861	Looser Holding AG
D	CH0039542854	MCH Group AG
D	CH0012337421	Micronas Semiconductor Holding AG
D	CH0003390066	Mikron Holding AG
D	CH0019624805	Myriad Group AG
D	CH0003420806	Orell Füssli Holding AG
D	CH0111677362	Orior AG
D	CH0002187810	Phoenix Mecano AG
D	CH0016405844	Repower AG
D	CH0027148649	Santhera Pharmaceuticals Holding AG
D	CH0011178255	Tamedia AG
D	CH0011607683	Tornos Holding AG
D	CH0048265513	Transocean Ltd
D	CH0006227612	Vetropack Holding AG
D	CH0003245351	Von Roll Holding AG
D	CH0019396990	Ypsomed Holding AG
D	CH0002661731	Zwahlen & Mayr SA

Table 6: Cluster D stocks.

Cluster	Company	ISIN
E	CH0001366332	Accu Holding AG
E	CH0008967926	Adval Tech Holding AG
E	CH0012488190	AEVIS Holding SA
E	CH0010947627	Airesis SA
E	CH0189009324	Alpha PetroVision Holding AG
E	CH0008207356	BVZ Holding AG
E	CH0001931853	Cham Paper Group Holding AG
E	FR0000125007	Compagnie de Saint-Gobain
E	CH0011115703	Crealogix Holding AG
E	CH0011025217	Cytos Biotechnology AG
E	CH0008531045	Datacolor AG
E	CH0024736404	Edisun Power Europe AG
E	CH0005319162	Elma Electronic AG
E	CH0183903761	Forbo Holding AG
E	CH0012949464	Groupe Minoteries SA
E	CH0003583256	Highlight Event and Entertainment AG
E	CH0000140787	Intersport PSC Holding AG
E	CH0187624256	IVF HARTMANN Holding AG
E	CH0002045497	Loeb Holding AG
E	CH0009115129	Perfect Holding SA
E	CH0252620700	Perrot Duval Holding SA
E	CH0016405836	Repower AG
E	CH0025607331	Romande Energie Holding SA
E	CH0002277314	Schlatter Industries AG
E	CH0002361068	Starrag Group Holding AG
E	CH0012453913	Temenos Group AG
E	CH0100191136	THERAMetrics holding AG
E	CH0002609656	Villars Holding S.A.

Table 7: Cluster E stocks.