Stability and Potential Functions of Market States

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Contents

Intro

- Project being done in collaboration with Oldenburg (J. Peinke and P. Rinn)
- Goal is to quantitatively investigate stability of the market states with help of potential functions
- Pure **EconoPhysics** because a method from "real"physics successfully applied to economics
- Method tested in different systems

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1d Newtonian Systems: Pohls Pendulum

Source: LD Didactic GmbH

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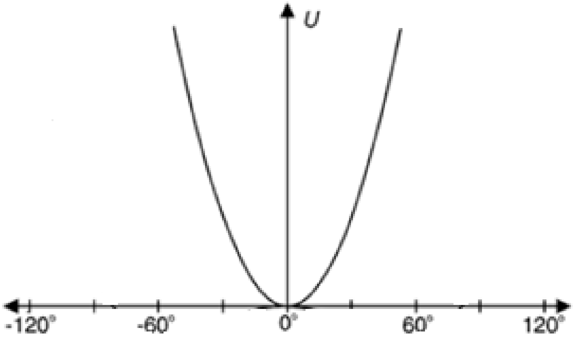

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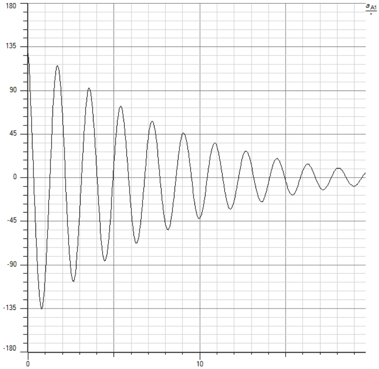

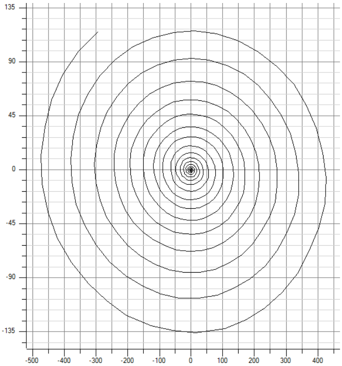

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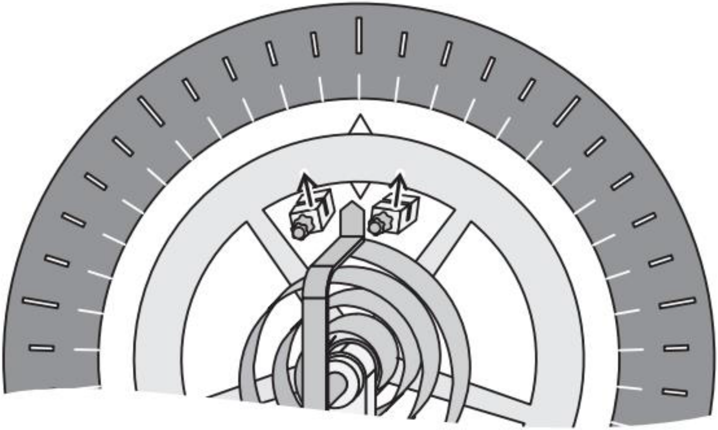

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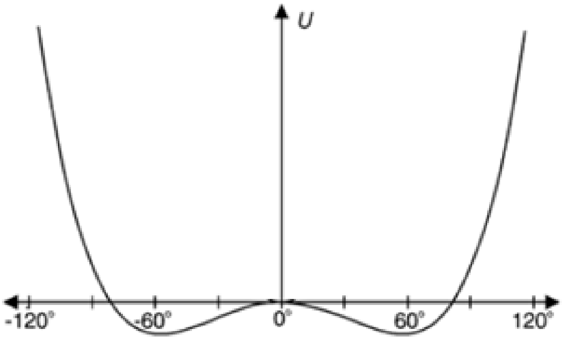

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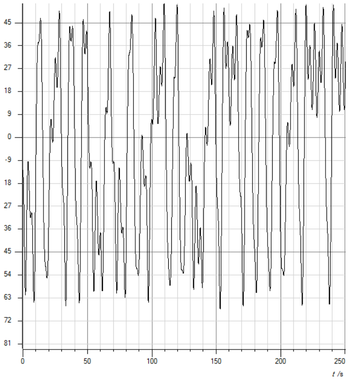
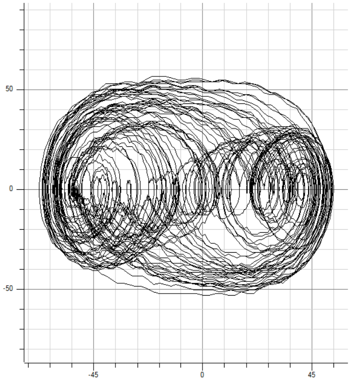




Data Analysis

Brownian Motion: Langevin [2] Equation

Original Form:

$$m\ddot{\overrightarrow{X}} = -\lambda\dot{\overrightarrow{X}} + \overrightarrow{\eta}(t)$$

Modern Form [1]:

$$\dot{\overrightarrow{X}} = \overrightarrow{D^{(1)}} + \underline{\underline{\overrightarrow{D^{(2)}}}} \cdot \overrightarrow{\Gamma}$$

With the **deterministic** force

$$\vec{X} \mapsto \overrightarrow{D^{(1)}}(\vec{X})$$

[1] H. Risken, The Fokker-Planck Equation (Springer, 1996)

[2] Langevin, P. (1908). *On the Theory of Brownian Motion*. C. R. Acad. Sci. (Paris) 146: 530–533.

Determining $\overrightarrow{D^{(1)}}(\vec{X})$ From Empirical Data

Prof. J. Peinke [3] [4] has contributed to development of the method to obtain deterministic force from empirical data:

$$D_i^{(1)}(\vec{X}) = \lim_{\tau \to 0} \frac{1}{\tau} \langle X_i(t+\tau) - x_i \rangle \Big|_{X(t)=x}$$

[3]Phys. Lett. A 243, 275 (1998)
[4]Phys. Lett. A 271, 217 (2000)

1d Example

In Phys. Lett. A 243, 275 (1998) authors synthesized:

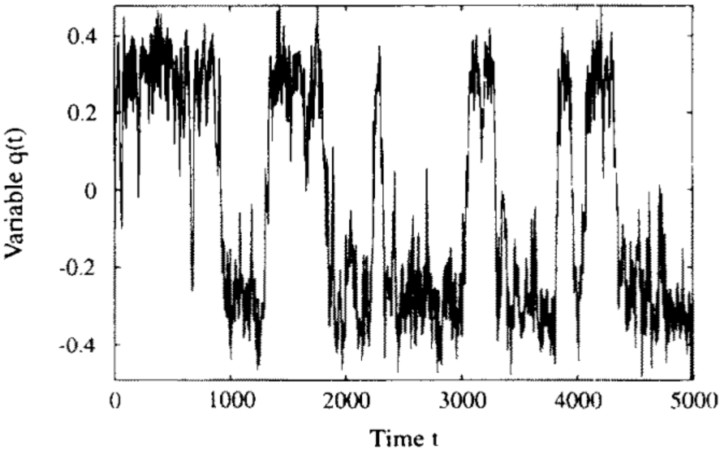
$$\dot{q}(t) = D^{(1)}(q) + \Gamma(t).$$

With

$$\begin{aligned} D^{(1)}(q) &= \epsilon \cdot q(t) - q(t)^3 \\ \Gamma(t) &= 0.05 \cdot F(t) \end{aligned}$$

where $F(t)$ is Gaussian distributed force.

1d Example



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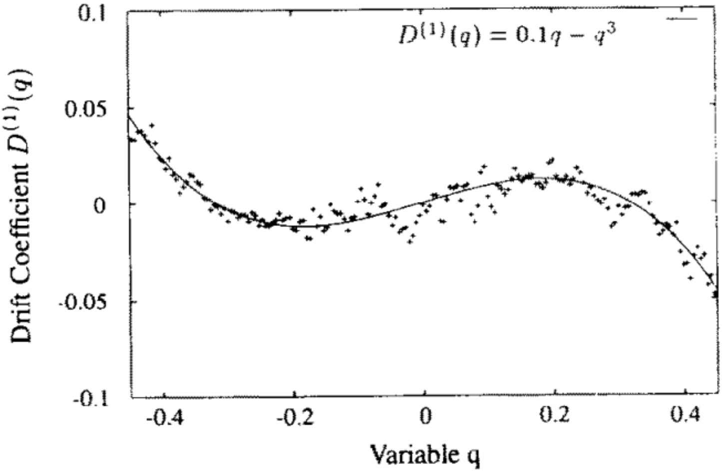

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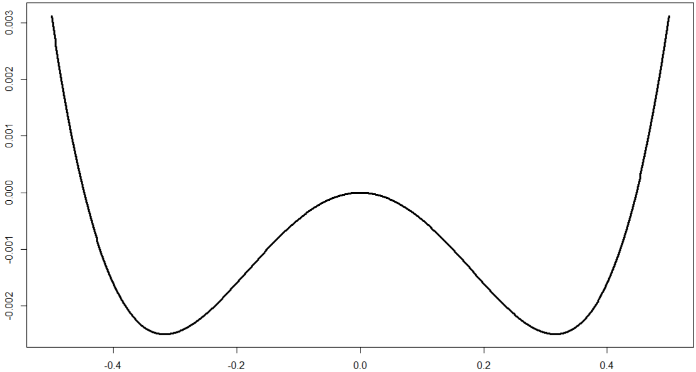
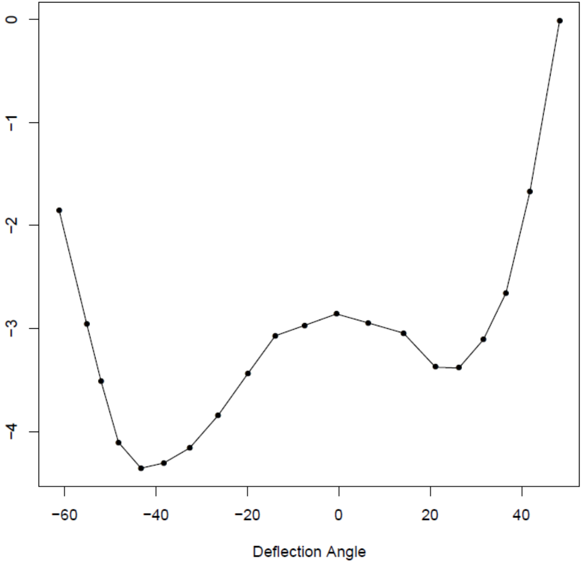


$$U(q) = -\int_{0}^{q} \left[0.1 \cdot s - s^3\right] ds = -0.05q^2 - 0.25q^4$$

1d Example



Data Analysis: Remarks

- The method works in any dimensions
- The data amount needed $\sim a^d$ in d dimensions
- 1d force always has a potential
- In Phys. Rev. Lett. 84, 5224 (2000) authors apply the method to the U.S. dollar–German mark exchange returns

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Correlation Dynamics

Correlation Dynamics

- Daily data of **S&P 500** stocks in a 21 years period 1992 - 2012, with $K = 307$ stocks
- For each two trading months (42 tr. days) a correlation matrix $\vec{C}(t)$ is obtained, $N \approx 5000$
- Due to symmetry only $d = 0.5 \cdot (K^2 - K) == 46971$ entries are independent

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- Market dynamics is thus studied by the d dimensional observable
$$\vec{C}(t) \in \mathbb{R}^d$$
the **ortsvector of the financial** market.

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- Too many dimensions for $N = 5000$ data points

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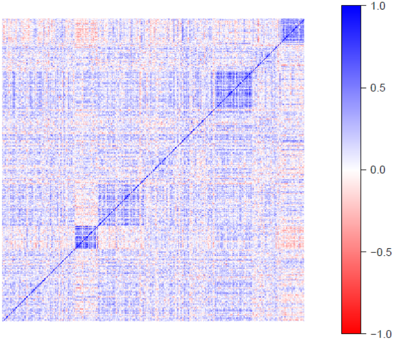

Reducing dimensionality by averaging over 10 industrial sectors gives $d = 0.5 \cdot (10^2 + 10) = 55$ dimensions and less noise

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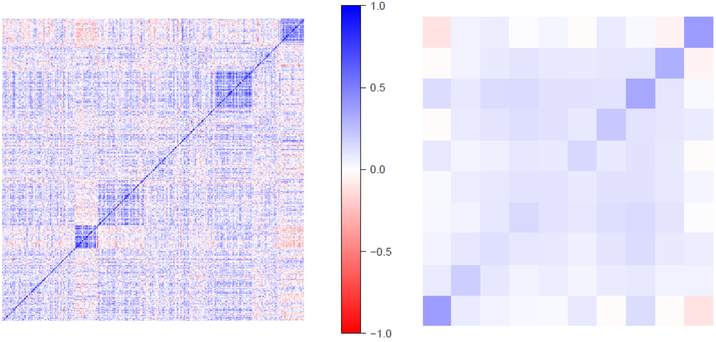

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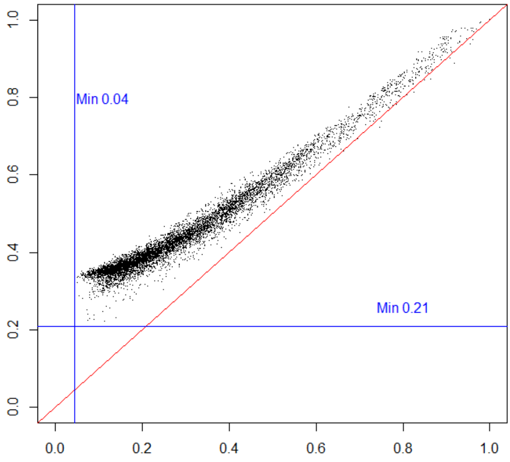
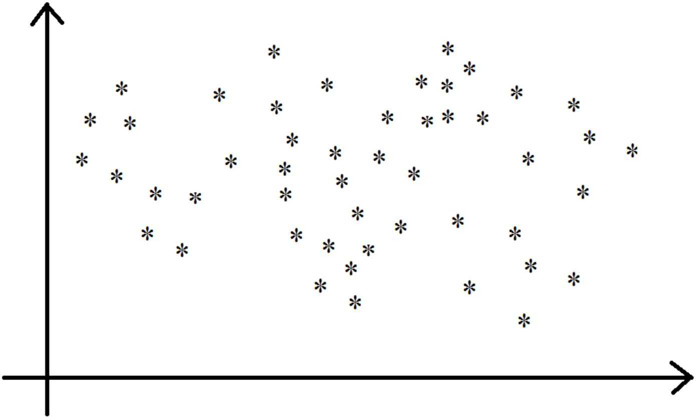


Entries of the full correlation matrices vs. those of averaged over industrial sectors

Market States



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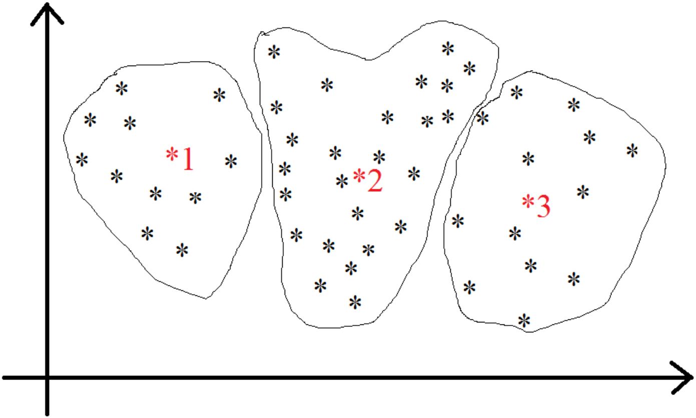

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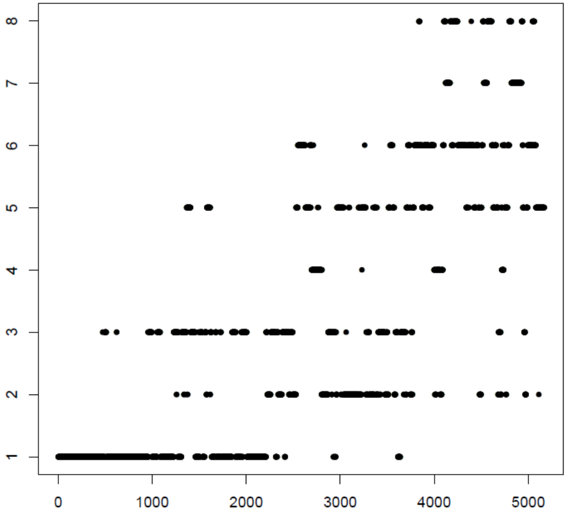
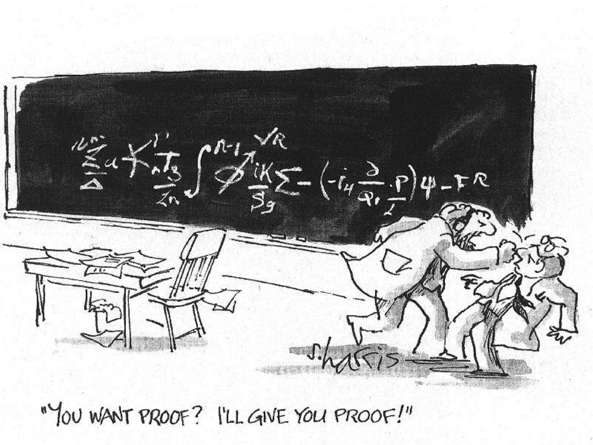
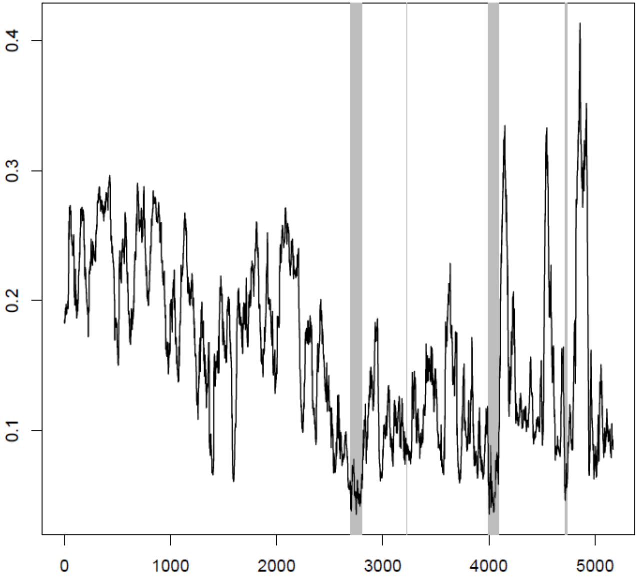


Analysis of Economical Data



Analysis of Economical Data

$$\gamma(t)_k = ||\vec{C}(t) - \vec{\mu}_k||$$



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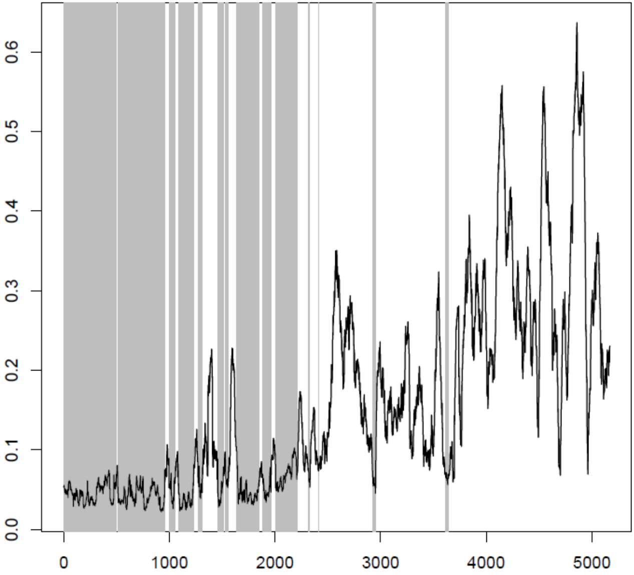
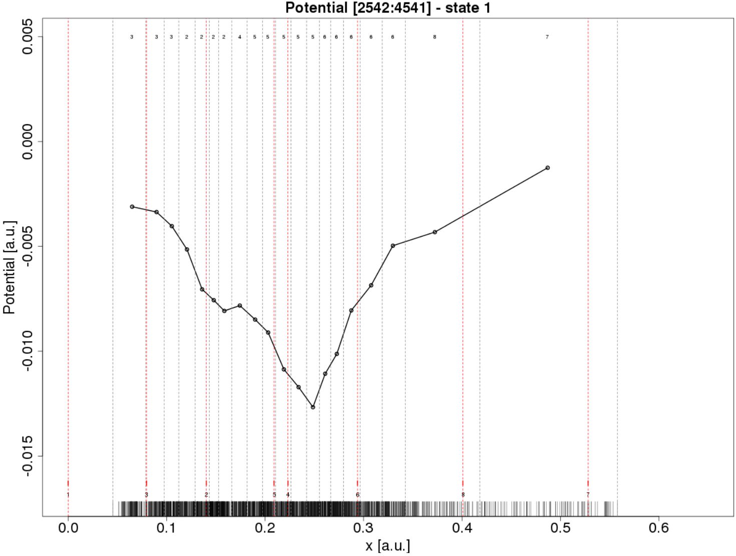


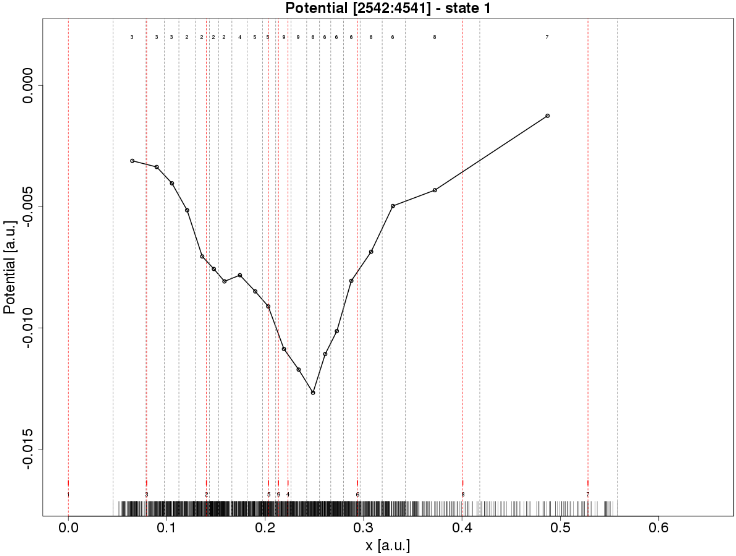
Analysis of Economical Data: 8 States

$$\gamma(t)_k = ||\vec{C}(t) - \vec{\mu}_k||$$



Analysis of Economical Data: 9 States

$$\gamma(t)_k = ||\vec{C}(t) - \vec{\mu}_k||$$



Analysis of Economical Data: 7 States

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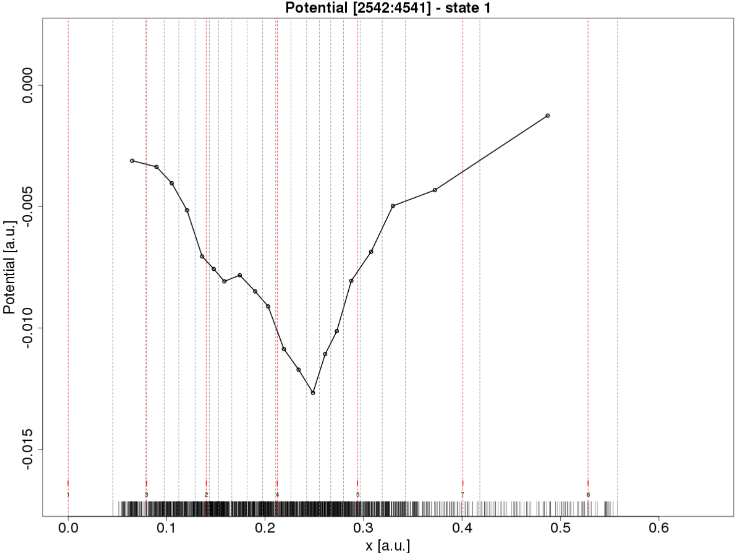

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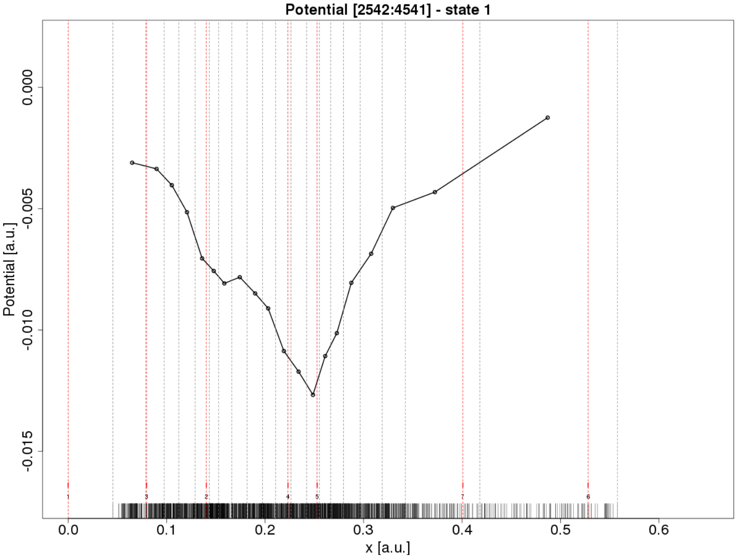
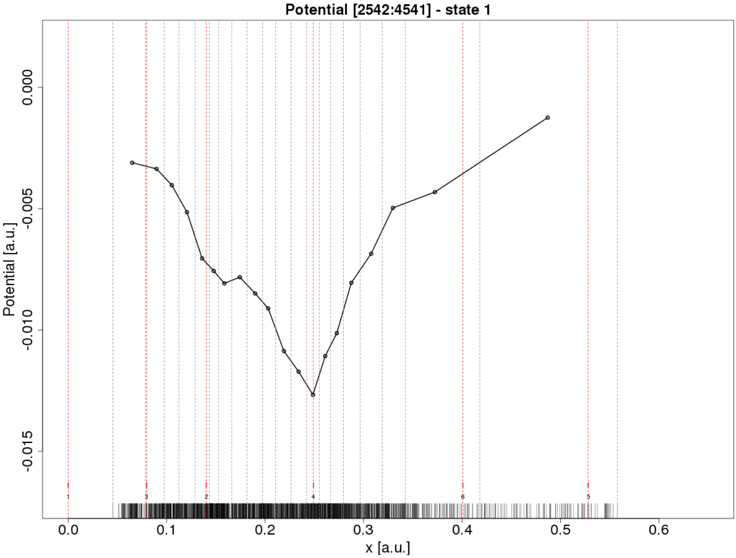


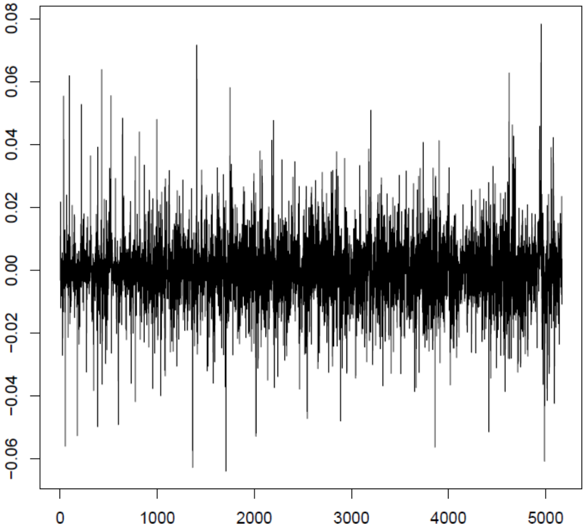
Analysis of Economical Data: 6 States

$$\gamma(t)_k = ||\vec{C}(t) - \vec{\mu}_k||$$



Analysis of Economical Data

Consider absolute correlation returns:
$\vec{r}_c(t) := \vec{C}(t+1) - \vec{C}(t)$



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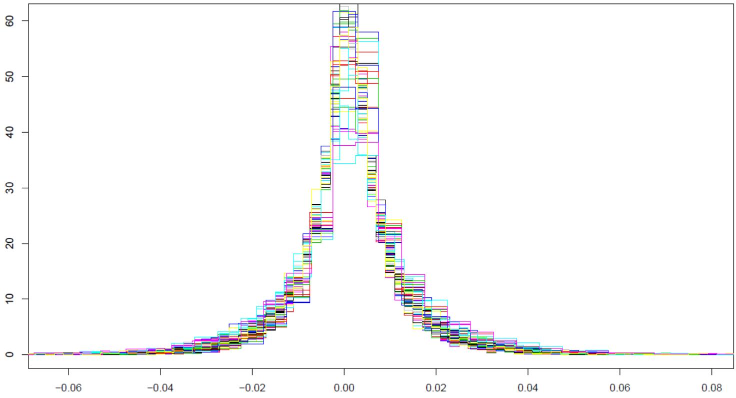
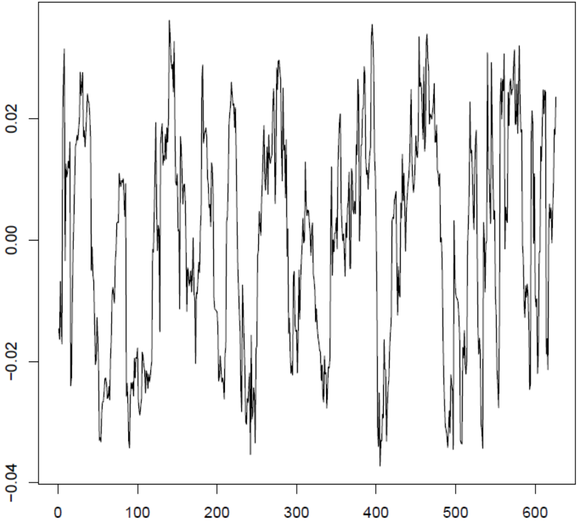


Analysis of Economical Data: Locally

$\gamma_k(t) := \langle \vec{C}^{(k)}(t) - \vec{\mu}_k \rangle_i$, here $k = 1$



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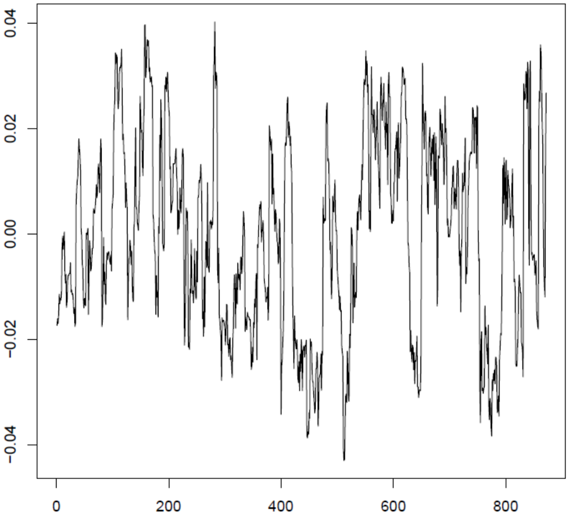
$\gamma_k(t) := \langle \vec{C}^{(k)}(t) - \vec{\mu}_k \rangle_i$, here $k = 2$



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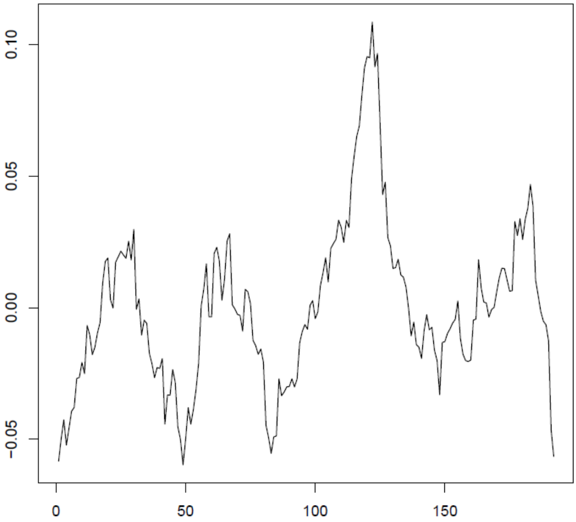

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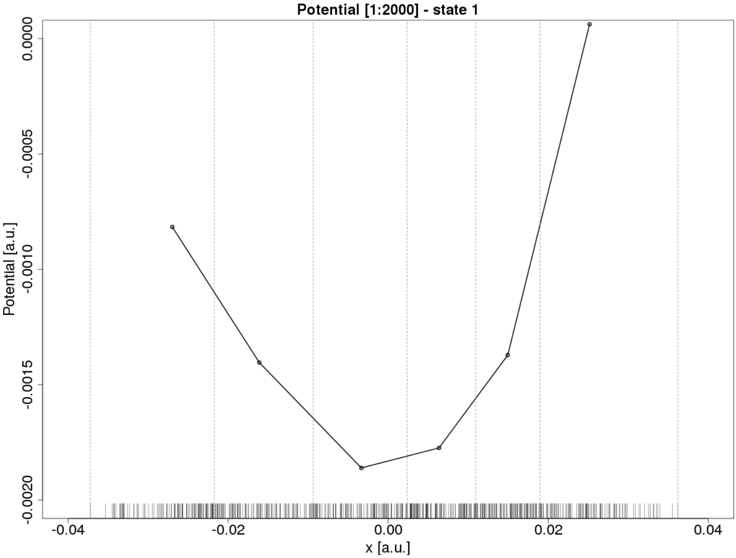

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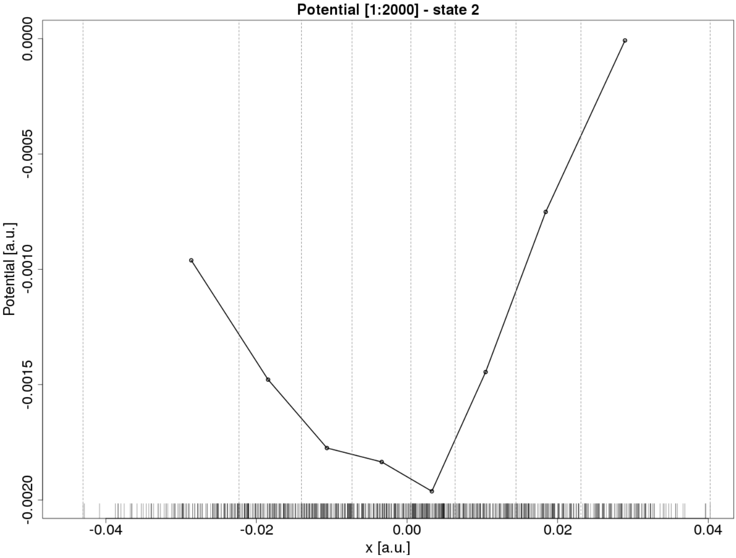
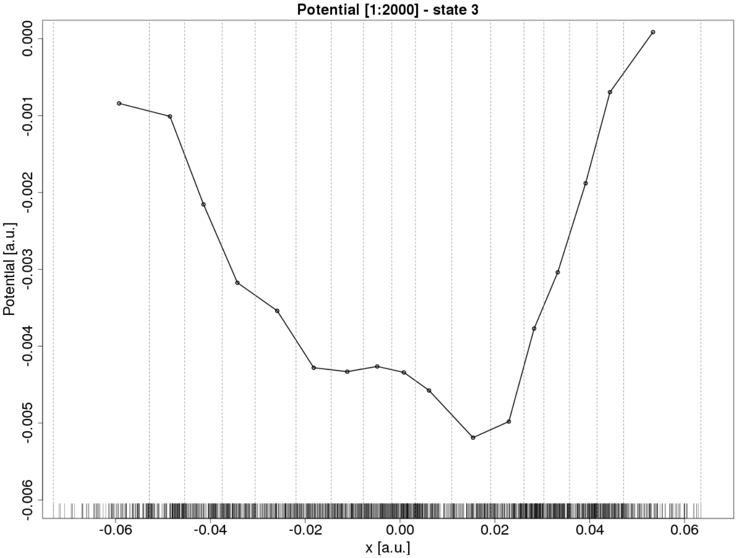


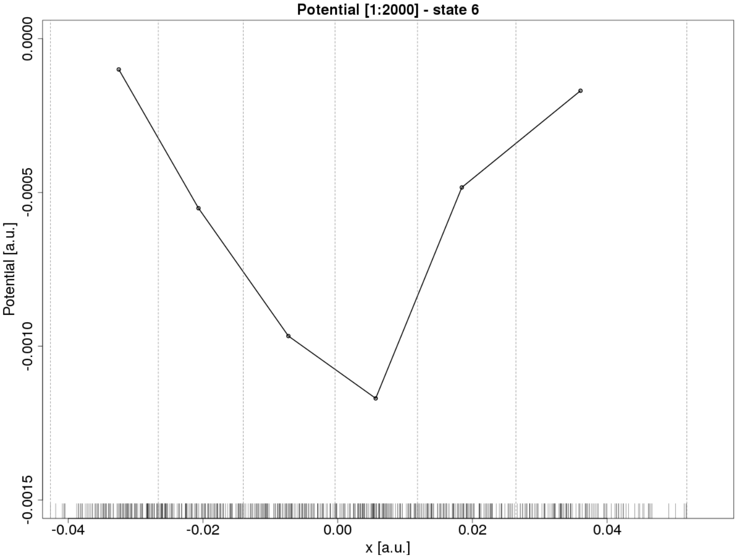
Analysis of Economical Data: Locally

$\gamma_k(t) := \langle \vec{C}^{(k)}(t) - \vec{\mu}_k \rangle_i$, here $k = 3$



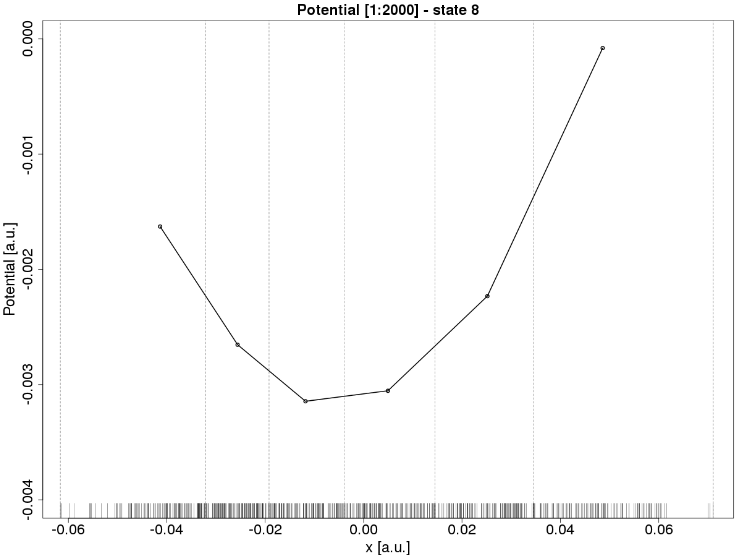
Analysis of Economical Data: Locally

$\gamma_k(t) := \langle \vec{C}^{(k)}(t) - \vec{\mu}_k \rangle_i$, here $k = 6$



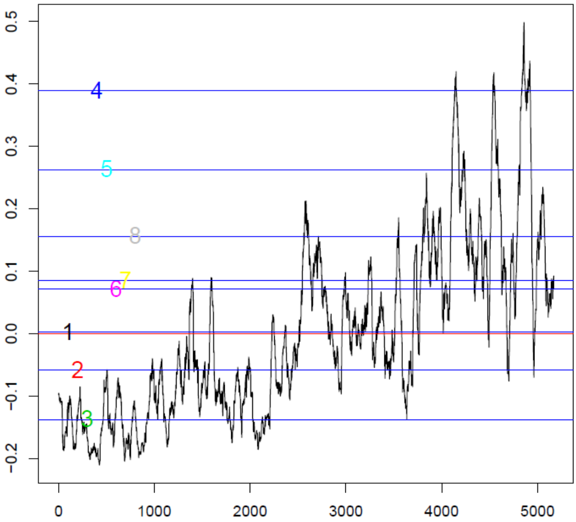
Analysis of Economical Data: Locally

$\gamma_k(t) := \langle \vec{C}^{(k)}(t) - \vec{\mu}_k \rangle_i$, here $k = 8$



Analysis of Economical Data: Globally

$\gamma_k(t) := \langle \vec{C}(t) - \vec{c}_0 \rangle_i$, here $\vec{c}_0 = \text{mean}(\vec{C}(t))$



Analysis of Economical Data: Globally

VIDEO! VIDEO! VIDEO!