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# AUFFÄLLIGKEITEN IN FINANZDATEN

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Dr. Stefanie Schwaar

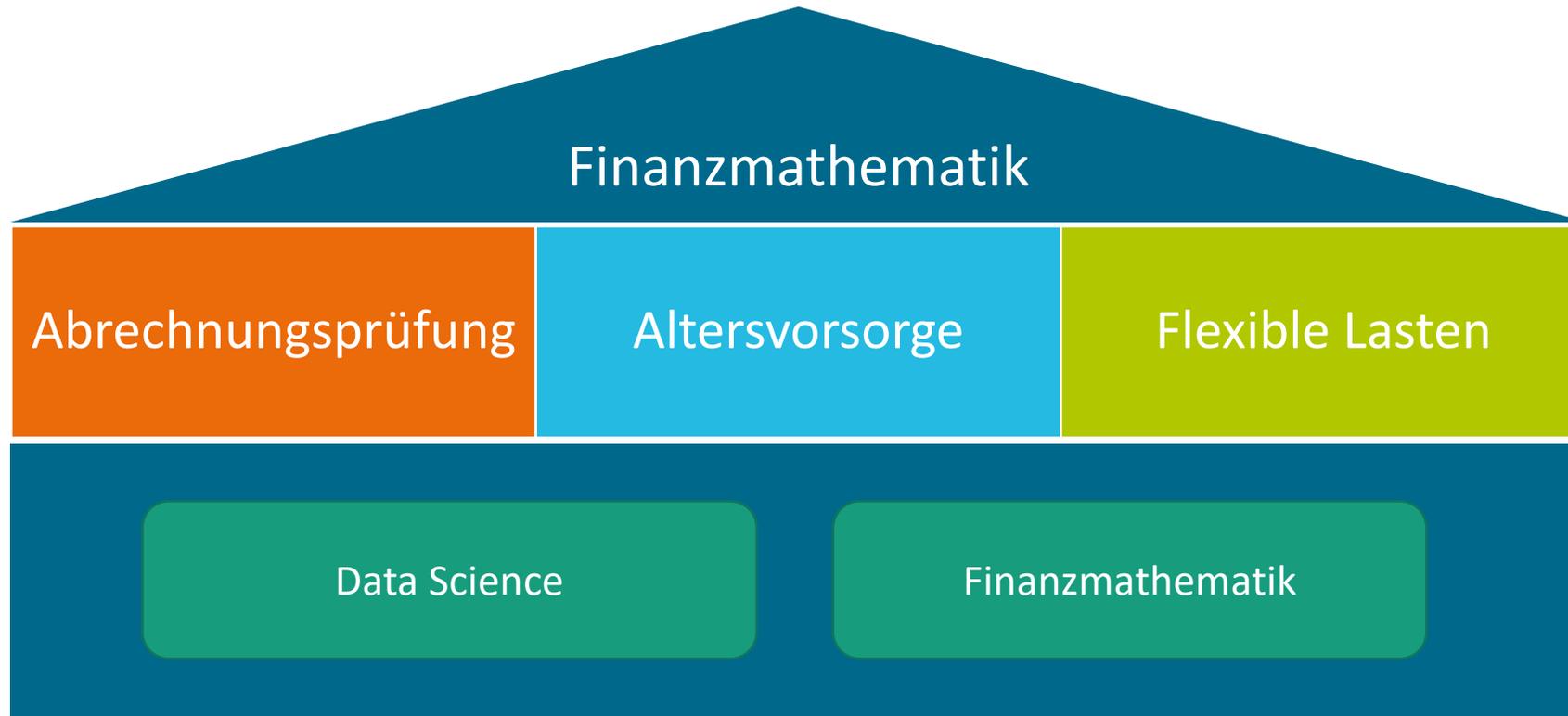
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Geschäftsfeldentwicklerin „Abrechnungsprüfung“  
Abteilung Finanzmathematik

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Wirtschaftsmathematik (ITWM)  
Fraunhofer-Platz 1  
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# Die Abteilung Finanzmathematik ist mehr als Mathematik für Banken und Versicherungen





# Abrechnungsprüfung beginnt bei der Datenerfassung und endet bei der Entscheidung

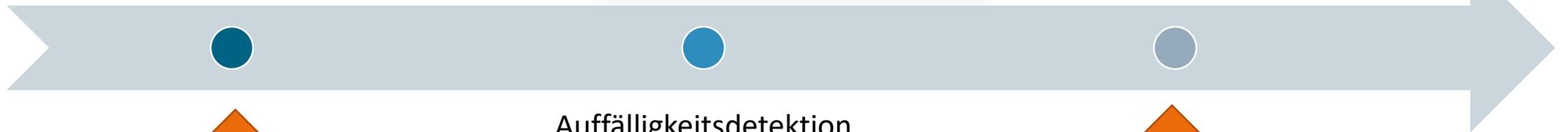


# Projekte aus dem Geschäftsfeld Abrechnungsprüfung setzen an unterschiedlichen Positionen an



Datenerfassung

Operationalisierung



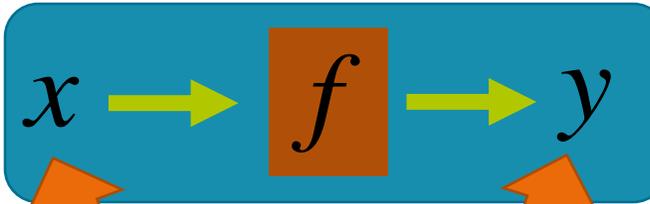
# Abrechnungen sind verschiedene mathematische Objekte

Regressionsmodell:

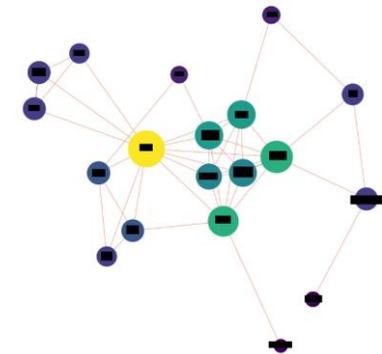
$$f(x_{1i}, x_{2i}, \dots, x_{di}) = y_i$$

Zeitreihen:

$$f(x_{1t}, x_{2t}, \dots, x_{dt}) = y_t$$



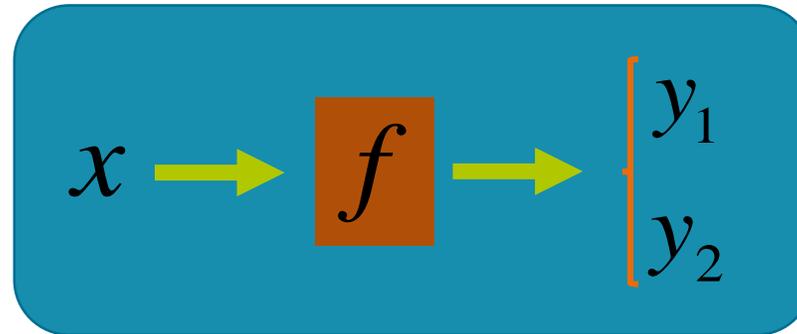
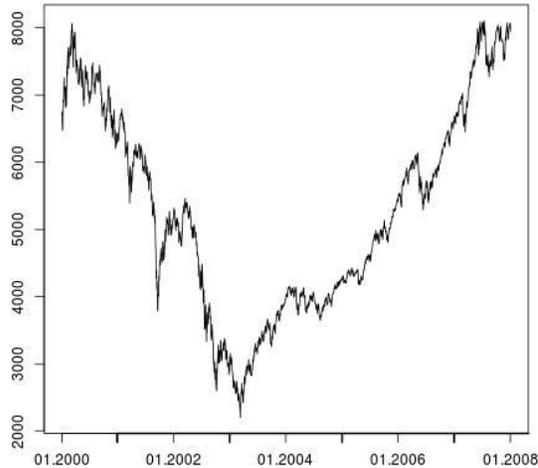
Netzwerke:



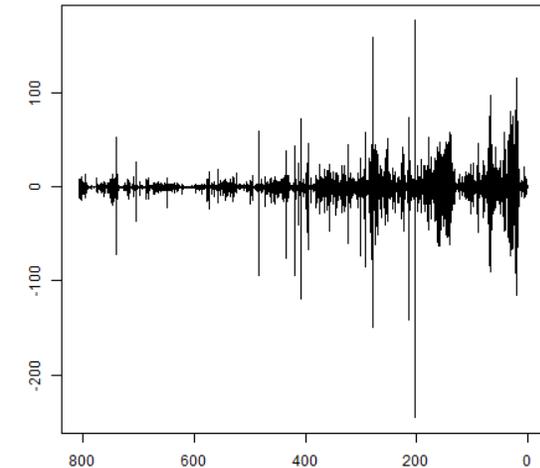
Bestandteile einer Rechnung:

- Beschreibung des abzurechnenden Objektes
- Zeitpunkt der Abrechnung
- Ort der Abrechnung
- Elemente der Rechnung (Arbeitszeit, Material)
- Kosten
- Zusätzliche Informationen

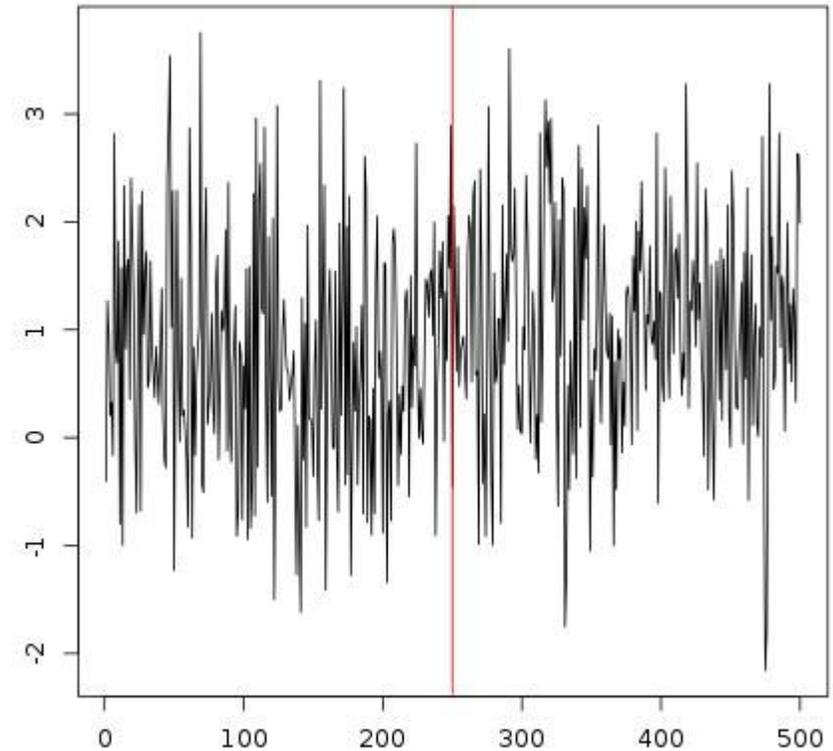
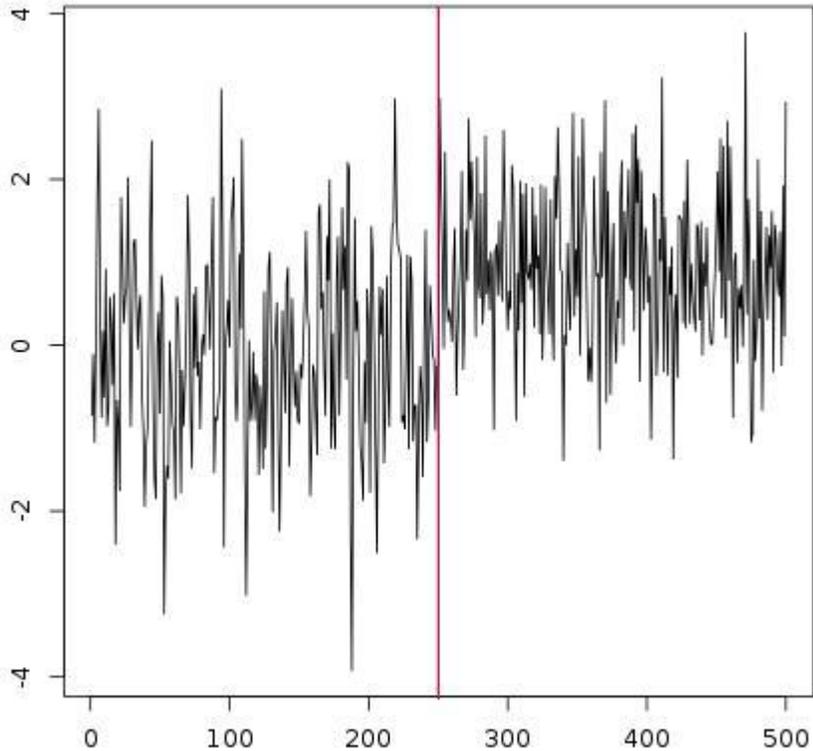
# Auffälligkeiten können unterschiedlichster Natur sein



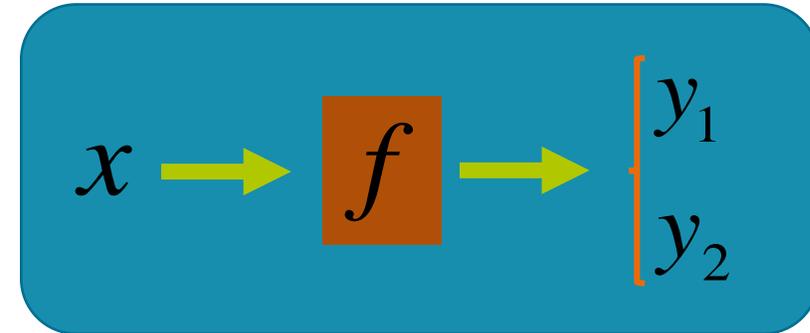
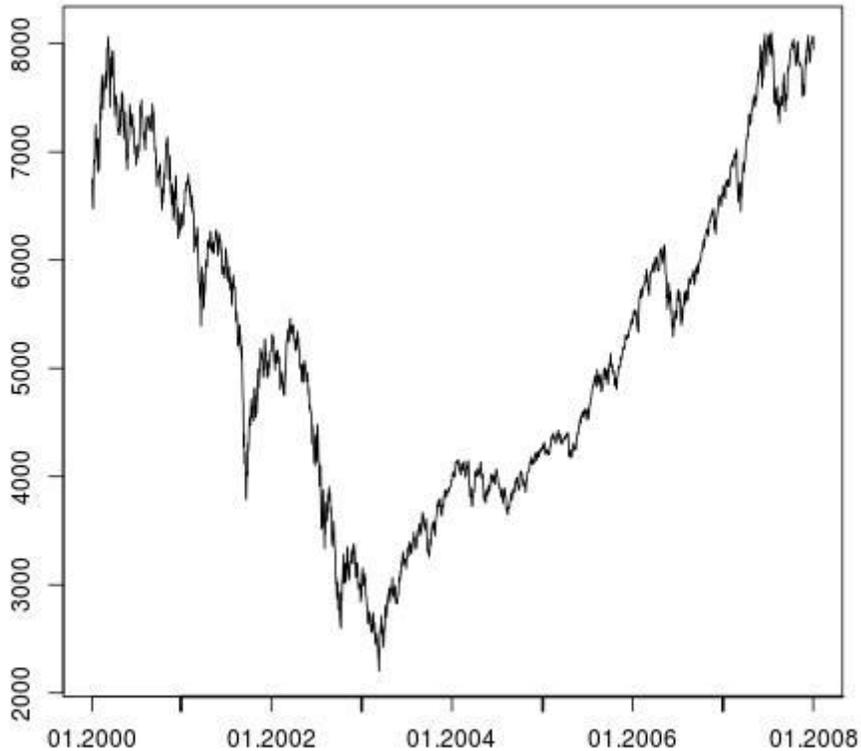
Ausreißer in den Beobachtungen  
Zeitliche Änderungen des  
Zusammenhangs



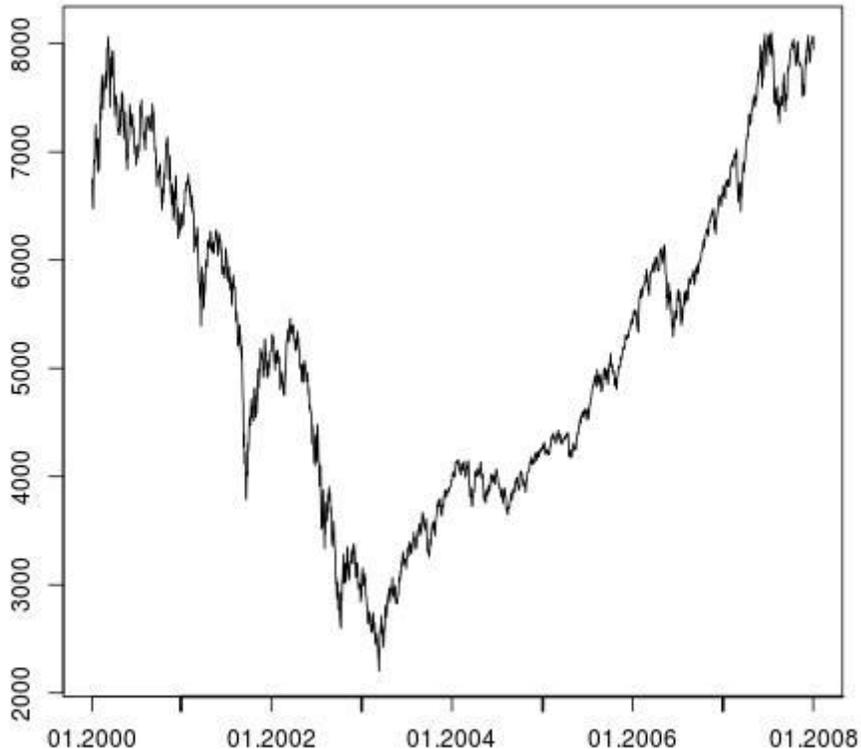
# Strukturänderungen in Zeitreihen erkennen ist eine Herausforderung



# Erkennen von Änderungen in den Zusammenhängen



# Erkennen von Änderungen in den Zusammenhängen



$$X_t = \begin{cases} g_1(\mathbb{X}_t) + \varepsilon_t, & t \leq m \\ g_2(\mathbb{X}_t) + \varepsilon_t, & t > m \end{cases}$$

Hierbei sind unbekannt:

- Funktionen  $g_1$  und  $g_2$
- der Change-Point  $m$  und
- das „Rauschen“  $\varepsilon_t$ .

# Neuronale Netze zur Bestimmung von Änderungen in Zeitreihen verwenden

Idee:

Nutzen der **Universalapproximationseigenschaft** von Neuronalen Netzen, d.h.

$$g(x) \approx f(x, \theta) = v_0 + \sum_{i=1}^H v_i \phi(\langle \alpha_i, x \rangle + \beta_i)$$

$f$  ein Neuronales Netz mit sigmoider Aktivierungsfunktion wodurch der unbekannte Zusammenhang approximiert wird

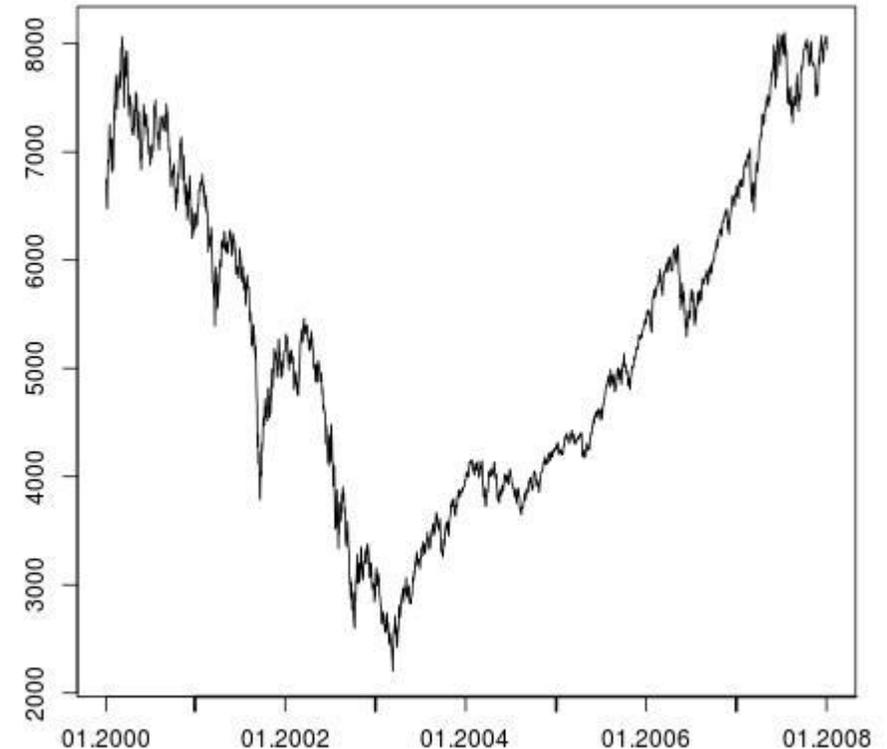
Hornik et al. (1989),  
Multilayer feedforward networks are universal approximators

# Praktische Anwendungen liefern vielversprechende Resultate

$$X_t = \begin{cases} f(\mathbb{X}_t, \theta_1) + \varepsilon_t & 1 \leq t \leq m \\ f(\mathbb{X}_t, \theta_2) + \varepsilon_t & m < t \leq n \end{cases}$$

$$\hat{\theta} = \arg \min_{\theta} \left\| \sum_{t=1}^n (X_t - f(\mathbb{X}_t, \theta))^2 \right\|$$

$$T(X) = \max_{1 \leq k < n} \frac{1}{\sqrt{n}} \left\| \sum_{t=1}^k (X_t - f(\mathbb{X}_t, \hat{\theta})) \right\|$$



Kirch, Tadjidje Kamgaing (2014),

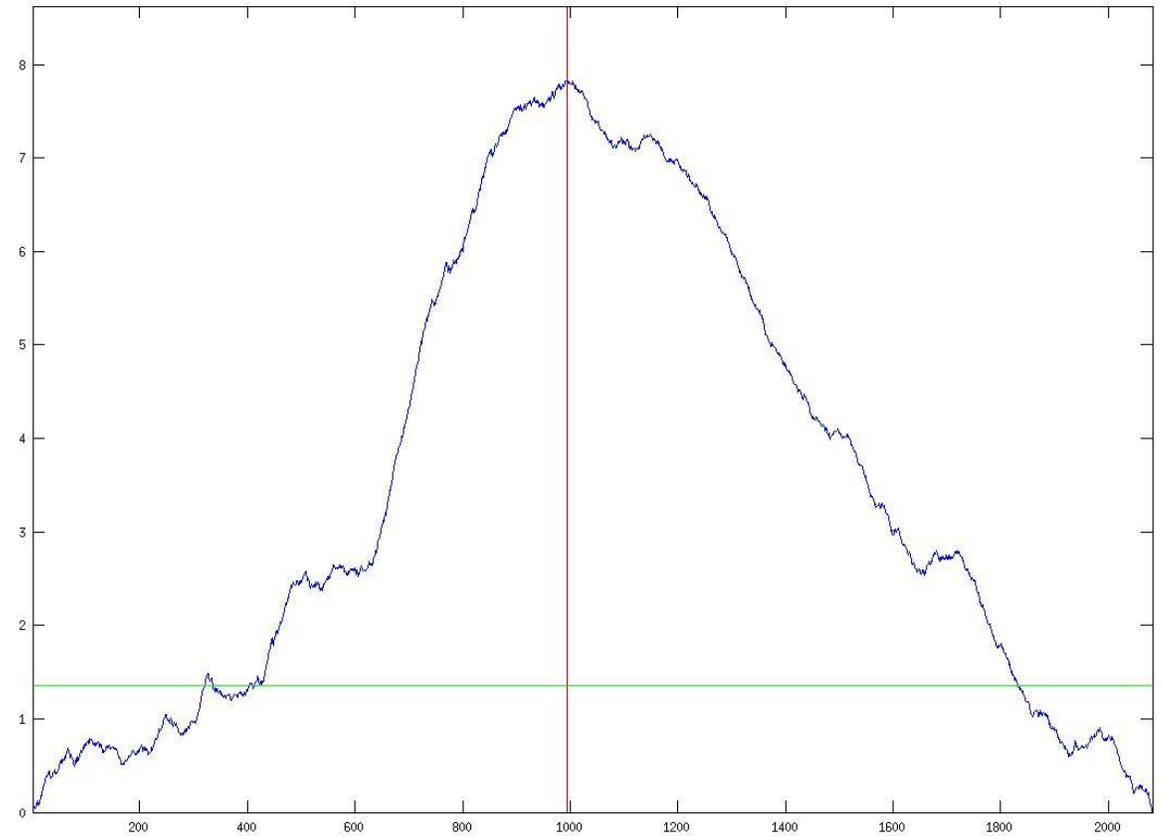
A uniform central limit theorem for neural network-based autoregressive processes with applications to change-point analysis

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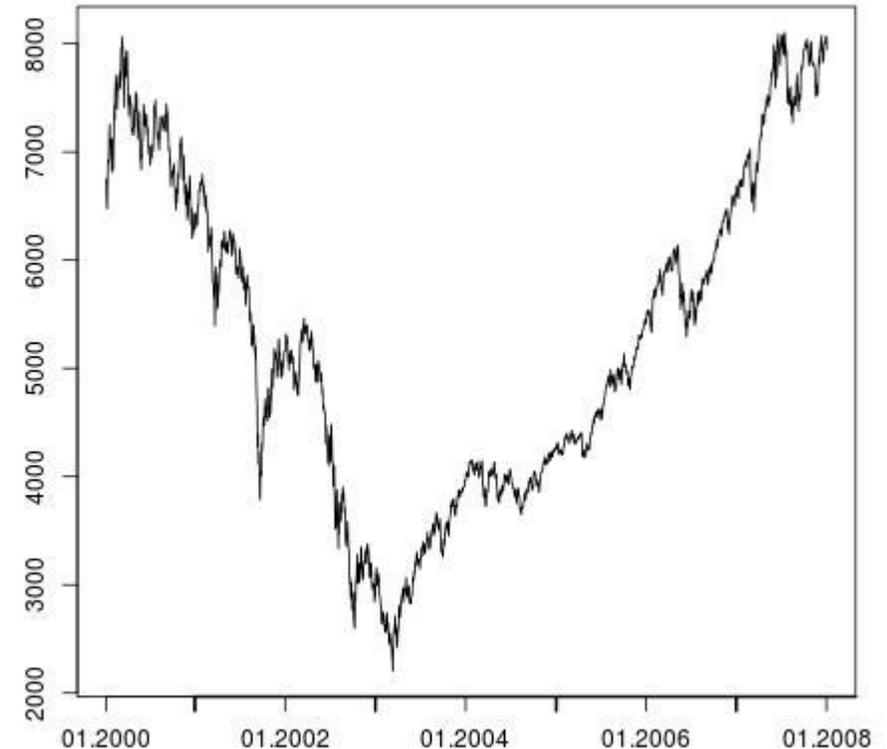
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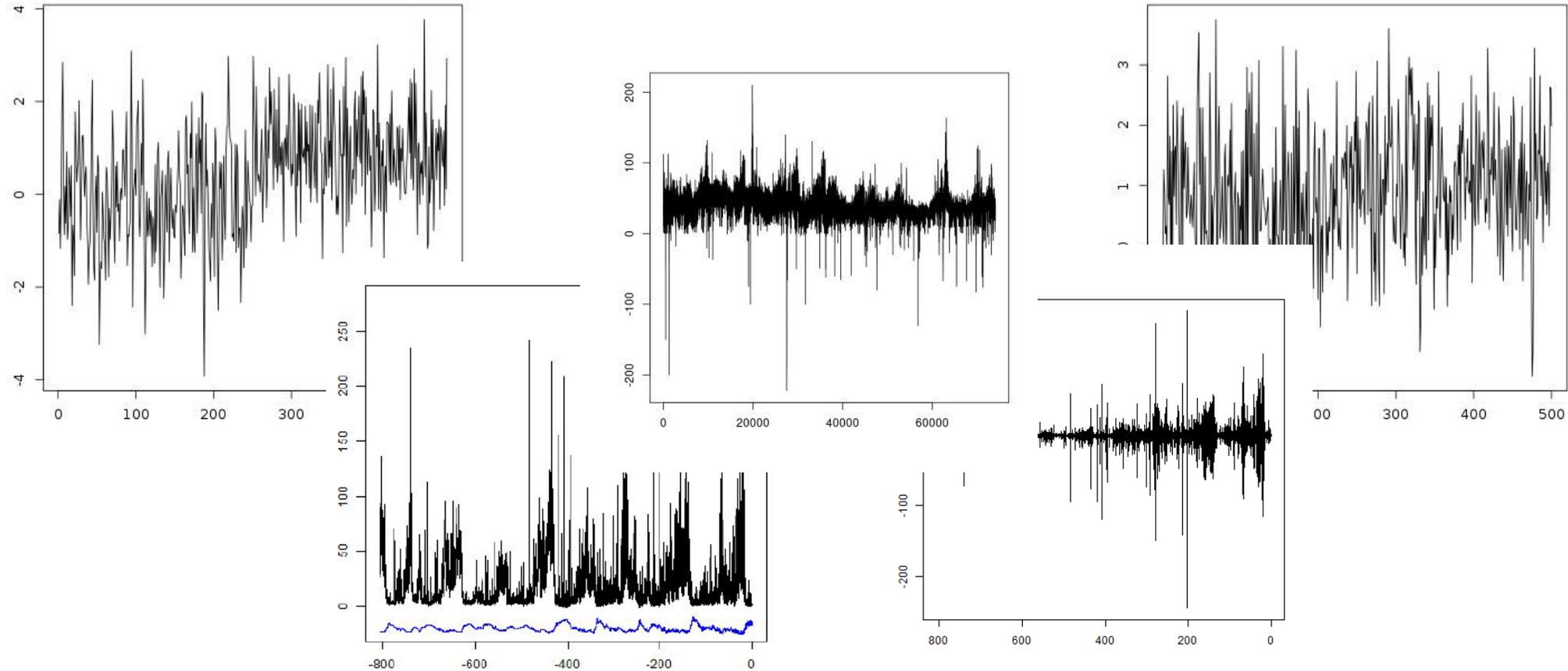
$$T(X) = \max_{1 \leq k < n} \frac{1}{\sqrt{n}} \left\| \sum_{t=1}^k (\nabla f(\mathbb{X}_t, \hat{\theta})) (X_t - f(\mathbb{X}_t, \hat{\theta})) \right\|$$

$$\hat{m} = \arg \max_{1 \leq k < n} \left\| \sum_{t=1}^k (\nabla f(\mathbb{X}_t, \hat{\theta})) (X_t - f(\mathbb{X}_t, \hat{\theta})) \right\|$$



Schwaar (2016),  
Asymptotics for change-point tests and change-point estimators

# Die Anwendung ist in verschiedenen Bereichen möglich



# Aktuelle Forschungsgebiete in Zeitreihen beinhalten verschiedene Aspekte

Machine Learning on EPEX Order Books:  
Insights and Forecasts  
S. Schneider\* and A. Wagner  
Fraunhofer Institute for Industrial Mathematics ITWM, Fraunhofer-Platz 1, 67663  
Kaiserslautern, Germany  
June 17, 2019

**Abstract**  
This paper explores machine learning algorithms to forecast Germany's electricity spot market prices. The forecasts utilize in particular 1 min order book data from the spot market but also fundamental data like renewable infeed and expected demand. Appropriate test functions for the order book data is developed. Using cross-validation hypothesis tests, neural networks and random forests a proof and compared to statistical reference models. The machine's models outperform traditional approaches.

**Keywords:** Machine Learning, Neural Networks, Random Forest, Electricity Market, Renewables, Spot Price, Forecasting.

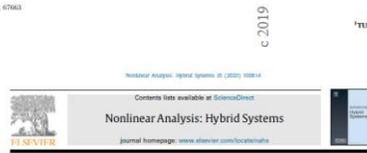
## 1 Introduction

Forecasting electricity prices is an important task in an energy utility not only for proprietary trading but also for the optimization of production schedules and other technical issues. A promising approach price forecasting is based on a modelization of the order book using market fundamental like demand or renewable infeed. However, it requires extensive statistical analysis of market data. In this paper, if and how this statistical work can be reduced using machine learning focuses on two research questions:

- How can order books from electricity markets be included in learning algorithms?
- How can order-book-based spot price forecasts be improved in learning?

We consider the German/Austrian EPEX spot market for electricity in a daily auction for electricity with delivery the next day. All 24 day are traded as separate products. Figure 1 shows auction results

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Discrete-time implementation of continuous-time filters with application to regime-switching dynamics estimation<sup>1</sup>  
Stefanie Grimm<sup>a</sup>, Christina Erwin-Sayer<sup>b</sup>, Rogemar Mamon<sup>a,c,\*</sup>

<sup>a</sup>Wolfgang Pauli Institute, Vienna  
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<sup>c</sup>Department of Statistics and Applied Mathematics, University of the Philippines Diliman, Philippines

## HIGHLIGHTS

- A discrete-time implementation of continuous-time filters is carried out.
- Certain aspects of statistical model validation, diagnostics, and inference are tackled.
- A continuous-time mean-reverting model is employed to capture a 1D overnight yield curve.
- Data's regime-switching evolution was analyzed via 3-D financial-market developments.

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Filtering

## 1. Introduction

The various steps and practical aspects of applying a stochastic model to give down the pricing distribution characteristics of a random process is a complex concern both from the theoretical and applied perspectives. Using discrete and continuous-time modeling frameworks along with a Markov-switching control (e.g. Wang et al. [1]) and dynamic determinants is vital for a complete system, and a specific case is model implementation in economic issues and the financial market (e.g. Barone et al. [2] and Faurer et al. [3]).

In this paper, we focus on an interest rate process that exhibits mean reversion and stochasticity. Its importance is recognized being a key financial and economic indicator. Although the discussion of the implementation centers on a

<sup>1</sup> No author associated with this paper has disclosed any potential or perceived conflicts which may be perceived to have impacted the conduct of this research. All disclosures were made by the authors to the editorial board and are available upon request from the corresponding author.

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## Quant GANs: Deep Generation of Financial Time Series

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## Abstract

Financial time series written by stochastic processes is a challenging task and a research in financial mathematics. As an alternative, we introduce a deep-down model which is inspired by the recent success of neural networks (GANs). Quant GANs consist of a generator and a discriminator, which utilize temporal convolutional networks (TCNs) to capture long-range dependencies such as the presence of a trend. The generator function is explicitly constructed such that the stochastic process allows a transition to its risk neutral distribution. Our results highlight the distributional properties for small and large jumps of asset prices and dependence properties such as volatility clusters, and serial autocorrelations can be generated by the generator in GANs, demonstrably in high fidelity.

Results of AlexNet (Krizhevsky et al. 2012) at the ImageNet competition, and its various successors from generating realistic audio waves (Gatzert and using human level performance on ImageNet (Lee et al. 2015) or beating a game Go (Silver et al. 2016). While NNs have already become standard in application in finance is still in early stages. Citing a few, Brubaker et al. (2017) performed a review, Richter et al. (2018) on the optimal stopping (Richter et al. 2017) (2018) detect anomalies in accounting data and show how likely by deep learning.

or the problem of approximating a realistic asset price simulator by using deep learning. Such a path simulator is useful as it can be used to extend old datasets, which is then can be used for the time or volatility financial

time path simulator we propose Quant GANs. Quant GANs are based on two adversarial networks (GANs) (Goodfellow et al. 2014) and an local approaches such as historical simulation and model driven methods such as modeling an underlying stock price model like the Black-Scholes model (Black-Scholes stochastic volatility model (Eberlein, 1999) or Levy process (Eberlein, 2002)).

As an application in the fundamental principle of GANs. While one NN, a responsible for the generation of stock price paths, the second one, the discriminator, is responsible for the classification of the generated paths.

## Aktuelle Forschung behandeln:

- Forecasting mit Machine-Learning Algorithmen
- Simulation von Zeitreihen
- Detektion von verborgenen Zuständen
- Einfluss von Datenfehlern

Weitere Forschungsprojekte finden Sie auf:

<https://www.itwm.fraunhofer.de/de/abteilungen/fm/aktuelles/aktuelle-forschungsthemen.html>

# Das Zusammenspiel unterschiedlicher Techniken liefert effiziente Unterstützung



# Auffälligkeiten in Finanzdaten

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