

統計関連学会連合大会プレナリーセッション

第 2 回 赤池メモリアルレクチャー

【日 時】2018 年 9 月 10 日(月)10:30~12:00

【会 場】中央大学・後樂園キャンパス 5 号館 5 階 5534 教室(A 会場)

【主 催】統計関連学会連合大会組織委員会、統計数理研究所

【司 会】栗原 考次(統計関連学会連合大会組織委員長)

【座 長】樋口 知之(統計数理研究所長)

【概 要】「赤池メモリアルレクチャー賞」は、2016 年 5 月に統計数理研究所と日本統計学会により共同で設立されました。統計科学の分野において多大な功績を残し、その発展に大きな影響を及ぼした故赤池弘次博士の功績を記念したものです。

今年度、第 2 回受賞者がデューク大学の Mike West 教授に決定し、受賞式及び記念講演を 2018 年度統計関連学会連合大会のプレナリーセッションで行います。

【プログラム】

10:30~10:40

赤池メモリアルレクチャー賞の説明および授賞式

樋口 知之(統計数理研究所長)

10:40~11:40

赤池メモリアルレクチャー

“Bayesian Forecasting of Multivariate Time Series: Model Scalability, Structure Uncertainty and Decisions”

Mike West 教授(米国デューク大学 特別荣誉教授)

11:40~12:00

二人の若手研究者による討論および West 教授の答弁

中島 上智 博士(国際決済銀行)

Assist. Prof. Christopher D. Glynn(ニューハンプシャー大学)

【受賞者】

Mike West 教授

略歴:

- 1978年 イギリス ノッティンガム大学数学部 卒業 *一等学位
- 1982年 博士(数学(統計学))取得(イギリス ノッティンガム大学)
- 1981-1988年 イギリス ウォーリック大学 統計学科講師
- 1984年 アメリカ ハーバード大学客員教授
- 1987年 アメリカ パデュー大学客員教授
- 1988-2003年 イギリス ウォーリック大学 統計学部准研究員
- 1994年 アメリカ 国立統計科学研究所(NISS)上席・大学研究員
- 1988-1992年 アメリカ デューク大学 統計科学・意思決定科学研究所准教授
- 1990-2002年 同 所長
- 1992-2007年 同 教授
- 1999年-現在 デューク大学 特別荣誉教授(Distinguished Professor)
- 2007年-現在 デューク大学 統計学科教授

【討論者】

中島 上智 博士 Dr. Jouchi Nakajima
シニアエコノミスト Senior Economist
金融経済局 Monetary and Economic Department
国際決済銀行 Bank for International Settlements

Dr. Christopher Glynn
Assistant Professor of Decision Sciences
Peter T. Paul College of Business and Economics
University of New Hampshire

<本件に関するお問い合わせ先>

大学共同利用機関法人 情報・システム研究機構 統計数理研究所
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〒190-8562 東京都立川市緑町 10-3

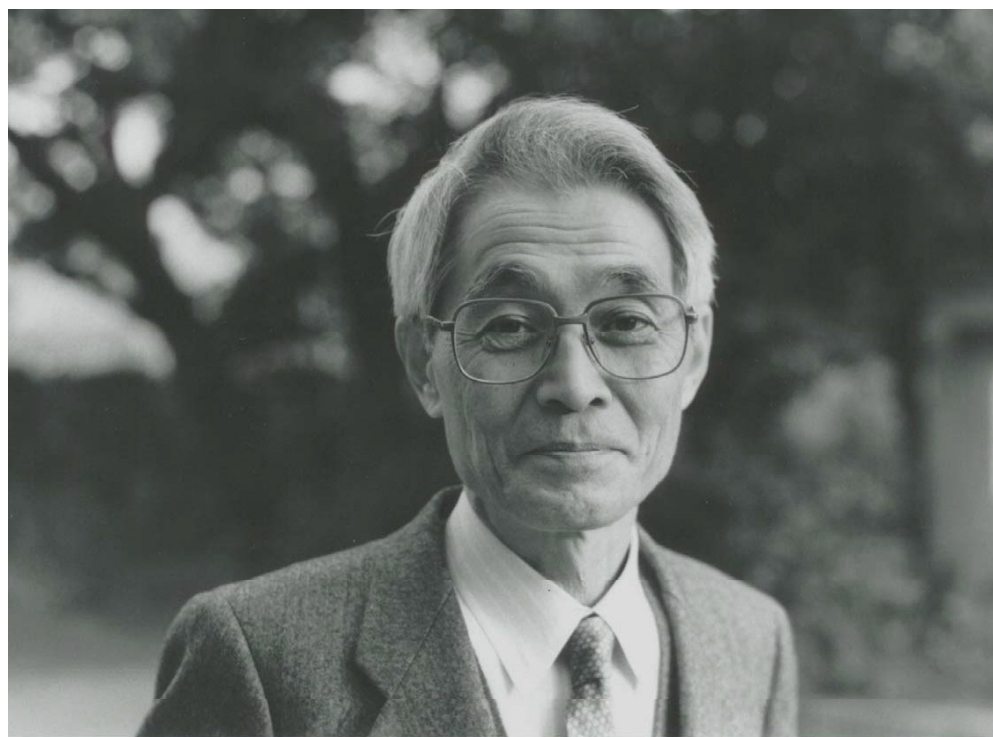
Introduction of the Akaike Memorial Lecture Award

Prof. Tomoyuki Higuchi

Director-General,
The Institute of Statistical Mathematics (ISM)

Hirotsugu Akaike (1927–2009)

赤
池
弘
次



Brief History

- 1952 Graduated from Math. Dept., Tokyo University Researcher of the **Institute of Statistical Mathematics**
- 1962 Head of 2nd Section, 1st Division
- 1973 Director of **5th Division**
- 1985 Director of **Dept. of Prediction and Control**
- 1986 Director-General of ISM (-1994)
- 1988 Member of **Science Council of Japan** (- 1991)
Chair of Dept. of Statistical Science, Graduate University of Advanced Study
- 1994 Prof. Emeritus, ISM
Prof. Emeritus, Graduate Univ. for Advance Study



Prizes

- 1972 Ishikawa Prize**
(Establishment of statistical analysis and control method for dynamic systems)
- 1980 Okochi Prize**
(Research and realization of optimal steam temperature control of thermal electric plant)
- 1989 Asahi Prize**
(Research on statistics, in particular theory and applications of AIC)
- The Purple Ribbon Medal**
(Statistics, in particular time series analysis and its applications)
- 1996 The 1st Japan Statistical Society Prize**
(Contributions to statistical theory and its applications)
- 2000 The Order of the Sacred Treasure**
- 2006 Kyoto Prize**
(Major contribution to statistical science and modeling with the development of AIC)

Fellow of ASA, RSS, IMS, IEEE, JSS



Laureate of 22nd Kyoto Prize

稲盛財団
INAMORI FOUNDATION
2006.6.9
プレスリリース

第22回(2006)京都賞受賞者の決定

財団法人稲盛財団(理事長・稲盛和夫)は第22回(2006)京都賞の受賞者を決定しました。本年の受賞者は、以下の3名です。

- 先端技術部門
本年授賞対象分野: バイオテクノロジー及びメディカルテクノロジー
レナード・アーサー・ハーツェンバーク博士(アメリカ・74歳・スタンフォード大学教授)
- 基礎科学部門
本年授賞対象分野: 数理論理学
赤澤弘次博士(日本・78歳・統計数理研究所名誉教授)



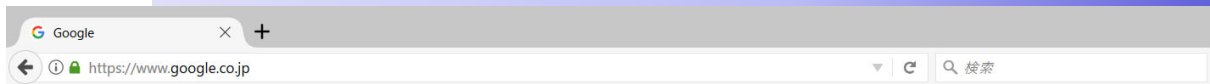
"Major contribution to statistical science and modeling with the development of the Akaike Information Criterion (AIC)"



Research Organization of Information and Systems

*This slide was made by Dr. Genshiro Kitagawa, Ex. President of the Research Organization of Information and Systems (ROIS)

Celebration for the 90th-Birthday of Dr. Hirotugu Akaike



この Doodle の表示地域



Google 検索

I'm Feeling Lucky

If you've ever conducted a statistical analysis, you might've spent hours thinking about which variables to include and the impact each would have on the outcome. But to ensure the model itself is accurate, shouldn't someone measure the measurers?

In the early 1950s, a young Japanese scientist named Hirotugu Akaike asked this simple but crucial question. More than two decades of research later, he presented the answer as a simple equation known as the Akaike Information Criterion. With AIC, analysts select a model from a set of options by measuring how close the results are to the (hypothetical) truth.

For Dr. Akaike, experience was core to creativity. To get 'a direct feel of random vibrations,' for example, he bought a scooter and rode it around Mount Fuji. This first-hand experience helped him differentiate between the vibrations of riding on normal and heavily-trucked roads.

Today's Doodle portrays Dr. Akaike against a Google-inspired approximation of functions, parameters, and their respective curves.

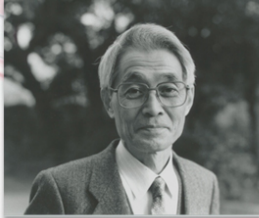
Below are a few initial conceptualizations of the Doodle.

For more information of Dr. Hirotugu Akaike, please visit our website.



<http://www.ism.ac.jp/akaikememorial/index-e.html>

Home	Profile	C.V.	English Papers	Japanese Papers	Books
Number of Citations	Pictures	Akaike Guest House	Information Related to AIC	About this Site	Japanese



Dr. Hirotugu Akaike

Dr. Hirotugu Akaike passed away on Aug. 4, 2009, at the age of 81.

Dr. Akaike was never satisfied with his past achievements and always tried new research collaborated with diverse areas.

Dr. Akaike's great passion to his research urged him to continue tackling with his new work even when he was sick in bed.

On the other hand, with his gentleness and tenderness as a person, Dr. Akaike stayed in touch with so many people.

This web site was created in honor memory of Dr. Akaike as a great researcher, as a great person.


Hirotugu Akaike (Nov.1927-Aug.2009)

What's new


- 25.06.2018 [Announcement of the Awardee of the Second Akaike Memorial Lecture Award.](#)
- 15.03.2018 [The Invited Article of the first Akaike Memorial Lecture \(with Discussion\) on AISM has been published.](#)
- 05.11.2017 [Celebration for Dr. Hirotugu Akaike's 90th Birthday on the Googldoodle](#) You can see the video on [YouTube](#)
- 01.19.2017 [The report and handouts of the Akaike Memorial Lecture on Sep. 5, 2016 have been uploaded.](#)
- 07.29.2016 [Akaike Memorial Lecture will be held on Sep. 5, 2016.](#)
- 07.22.2016 [\[EurekAlert!\] Akaike Memorial Lecture Award, Selection of the First Awardee.](#)
- 07.14.2016 [\[Pressrelease\]The Institute of Statistical Mathematics and the Japan Statistical Society Joint Inaugural Akaike Memorial Lecture Award, Selection of the First Awardee.](#)
- 07.14.2016 Some parts of the information of the Number of Citations have been updated.
- 10.16.2012 Some parts of the information of the Number of Citations have been updated.
- 08.31.2011 English PDF file Statistical World of Hirotugu Akaike uploaded.
- 03.03.2011 This site has been opened.

Research

Statistical World of Hirotugu Akaike



Sokendai Journal No.12 Featured the Statistical World of Hirotugu Akaike. (in Japanese)



Akaike Memorial Lecture Award

The Institute of Statistical Mathematics Japan Statistical Society



June 25, 2018

Announcement of the Awardee of the Second Akaike Memorial Lecture Award

◆ Overview:

In May of 2016, the Institute of Statistical Mathematics (ISM) and the Japan Statistical Society (JSS) have jointly created the Akaike Memorial Lecture Award to celebrate the outstanding achievements of the late Dr. Hirotugu Akaike. Dr. Akaike greatly influenced a wide range of research by proposing the Akaike Information Criterion (AIC) and establishing a novel paradigm for statistical modeling, which was distinguished by its predictive point of view, and was totally distinct from traditional statistical theory. The Akaike Memorial Lecture Award aims to encourage the education of talented young researchers by recognizing researchers who have achieved outstanding accomplishments that contribute to the field of statistical sciences.

With great pleasure, we announce that the awardee of the Second Akaike Memorial Lecture Award is Professor Mike West of Duke University in USA. Professor West's contributions to Bayesian statistics include seminal work in dynamic modeling, and the implementation of nonparametric models that paved the way to practical data analyses via the first realization of large-scale simulation-based methods. Professor West himself has also actively worked at the frontiers of various research fields to which Bayesian statistics can be applied and contributed to the creation of data-driven sciences. For example, he established a new approach for biomarker discovery using gene expression data, thus creating a novel trend in omics biology based on data analysis. The award ceremony and memorial lecture will be held during the plenary session of the Japanese Joint Statistical Meeting 2018, which will take place at the Korakuen Campus of Chuo University on September 10, 2018.

Reason for Selection:

Professor Mike West is a great pioneer in the field of Bayesian statistics. He receives the Second Akaike Memorial Lecture Award for his wide-ranging and outstanding research accomplishments in both theoretical and practical aspects of this field.

Professor West has made significant contributions to the development of statistical sciences, including dynamic modeling, space-time data analysis, sparse modeling, Bayesian computation, and non-parametric Bayesian analysis. The applied fields to which Prof. West has contributed include finance, macroeconomics, climatology, and biology. His paper on Dirichlet Process mixture models, published in 1995, offered an easy-



to-implement and efficient algorithm for the model. Previously, even though its usefulness had been understood theoretically, this model had not been used in practice due to difficulties in its computation. Professor West's algorithm represented a major contribution to the practical realization of the non-parametric Bayesian analysis. The magnitude of this influence is illustrated by the fact that the paper has been cited more than 2000 times [1]. In addition, in 2001 and 2006, Professor West published important papers pertaining to cancer prognosis using gene expression data, conducted jointly with leading molecular geneticists. These papers identified patterns of cell signaling pathway deregulation by combining signature-based predictions and developed predictive models for identifying types of breast cancer [2,3]. These outcomes led to the occurrence of a mega-trend in omics biology: biomarker discovery through gene expression profiling.

For these reasons, the nominating committee is proud to select Professor West as the awardee of the Second Akaike Memorial Lecture Award.

◆ About the Second Awardee: Professor Mike West

Research Achievements

Professor Mike West is one of the pioneers who have led the field of the Bayesian statistics. In particular, Professor West's research on Bayesian modeling of dynamic processes, high-dimensional data and large-scale complex systems has significantly influenced the development of the theory and practice of statistics. Professor West's broad activities range from statistical theory, including time series, high-dimensional space-time data analysis and sparse modeling, to application, including decision-making theory for financial time-series data analysis, structure modeling, analysis of high-frequency financial time series data, macroeconometrics, dynamic network analysis, image recognition, system biology, and analysis of air environment monitoring data.

After obtaining his Ph.D. in Mathematics at the University of Nottingham, UK, Professor West has published nearly 200 papers in numerous fields, ranging from pure statistical theory to applied research in fields including business, economy and finance, signal processing, climatology, public health sciences, genome sciences, immunology, neurophysiology, and systems biology.

Professor West has devoted himself passionately to education in statistics, and has made outstanding accomplishments in education. Over the course of his career, he has instructed young statisticians from industry, government, and academia around the world, and mentored more than 55 talented doctoral students and post-doctoral researchers.

Additionally, Professor West was awarded the Mitchell Prize (three times, in 1994, 1997, and 2012); the American Statistical Association Outstanding Statistical Application Paper Award (1997); the American Statistical Association NC Chapter Award (2014); and the Zellner Medal from the International Society for Bayesian Analysis (2014).



- [1] Escobar, M.D., West, M.(1995). Bayesian density estimation and inference using mixtures. *Journal of the American Statistical Association* 90:577-588.
- [2] Bild, A.H., Yao, G., Chang, J.T., Wang, Q., Potti, A., Chasse, D., Joshi, M., Harpole, D., Lancaster, J.M., Berchuck, A., J.A. Olson, J.R.M., Dressman, H.K., West, M., Nevins, J.R.(2006). Oncogenic pathway signatures in human cancers as a guide to targeted therapies. *Nature* 439:353-357.
- [3] West, M., Blanchette, C., Dressman, H.K., Huang, E.S., Ishida, S., R. Spang, H.Z., Marks, J.R., Nevins, J.R. (2001). Predicting the clinical status of human breast cancer utilizing gene expression profiles. *Proceedings of the National Academy of Sciences* 98:11462-11467.

Current Position

The Duke University distinguished Arts & Sciences Professor of Statistics and Decision Sciences, in the Department of Statistical Science, Duke University

Biography

Date of birth: October 30th, 1956 (current age, 61)

Education:

1978 B.Sc. Mathematics, First Class Honors, Department of Mathematics, University of Nottingham, UK

1982 Ph.D. in Mathematics (Statistics), University of Nottingham, UK

Professional Summary

1981–1988 Lecturer at Department of Statistics of University of Warwick, UK

1984 Visiting Professor at Harvard University, USA

1987 Visiting Professor at Purdue University, USA

1988-2003 Associate Fellow at Department of Statistics of University of Warwick

1994 Senior & University Fellow at the National Institute of Statistical Sciences (NISS), USA

1988–1992 Associate Professor at the Institute of Statistics and Decision Sciences (ISDS) of Duke University, USA

1990–2002 Director at ISDS

1992–2007 Professor at ISDS

1999–present Distinguished Professor at Duke University

Professor in the Division of Statistics of Duke University

2007–present Professor in the Department of Statistical Science, Duke University

◆ Overview of the Akaike Memorial Lecture Award

The Akaike Memorial Lecture Award was inaugurated in 2014 under the joint sponsorship of ISM and JSS. The Award was named after the late Dr. Hirotugu Akaike (*1), who left a wide-reaching and influential legacy



of research in the statistical sciences. Along with the Award, the ISM and JSS organize a memorial lecture by the awardee, offering opportunities for exchange among statistical researchers from within and outside Japan as well as inspiration to young and talented researchers. Thus, the Award contributes to further advances in this field.

Every 2 years, one awardee is selected from among those individuals who are, like the late Dr. Akaike, ahead of their times, exercising an international influence over a wide range of fields in the statistical sciences (including mathematical sciences and mathematical engineering, such as control and optimization) and related applied fields. The awardee receives a ¥100,000 honorarium, an award plaque, and travel expenses.

For educational purposes, the Memorial Lecture will be followed by time for question and discussion involving the Awardee and selected students and young researchers. The contents of the lecture, including the accompanying discussion, will be published as an invited article in the Annals of the Institute of Statistical Mathematics (AISM).

◆ The Second Akaike Memorial Lecture

The Second Akaike Memorial Lecture will be held during the plenary session of the 2018 Japanese Joint Statistical Meeting, which will be co-organized by the Institute of Statistical Mathematics and the Organizing Committee of the Japanese Joint Statistical Meeting 2018, commissioned by The Japan Statistical Society.

- Lecturer: Professor Mike West (Duke University)
Title: Bayesian Forecasting of Multivariate Time Series:
Model Scalability, Structure Uncertainty and Decisions
Discussants: Dr. Jouchi Nakajima (Bank for International Settlements)
Dr. Christopher D. Glynn (University of New Hampshire)
Date/Time: September 10, 2018 (a.m.)
Venue: Building No. 5, Room 5534, Korakuen Campus, Chuo University
(1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan
<http://global.chuo-u.ac.jp/english/siteinfo/visit/korakuen/>)

Note: Detailed information will be uploaded on the following websites:

Institute of Statistical Mathematics (http://www.ism.ac.jp/index_e.html)

Japanese Joint Statistical Meeting 2018 (<http://www.jfssa.jp/taikai/2018/english/index.html>)

Japan Statistical Society (<http://www.jss.gr.jp/en/>).

**(*1) Biography of Dr. Hirotugu Akaike**

Born on November 5, 1927 in Shizuoka Prefecture, Japan, Hirotugu Akaike graduated from the Imperial Naval Academy, the First Higher School, and the Department of Mathematics, and the Faculty of Science, The University of Tokyo. He joined the Institute of Statistical Mathematics in 1952.

In the 1960s, Dr. Akaike led the field of time series analysis through his research and development of spectral analysis techniques, multivariate time series models, statistical control methods, and TIMSAC (Time Series Analysis and Control), a software package designed for time-series analysis. In the 1970s, Dr. Akaike proposed the Akaike Information Criterion (AIC). Thus, he established a new paradigm of statistical modeling, which was characterized by a predictive point of view, and therefore completely distinct from traditional statistical theory. His accomplishments have greatly influenced research in a variety of fields. In 1980s, Dr. Akaike advanced his research to realize the practical application of Bayesian modeling. His research played a pioneering role in the development of new information processing systems that could meet the demands of the era of large-scale information. His research results were held in the highest esteem by his colleagues and earned him many prizes, including the Medal of Honor (Purple Ribbon), the Second Class Order of the Sacred Treasure, and the Kyoto Prize. His work continues to be cited today.

Dr. Akaike took the position of Director-General of the ISM in 1986. While overseeing the operation of the Institute, he also took part in establishing and teaching in the Statistical Studies program at the Graduate University for Advanced Studies. His term as Director-General ended in 1994. At that time, he was appointed Professor Emeritus at the Graduate University for Advanced Studies, but never lost his passion for research; rather than resting on his well-deserved laurels, he continued his work, publishing studies of topics as diverse as Bayesian models and the golf swing. He also served as the 19th president of the JSS from January 1989 to December 1990. He passed away in Ibaraki Prefecture, Japan on August 4, 2009 (age 81).

On November 5, 2017, a celebration of Dr. Hirotugu Akaike's 90th Birthday appeared on the Google Doodle in 16 countries and regions around the world.

Memorial Website for Late Dr. Akaike: Hirotugu Akaike Memorial Website

<http://www.ism.ac.jp/akaikememorial/index-e.html>

Press Contact:

URA Station in ISM

E-mail: ask-ura@ism.ac.jp

TEL: +81-50-5533-8580



Bayesian Forecasting of Multivariate Time Series: *Model Scalability, Structure Uncertainty and Decisions*



Mike West
Duke University



Akaike Memorial Lecture : Some of today's themes



Hirotugu Akaike

- Bayesian state-space time series
- Prediction and decisions
- Model structure uncertainty
- Computational feasibility
- Applied motivations



Institute of Statistical Mathematics



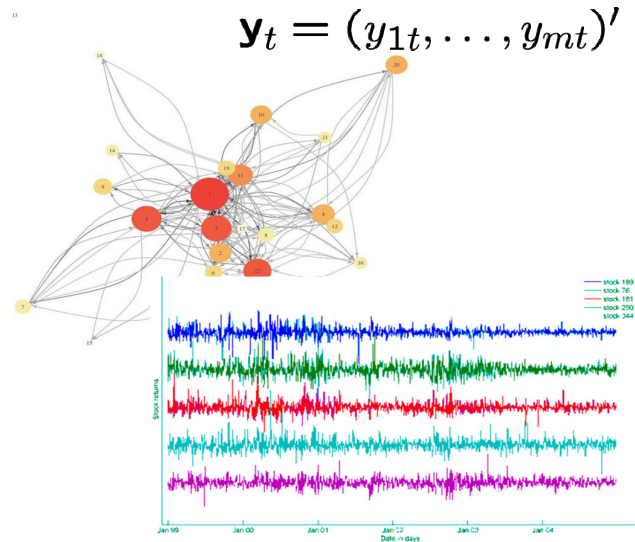
State-space modelling
- innovators and leaders



- Challenges -
 Flexible multivariate models
 Computationally feasible
 Scale up in m

- Increasingly large-scale:
 - High-dimensional time series
 - Dynamic networks
 - Large-scale hierarchical systems

- Sequential analysis, forecasting, decisions:
 - Financial portfolios
 - Multi-step macroeconomics
 - Monitoring networks- change/anomaly detection
 - Large-scale commercial sales forecasting
 - Business/corporate financial flows, investment decisions

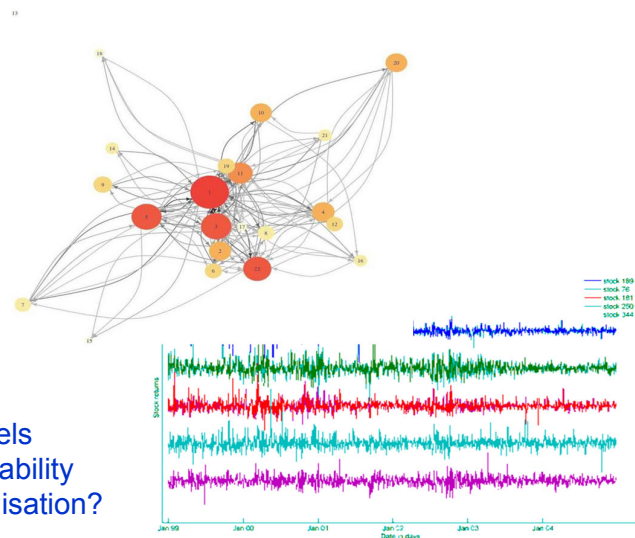


DECOUPLE - univariate time series

- Customisable series-specific models
- State-space models: analytic tractability
- Sequential analysis: fast? parallelisation?

RECOUPLE - Critical cross-series / multivariate structure

- Sensitive dependence / "co-volatility" modelling
- Sensitive online monitoring, adaptation to change
- Coherent joint forecast distributions, resulting decisions





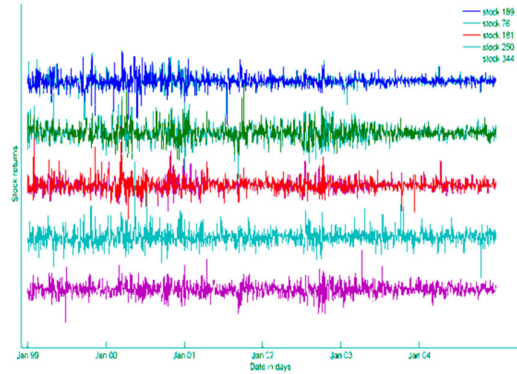
Decouple/recouple : Example 1 - Multivariate volatility

Financial time series: FX, commodities, stocks ..

Multi-step forecast and portfolio goals

- daily/weekly: sequential, repeat

$$\mathbf{y}_t = \mathbf{f}_t + N(\mathbf{0}, \Sigma_t)$$



Critical cross-series / multivariate structure

- o Sensitive dependence / "co-volatility" modelling ?

Existing models

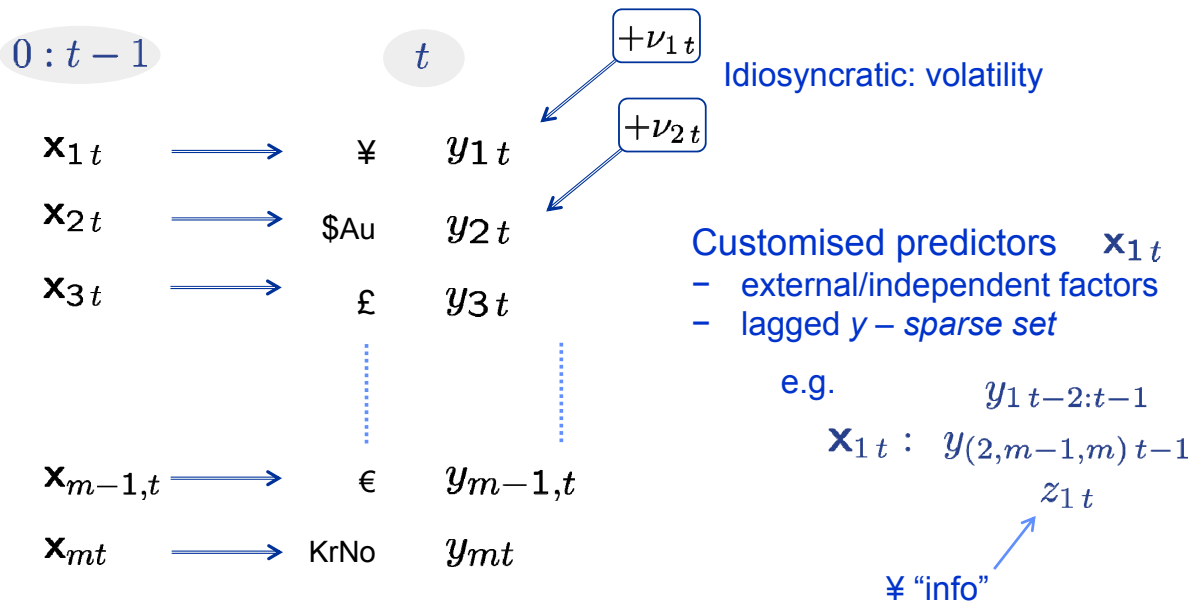
- o Wishart or Inverse Wishart processes, MGARCH, ...
- o (In)flexibility?
- o Scalable – theoretically? computationally?



Decoupled, parallel univariate dynamic models

FX – daily price \$US

Cross-series: directed & sparse *graphical* structure – *lagged*



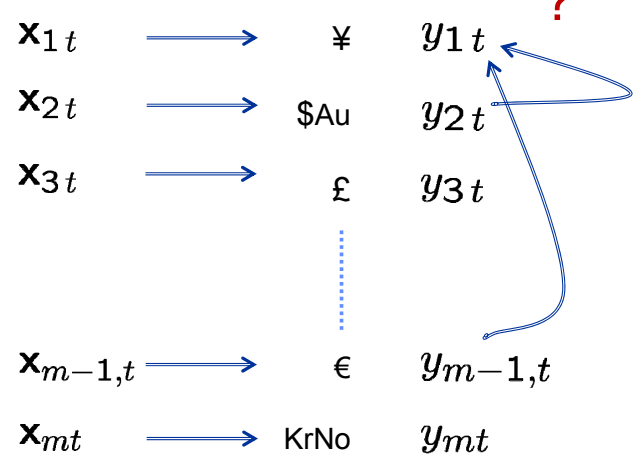


Contemporaneous coupling

Cross-series: *simultaneous* graphical structure

0 : t - 1

t



e.g.

$$\leftarrow y_{(2,m-1)t}$$

$$\leftarrow y_{(1,3)t}$$

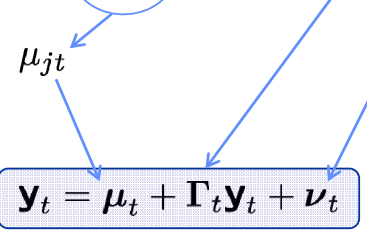
$y_{jt} \leftarrow \mathbf{y}_{sp(j)t}$
 $sp(j) \subseteq 1 : m \setminus j$

Sparse sets
simultaneous parents



Simultaneous dynamic models

$$y_{jt} = \mathbf{x}'_{jt} \boldsymbol{\phi}_{jt} + \mathbf{y}'_{sp(j),t} \boldsymbol{\gamma}_{jt} + \nu_{jt}$$



dynamic regressions & precision/volatility

$$\mathbf{y}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)^{-1} \boldsymbol{\mu}_t + N(\mathbf{0}, \boldsymbol{\Omega}_t^{-1})$$

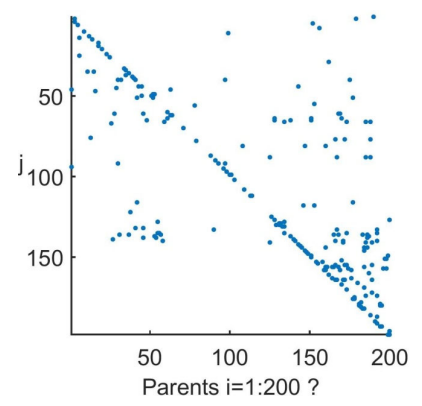
$$\boldsymbol{\Omega}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)' \boldsymbol{\Lambda}_t (\mathbf{I} - \boldsymbol{\Gamma}_t)$$

$$\boldsymbol{\nu}_t \sim N(\mathbf{0}, \boldsymbol{\Lambda}_t^{-1})$$

diag

$$\boldsymbol{\Gamma}_t = \begin{pmatrix} 0 & \gamma_{1,2,t} & \gamma_{1,3,t} & \cdots & \gamma_{1,m,t} \\ \gamma_{2,1,t} & 0 & \gamma_{2,3,t} & \cdots & \gamma_{2,m,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ \gamma_{m-1,1,t} & \cdots & \gamma_{m-1,m-2,t} & 0 & \gamma_{m-1,m,t} \\ \gamma_{m,1,t} & \gamma_{m,2,t} & \cdots & \gamma_{m,m-1,t} & 0 \end{pmatrix}$$

Sparse

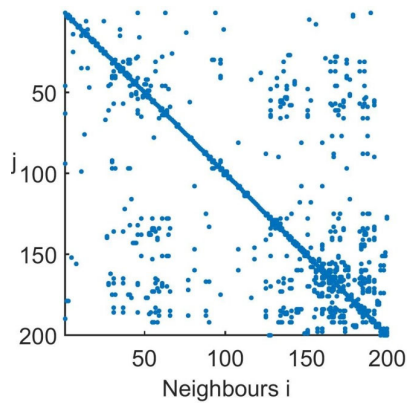


Non-zeros in $\boldsymbol{\Gamma}_t$

Notation: extend $\boldsymbol{\gamma}_{jt}$ to row j and pad with 0 entries

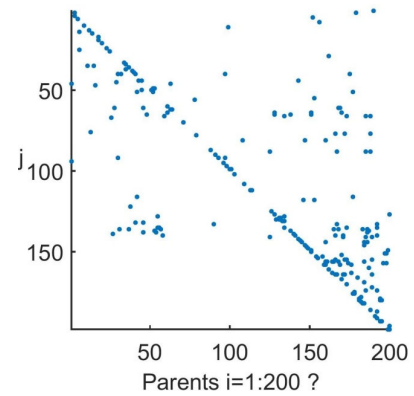


Dynamic graphical model structure induced



Non-zeros in Ω_t

zero precision:
conditional independence



Non-zeros in Γ_t

$$\Omega_t = (\mathbf{I} - \Gamma_t)' \Lambda_t (\mathbf{I} - \Gamma_t)$$

Sparse volatility matrix model



Simultaneous dynamic linear/state-space model

Multiple univariate models

- "decoupled"
- in parallel

$$y_{jt} = \mathbf{F}'_{jt} \boldsymbol{\theta}_{jt} + \nu_{jt}$$

Residual volatilities:
Tractable Markov dynamics

$$\mathbf{F}_{jt} = \begin{pmatrix} \mathbf{x}_{jt} \\ \mathbf{y}_{sp(j),t} \end{pmatrix}$$

$$\boldsymbol{\theta}_{jt} = \begin{pmatrix} \phi_{jt} \\ \gamma_{jt} \end{pmatrix}$$

Parallel states:
Linear, Gaussian, Markov
state evolution models



Special examples: Dynamic dependency network models

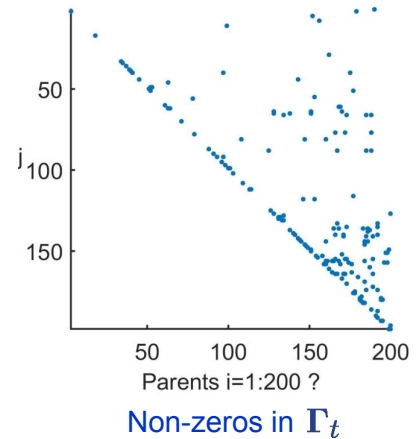
- Γ_t triangular form: *by choice or chance*
- Sparse Cholesky-style precision (... popular)
 - upper or lower triangular- same story: reorder

$$\Omega_t = (\mathbf{I} - \Gamma_t)' \Lambda_t (\mathbf{I} - \Gamma_t)$$

Order of series relevant

$$\Gamma_t = \begin{pmatrix} 0 & \gamma_{1,2,t} & \gamma_{1,3,t} & \cdots & \gamma_{1,m,t} \\ 0 & 0 & \gamma_{2,3,t} & \cdots & \gamma_{2,m,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \dots & 0 & 0 & \gamma_{m-1,m,t} \\ 0 & 0 & \dots & 0 & 0 \end{pmatrix}$$

Sparse, upper triangular

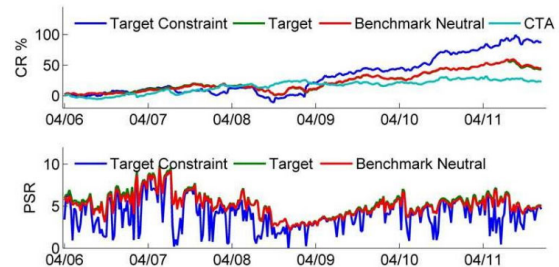


DDNMs

Decoupled univariate series: parallel, analytic filtering & forecasting
 Recoupling: simulate synthetic futures & combine
 - exploits triangular "hierarchy"

Finance:

Zhao, Xie & West, *ASMBI 2016*



Jouchi Nakajima

BIS Basel



Dynamic threshold DDNMs

Finance:

J Fin Econ 2013
Intl J Forecasting 2014

Macroeconomics:

J Bus & Econ Stats 2013

Neuroscience:

Dig Sig Proc 2015
BJPS 2017



- Customisable univariate models: decoupled, in parallel
- Parental structure: sparse stochastic volatility matrix
- On-line sequential learning: Analytic, fast, parallel
- Compositional recoupling for coherent inferences & predictions

BUT:

dependent on choice of order of named series $j=1:m$

Scale-up in dimension?

Choice/specification of order?

400 S&P stock price series?



SGDLMs: Simultaneous graphical dynamic models

$sp(j) \in \{1 : m \setminus j\}$

$$y_{jt} = \mathbf{F}'_{jt} \boldsymbol{\theta}_{jt} + \nu_{jt}, \quad \nu_{jt} \sim N(0, 1/\lambda_{jt})$$

$$= \mathbf{x}'_{jt} \boldsymbol{\phi}_{jt} + \mathbf{y}'_{sp(j),t} \boldsymbol{\gamma}_{jt} + \nu_{jt}$$

Simultaneous parents of j

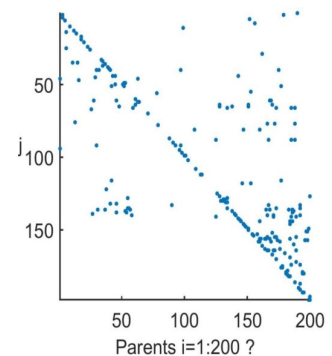
$$\boldsymbol{\Theta}_t = \{\boldsymbol{\theta}_{1t}, \dots, \boldsymbol{\theta}_{mt}\}$$

$$\boldsymbol{\Lambda}_t = \text{diag}(\lambda_{1t}, \dots, \lambda_{mt})$$

Joint pdf ...
likelihood for states and volatilities:

$$p(\mathbf{y}_t | \boldsymbol{\Theta}_t, \boldsymbol{\Lambda}_t) = |\mathbf{I} - \boldsymbol{\Gamma}_t| \prod_{j=1:m} N(y_{jt} | \mathbf{F}'_{jt} \boldsymbol{\theta}_{jt}, 1/\lambda_{jt})$$

- “almost” decoupled!
- - coupling/coherence: “complicating” determinant



Non-zeros in $\boldsymbol{\Gamma}_t$



Decouple/Recouple: Sequential analysis of SGDLM

$$p(\mathbf{y}_t | \Theta_t, \Lambda_t) = |\mathbf{I} - \Gamma_t| \prod_{j=1:m} \underbrace{N(y_{jt} | \mathbf{F}'_{jt} \boldsymbol{\theta}_{jt}, 1/\lambda_{jt})}_{\text{decoupled}}$$

↑
recouple

Recouple: importance sampling

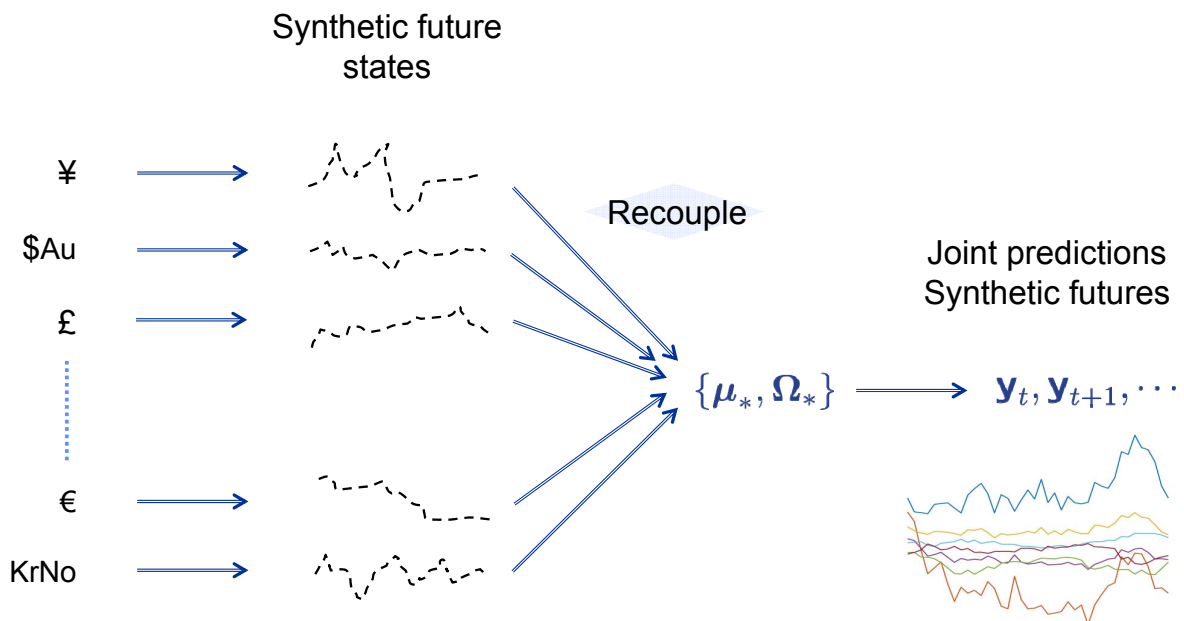
Decouple: variational Bayes



Decouple/Recouple: (i) Time $t-1$ predictions

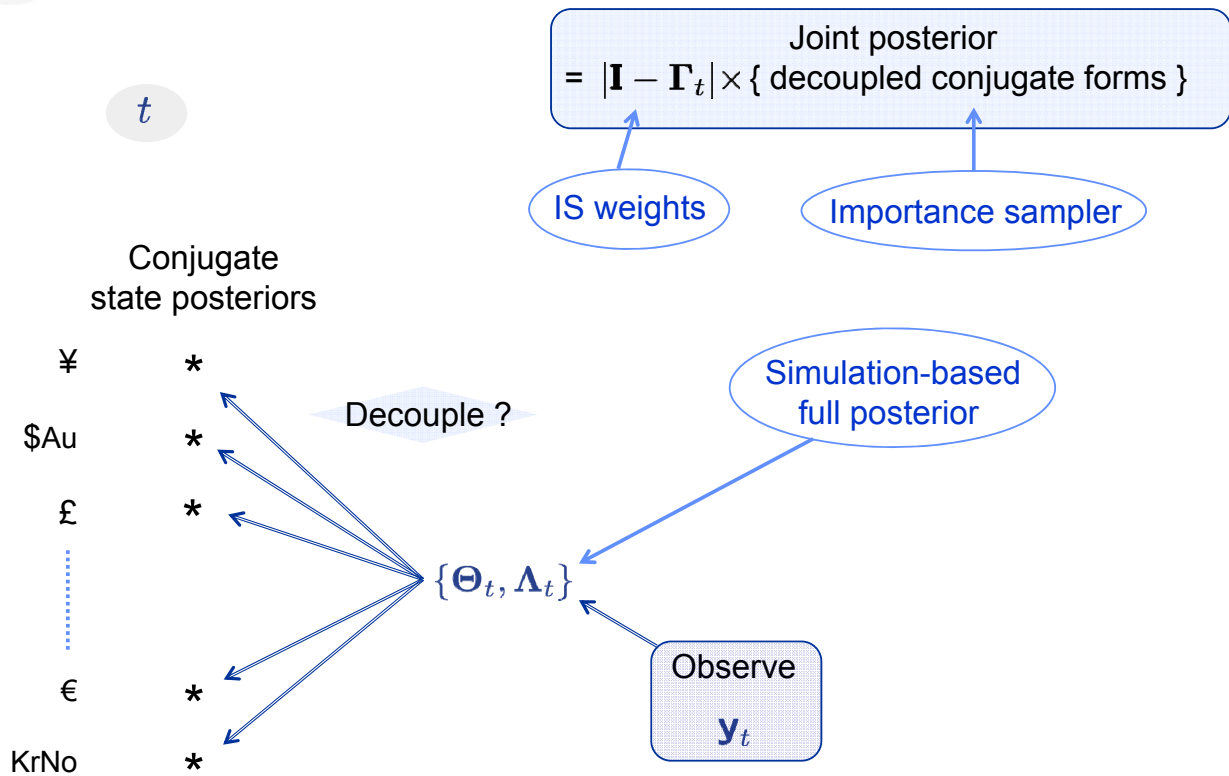
Decoupled parallel models: Conjugate state priors
- Evolve : Recouple : Forecast -

$t-1$





Decouple/Recouple: (ii) Time t updating



Decouple/Recouple: Time t decoupling

Joint posterior \implies decoupled conjugate margins
Variational Bayes (VB)

Decoupling at t :

Match product of conjugate forms with importance sample

- minimize Kulback-Leibler (KL) divergence
- Entropy measure of accuracy
- Relates to effective sample size (ESS) of importance sample

Monitor Entropy & ESS

Evolution to $t+1$: Decoupled, analytic



Example: S&P stock price series

Multiple models x portfolio utilities comparisons

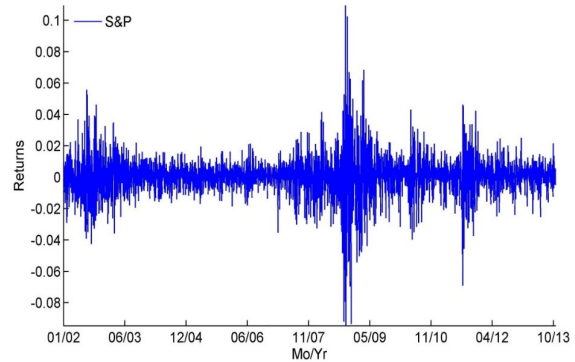
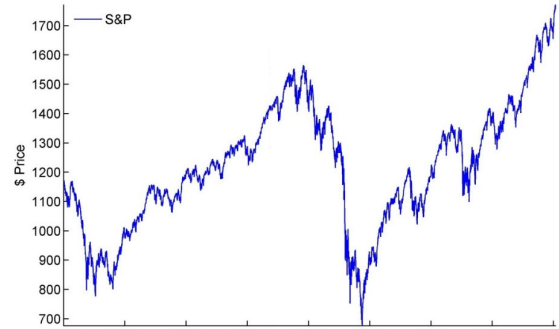
$m=401$: 400 stocks & S&P index
- daily closing prices

Q1/2002 – Q3/2013

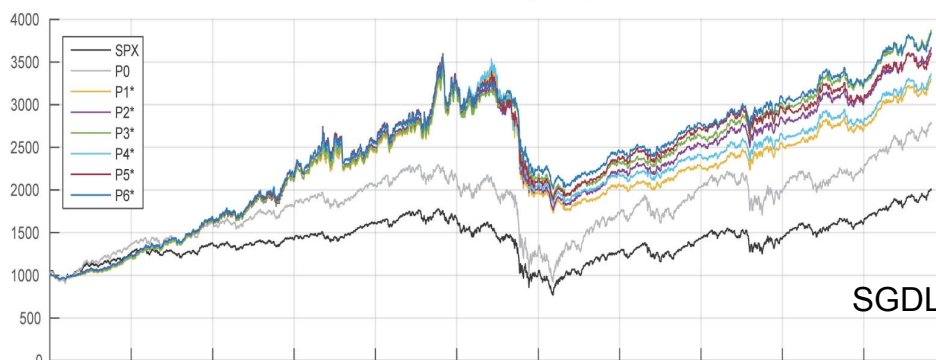
Model (log-difference) returns

Training data : 2002

Test/prediction/portfolio decisions :
Q1/2003 – Q3/2013



S&P400 portfolios: Examples of cumulative returns



SGDLM: M1



Wishart: W1

Trading costs adjusted returns
Uniform improvements (Sharpe ratios, etc) over WDLMs



Simultaneous parental set specification?

AIC / *IC / full Bayesian model selection / model averaging ?

Parallel stochastic search over parental sets ?

- Goals? Learning/choosing “best” statistical models ✗
- Multi-step forecasting ✓ ... but
- Decisions! Portfolio outcomes (risk, return, ...) ✓!

Adaptive “refresh” of parental sets
- monitor: candidates to add, remove each t -



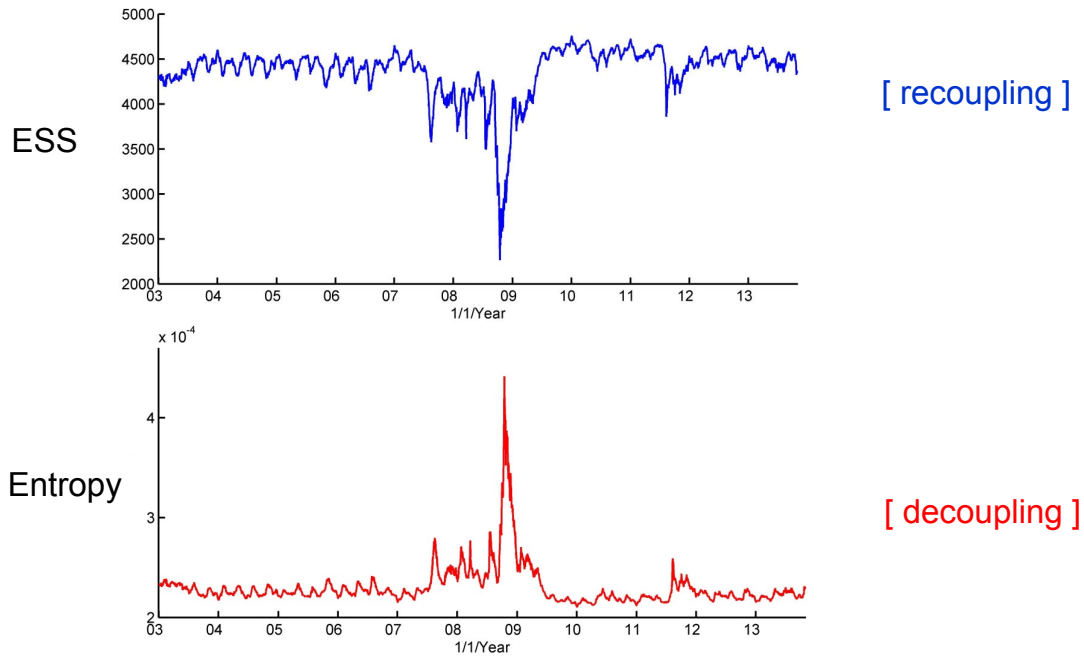
S&P example – Simultaneous parental set turnover





S&P example – Monitoring decoupling/recoupling

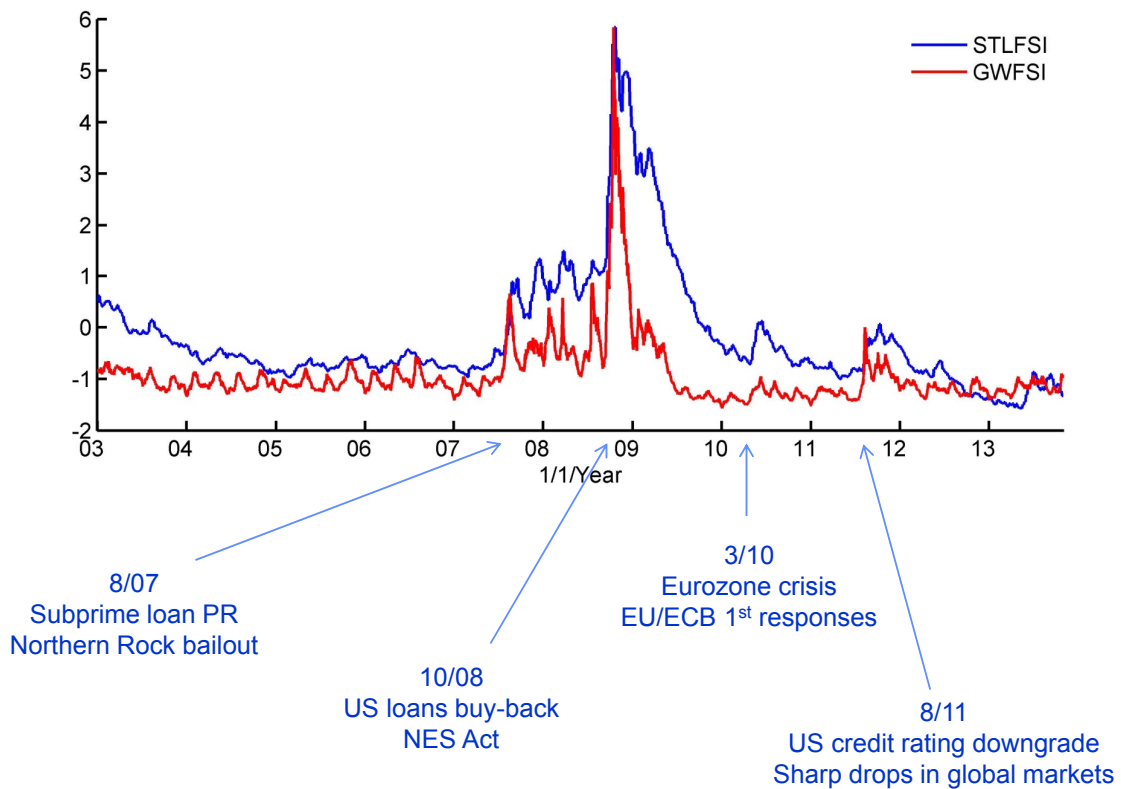
$I=5,000$ Monte Carlo sample size



Potential to intervene- “signal” of deterioration of ESS:
Increase sample size &/or modify model: parental sets, discounts, etc



St Louis Fed “Financial Markets Stress Index”





SGDLM decoupling/recoupling and computations

- Flexible, customisable univariate models
 - Flexible, sparse stochastic volatility matrix model
 - ~~No series-order dependence~~
 - Scale-up : conceptual & computational
-
- On-line sequential learning: Analytics + cheap simulation + VB
... parallelisable within each time step
 - GPU computation
 - Recouple: CPU for coherence
 - Decouple/Recouple IS&VB: theory, monitoring per series



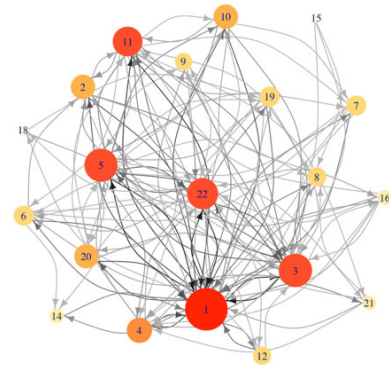
Decouple/recouple : Example 2 - Network flow monitoring

Counts/flows between nodes over time

- n nodes: $m=n \times n$ series

Web domain: e-commerce

- $n \sim 20-200+$
- Sensitive tracking of flow dynamics ?
- Characterize "normal" patterns of time variation ?
- Change/anomaly detection ?
- Fast! sequential analysis ?



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DECOUPLE - univariate count time series

- o Dynamic generalized linear state-space models

RECOUPLE – direct simulation

- o Map to dynamic random effects/interaction model
- o Bayesian "model emulation"



Decouple/recouple : Example 3 – Multi-scale forecasting

Consumer sales/supermarkets

- $m \sim 10,000-100,000s$
- Customize individual models
- Forecast 1-14 days ahead, each day
- Change/anomaly detection
- Link across-series : e.g., seasonality



Many series : “similar patterns”

- Hierarchical models ? Factor models ?
- Not scalable

DECOUPLE - univariate count time series

- o Dynamic binary & count mixture models

RECOUPLE – direct simulation

- o “Common” seasonal factors from external model
- o Series-specific mapping of common factors



Some Bayesian decouple/recouplers

Zoey Zhao
Citadel



DDNMs ASMBI 2016

Amy Xie
Duke



Jouchi Nakajima
BIS Basel



***DDNM*s** JBES, IJF, JFI, DPS BJPS
2013 - 17

Lutz Gruber
QuantCo & U Nebraska



SGDLMs BA 2016
EcoStat 2017

Xi Chen
LinkedIn



Network flows JASA 2018

Kaoru Irie
U Tokyo



Lindsay Berry
Duke



Multi-scale models 2018



Hirotugu Akaike

- Applied motivations: forecasting, monitoring & decisions
 - Conceptual innovation : [Decouple/recouple](#)
 - Technical innovation : [Context dependent structuring](#)
 - Practical, efficient and effective scalability