UNIVERSITY OF OXFORD

Institute for
New Economic Thinking
AT THE OXFORD MARTIN SCHOOL

INET OXFORD SUMMER RESEARCH UPDATE 2018

Agenda

- 2:00-2:15 Opening remarks
- 2:15-2:45 Complexity Economics
- 2:45-3:00 John Muellbauer - (presented by David Hendry)
- 3:00-3:30 Employment Equity & Growth
- *3:30-3:45 Tea break*
- 3:45-4:15 Economics of Sustainability
- 4:15-4:45 Economic Modelling
- 4:45-5:00 Closing remarks
- *5:00-5:15 Group photo*
- *5:30-7:30 Drinks at Vincent's Club, 1A, King Edward Street, OX1 4HS (smart dress required!)*

Who we are

- An institute within the Oxford Martin School with partnerships with 9 academic departments and colleges
- Currently 93 affiliated staff:
  - 7 Directors
  - 11 Senior Research Fellows
  - 23 Postdoctoral Fellows
  - 16 DPhil Students
  - 7 Research Assistants
  - 10 Visitors
  - 15 Associates
  - 4 Administrative Staff
- 35 active research projects
- A major hub in INET's global network

INET Oxford Topic Areas

Financial stability

Growth & innovation

Economic inequality

Sustainability

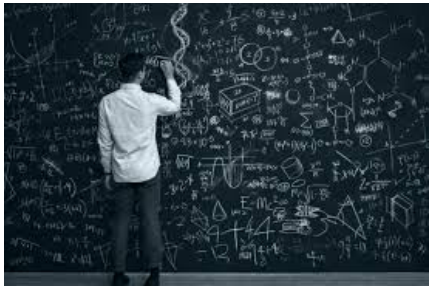
Macroeconomics

Future of capitalism

Ethics and economics

Our World in Data

Methodological foundations



New Joiners & Visitors Since June 2017

Economics of Sustainability (EoS):

Francois Cohen
Kirk Hamilton (returning)
Simona Sulikova
Sugandha Srivastav
Matthias Rosseti
Nicholas Cerkez
Ryan Rafaty
Yangsiyu Lu

Employment, Equity and Growth (EEG):

Lars Osberg
Iman Dadgar
Marc Morgan
Philippe Van Kerm
Marii Paskov (returning)

Complexity Economics (CE):

Juan Sabuco
Haoqian Zhang
Esti Kemp
David Zimmerman
Carlo Bottai
Garbrand Wiersema
Maarten Scholl
Donovan Platti
Anton Pichler
Andrea Bacilieri
Stefan Thurner
Qiang Yuan
Josef Taalbi
Jangho Yang
Pantelis Koutroumpis
Julian Winkler
Luca Mungo
Steven Kerr
Adarsh Prabhakaran
Matthew Ives

Economic Modelling (EMoD):

Moritz Schwarz
Sophia Carodenuto

Our World in Data (OWID):

Ruby Mittal
Sophie Ochmann
Diana Beltekian
Joe Hasell
Hannah Ritche

Our growing alumni group

EMoD:

Mike Mariathasan was appointed Assistant Professor in Finance at the University of Vienna in 2013.
James Wolter Associate Professorship in Financial Econometrics, University of Oxford
Vanessa Berenguer-Rico Assistant Professor in Economics at Mansfield College Oxford.
Vitaliy Oryshchenko Tenure Track Associate Professorship in the Economics Department at Manchester University
Daniel Gutknecht is at the University of Mannheim.
Felix Pretis received a British Academy 3-year Post-doctoral Research Fellowship Climate Econometrics.
Sebastian Konigs Research Affiliate at IZA, working as an Economist / Social Policy Analyst at the OECD.
Christoph Lakner Economist at the World Bank in Washington DC
James Duffy Assistant Professor, Corpus Christi College, Oxford
Ansgar Walther Assistant Professor of Finance, University of Warwick
Oleg Kitov Lecturer in Economics, Selwyn and Robinson College, Cambridge
Liang Chen Assistant Professor, Shanghai University of Finance and Economics

Complexity:

Fabio Caccioli Lecturer Dept. of Computer Science at UCL
Austen Gerig, Assistant Director, Division of Economic and Risk Analysis at U.S. Securities and Exchange Commission
Olaf Bochmann Research Associate at University of Cambridge
Milan Lovric Research Fellow at University of Southampton
Ioannis Psorakis Head of Machine Learning and Analytics at Thought Machine
Christoph Aymanns Research Officer at the Systemic Risk Centre, LSE
Hyejin Youn Assistant Professor, Kellogg School of Management, Northwestern University
Daniel Fricke Lecturer in Computational Finance at UCL
David Pugh Senior Research Analyst at the King Abdullah Petroleum Studies and Research Center (KAPSARC)
Paul Rauwolf Postdoctoral research assistant, School of Psychology at Bangor University

Sustainability:

Alex Pfeiffer Specialist Global Energy Insights, McKinsey & Company, Inc.
Niall Farrell Marie Curie Fellow, Potsdam Institute for Climate Impact Research

EEG:

Salvatore Morelli Visiting Assistant Professor at the Graduate Center City University of New York
Stefan Thewissen Research fellow, Overseas Development Institute
Andrea Geracci Research Fellow, European Commission, DG Joint Research Centre on Microeconomic Evaluation

A diverse group of funders

Institute for New Economic Thinking

OXFORD MARTIN SCHOOL

Resolution Foundation

OPEN SOCIETY FOUNDATIONS

European Commission

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PARTNERS FOR A NEW ECONOMY

EPSRC
Engineering and Physical Sciences Research Council

Ocean Conservancy

WILLIAM + FLORA Hewlett Foundation

GORDON AND BETTY MOORE FOUNDATION

Arrowgrass

BRITISH ACADEMY
for the humanities and social sciences

The Nature Conservancy

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

ROBERTSON FOUNDATION

MAVA
FONDATION POUR LA NATURE

BILL & MELINDA GATES foundation


John Fell Fund

ROTHSCHILD FOUNDATION

Amlin

Clarendon

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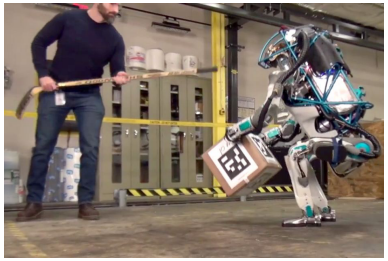
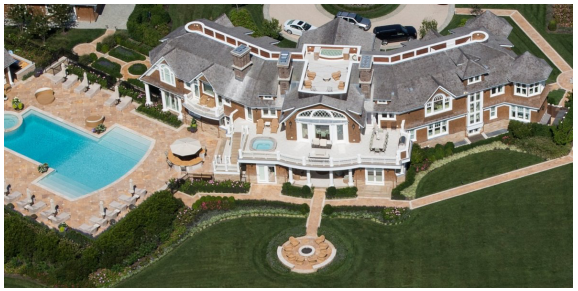
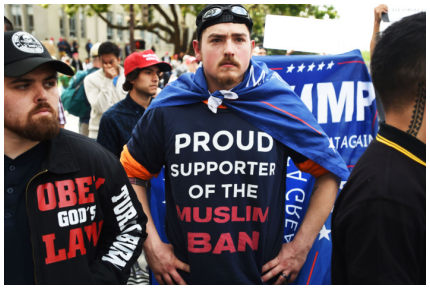
Why our work is important







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Review of Complexity economics research during 2017-2018

INET Summer Party
April June 11, 2018

J. Doyne Farmer

Institute for New Economic Thinking at the Oxford Martin School

Complexity economics publications

1. Lafond, F., A.G. Bailey, J.D. Bakker, D. Rebois, R. Zadourian, P. McSharry, J.D. Farmer, "How Well Do Experience Curves Predict Technological Progress? A Method For Making Distributional Forecasts". Technological Forecasting and Social Change (2018), Volume 128, Pages 104-117.
2. Sanders, J.B.T., J. D. Farmer and T. Galla, "The Prevalence Of Chaotic Dynamics In Games With Many Players", Scientific Reports 8:4902. (2018).
3. Yang, J. "A Quantal Response Statistical Equilibrium Model of Induced Technical Change in an Interactive Factor Market: Firm-Level Evidence in the EU Economies". Entropy 2018, 20, 156.

Publications …

4. Huang, J., Li, W., Huang, X. and Guo, L., (2017). "Analysis of the Relative Sustainability of Land Devoted to Bioenergy: Comparing Land-Use Alternatives in China". Sustainability, 9(5), p.801.

5. Taghawi-Nejad, D. et al. (2017). 'ABCE: A Python Library for Economic Agent-Based Modeling'. In: G. Ciampaglia, A. Mashhadi and T. Yasseri (eds.) "Social Informatics. SocInfo 2017". (Lecture Notes in Computer Science) Vol 10539. Springer

Almost published

1. Aymanns, C. Farmer, J. D., Kleinnijenhuis, A. M. and Wetzer, T. (2018). "Models of Financial Stability and Their Application in Stress Tests". INET Oxford Working Paper No. 2018-6. To appear in Handbook of Computational Finance.
2. Farmer, J.D. and Hepburn, C. (2018). “Less Precision, more truth”. In: Chichilnisky and Rezai (eds.) ‘Handbook on the Economics of Climate Change’. Edward Elgar
3. Mealy, P & Hepburn C. (2018). “Transformational Change: Parallels for addressing climate and development goals. In: Chichilnisky and Rezai (eds) "Handbook on the Economics of Climate Change”. Edward Elgar.

Almost published …

4.Huang, J., Li, W., Huang X., Wang Y., Guo L. (2018). "Technology and innovation in China: A patent citation-based analysis". Accepted by Science, Technology and Society

5. Mariani, M. S., Medo, M., & Lafond, F. (2018). "Early identification of important patents: Design and validation of citation network metrics. Technological Forecasting and Social Change". In press.

Working papers

1. Beinhocker, E. (2017) “The Tipping Point: How America Can Lead the Transition to a Prosperous Clean Energy Economy”. Prepared for the Aspen Institute Congressional Program, Energy for America: Challenges, Opportunities and Solutions, Oslo Norway, 9-15 August, 2017.
2. Mariani, M.S., Medo, M. & Lafond, F. (2017). 'Early identification of important patents through network centrality’.
3. Mealy, P. and Teytelboym, A. (2018). "Economic Complexity and the Green Economy”.

Working papers …

4. Mealy, P., Farmer, J. D. and Teytelboym, A. (2018). "A New Interpretation of the Economic Complexity Index".
5. Mealy, P., Del Rio Chanona, M. and Farmer, J. D. (2018). "What you do at work matters: New lenses on labour".
6. Pagallo, M., Heinrich, T. and Farmer, J. D. (2018). "Best reply structure and equilibrium convergence in generic games".
7. Loberto, M., A. Luciani and M. Pangallo. "The potential of big housing data: an application to the Italian real-estate market".

Working papers …

8. Korniyenko, Y., Patnam, M., del Rio-Chanona, R. M., & Porter, M. A. (2018). “Evolution of the Global Financial Network and Contagion: A New Approach”.
9. Paulo L. dos Santos & Jangho Yang, 2018. "Arbitrage, Information, and the Competitive Organization of Distributions of Profitability,”.
10. Luis Daniel Torres Gonzalez & Jangho Yang, 2018. "The Persistent Statistical Structure of the US Input-Output Coefficient Matrices: 1963-2007.”

Working papers …

11. Way, R., F. Lafond, J.D. Farmer, F. Lillo and V. Panchenko, “Wright Meets Markowitz: How Standard Portfolio Theory Changes When Assets Are Technologies Following Experience Curves”.
12. Mealy P, Farmer J.D & Hausmann, R. (2018). “Determining the differences that matter: New insights on development, dynamics and divergence in US states: 1850-2010”.

Funding

- Oxford Martin School, Sensitive intervention points in the transition to the post carbon society, £700,000, 01/09/2017 – 31/08/2020.
- ESRC, “Rebuilding Macroeconomics”, (Management Committee). Project led by NIESR to create a new roadmap for macroeconomic funding in the UK.
- Partners for a New Economy, “A new approach to modeling energy transitions”, £500,000, 01/01/2016 – 31/12/2019.
- Amlin Insurance, “Systemic risk of modeling in the insurance industry”, £480,000, 01/04/2016 – 31/09/2018.

Systemic risk & insurance risk model homogeneity

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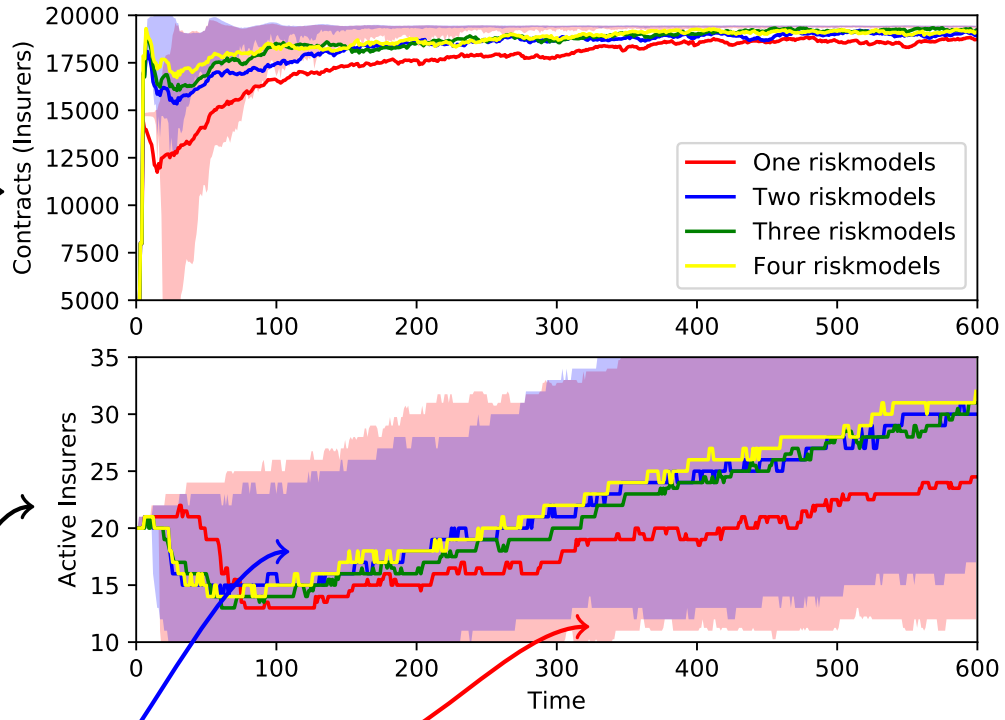
Torsten and Juan

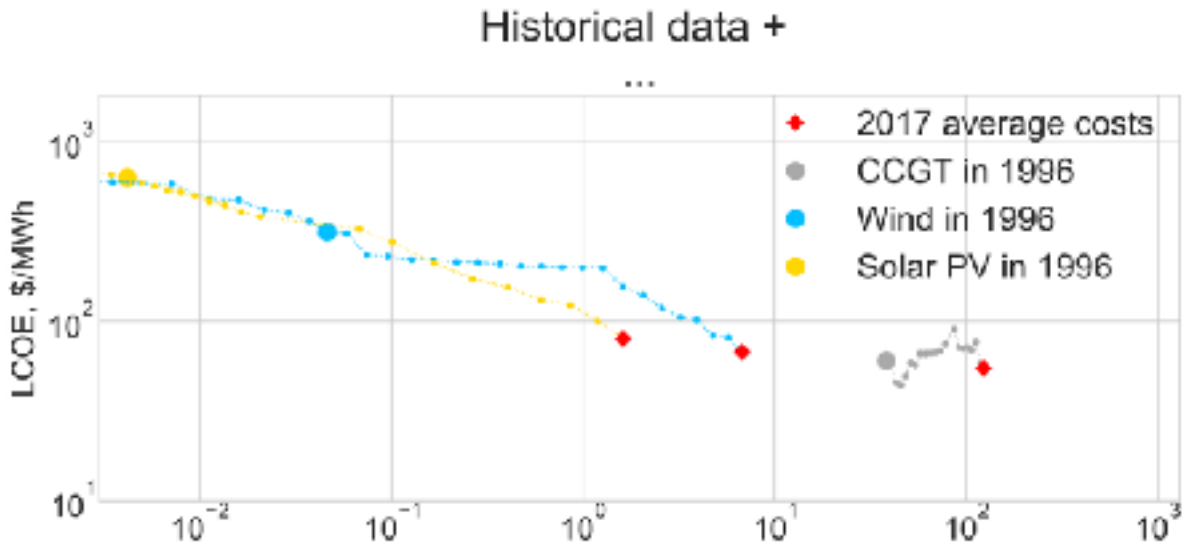
- Measures of systemic risk (surviving firms, number of contracts) in settings with homogeneous and diverse catastrophe risk models
- Ensemble of 300 replications (each setting)
- With reinsurance
- Mean and 25%, 75% quantiles for the number of contracts (upper panel)
- Median and 25%, 75% quantiles for the number of remaining active insurance firms (lower panel)

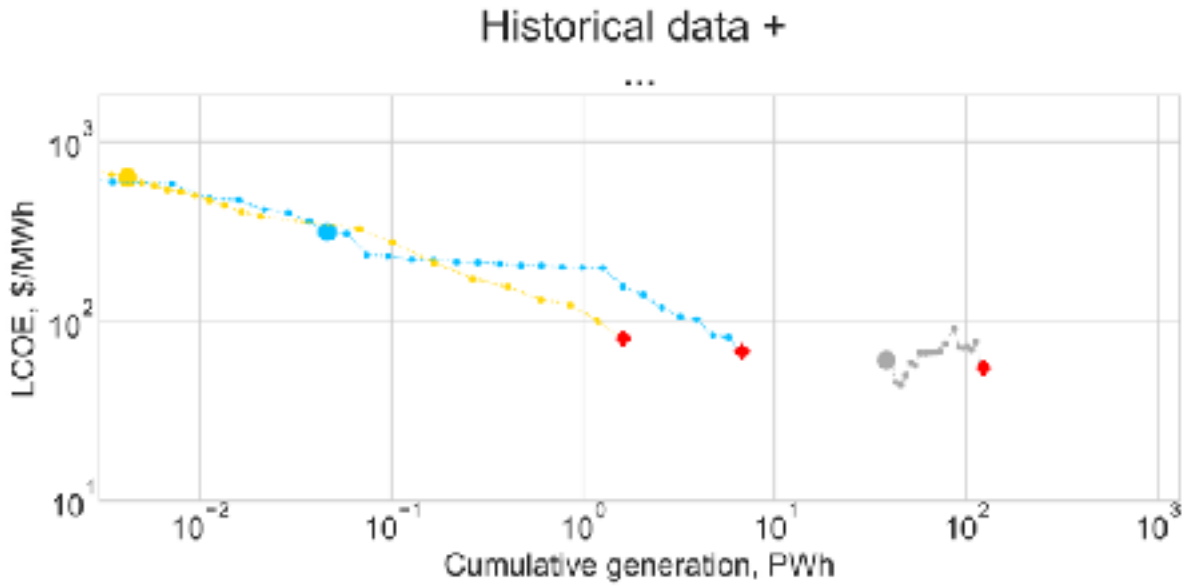


red shaded area: 25%-75% quantiles for one risk model

blue shaded area: 25%-75% quantiles for two risk models

Cost of clean energy transition





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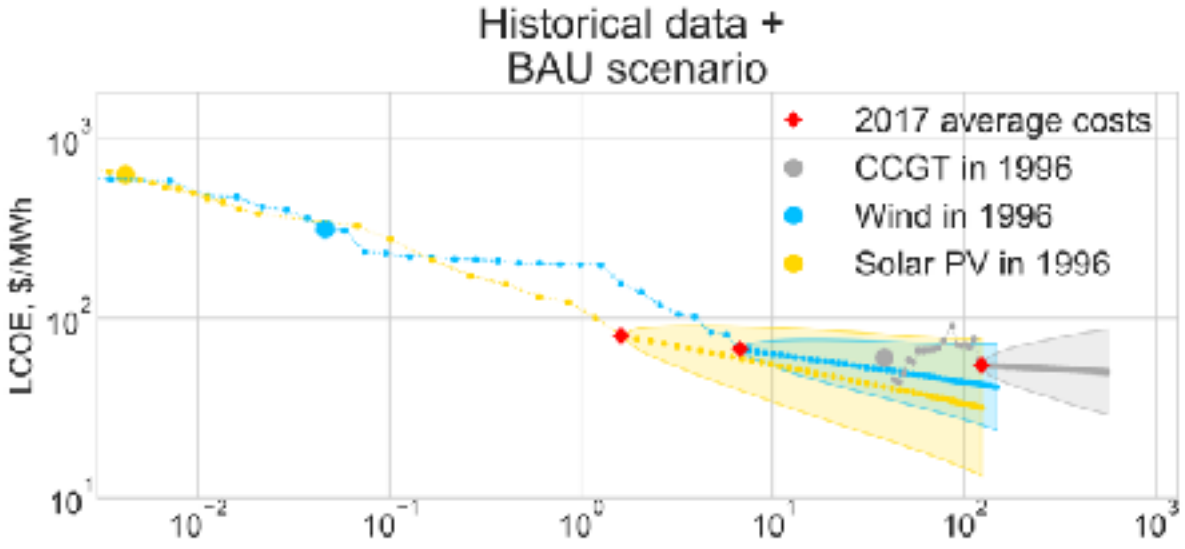
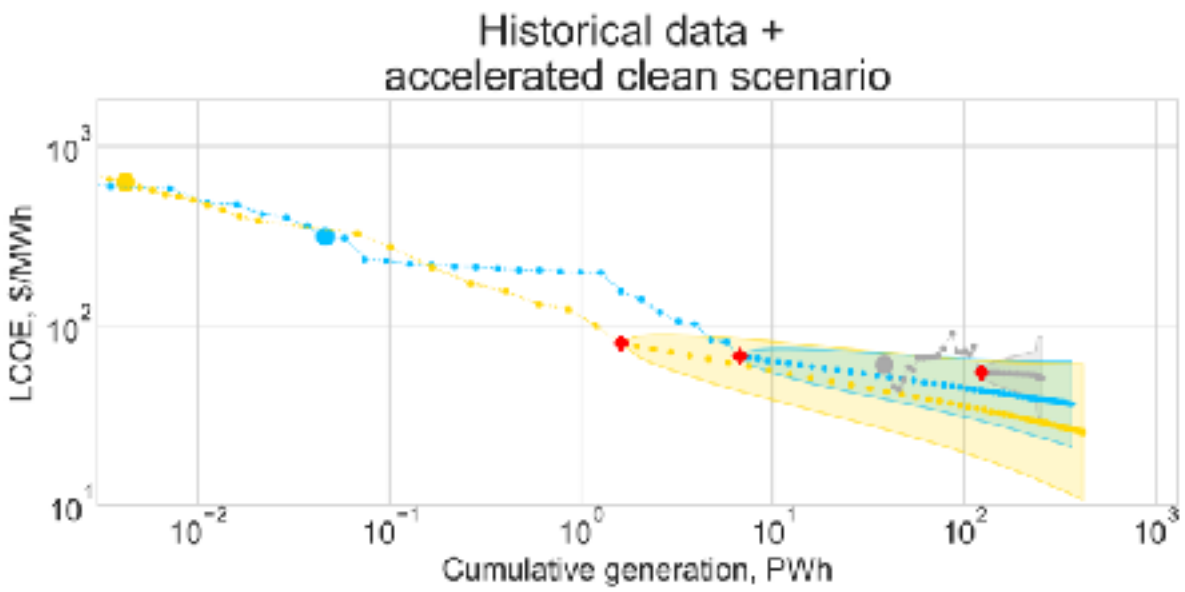
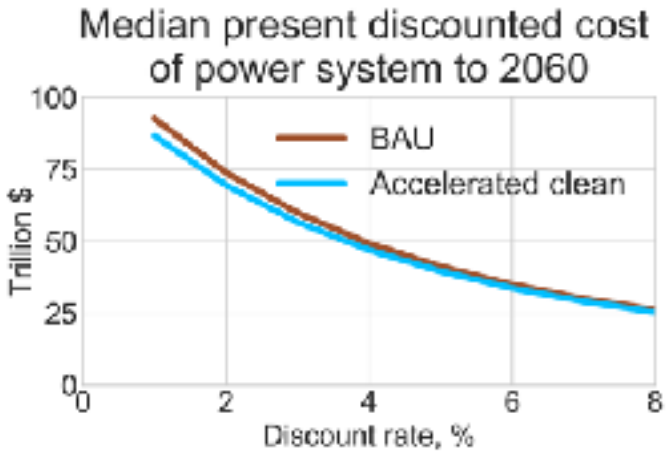
Cost of clean energy transition





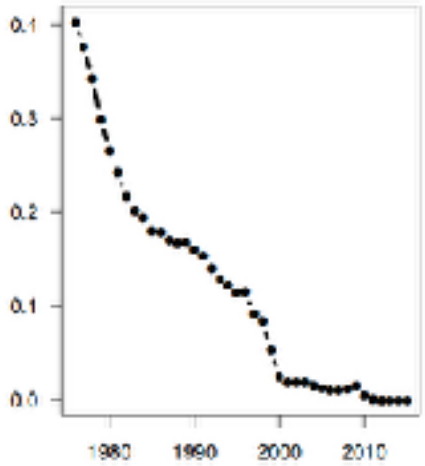
- Investment/production scenarios *determine* cost forecast distributions
- Use these to calculate BAU & clean acceleration cost distributions
- Median savings ~3TR$ NPC at 3%



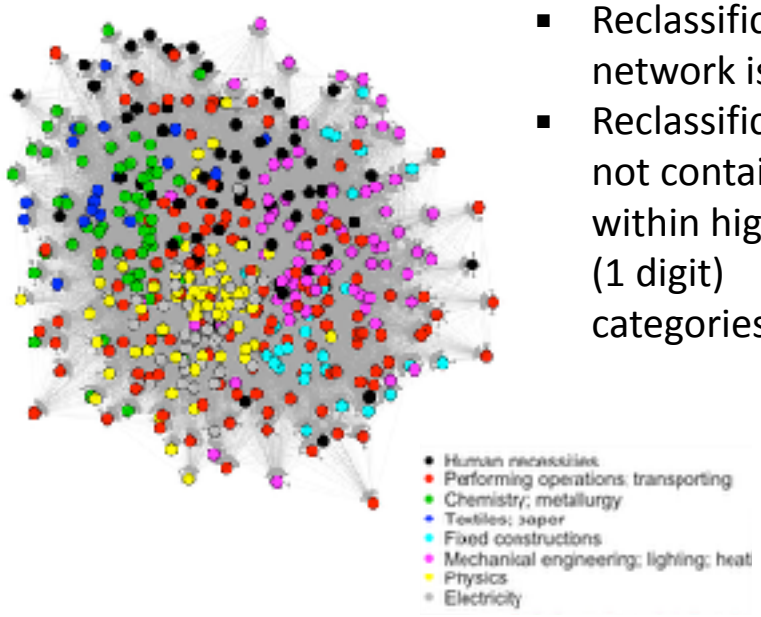
The origins of radical innovations

- Lafond and Kim (INET visitor), **Long-run dynamics of the US patent classification System**, R&R *Journal of Evolutionary Economics*
  - Patent classification systems change considerably, reflecting significant technological evolution
  - Reclassified patents are more cited
- Verendel (INET visitor), Lafond, and Farmer, **The origins of technological novelty**, *in progress*
  - Describe the entire evolution of the patent classification tree
  - Patent reclassification network as phylogenies: new categories are similar if they have similar parents

Share of reclassified patents



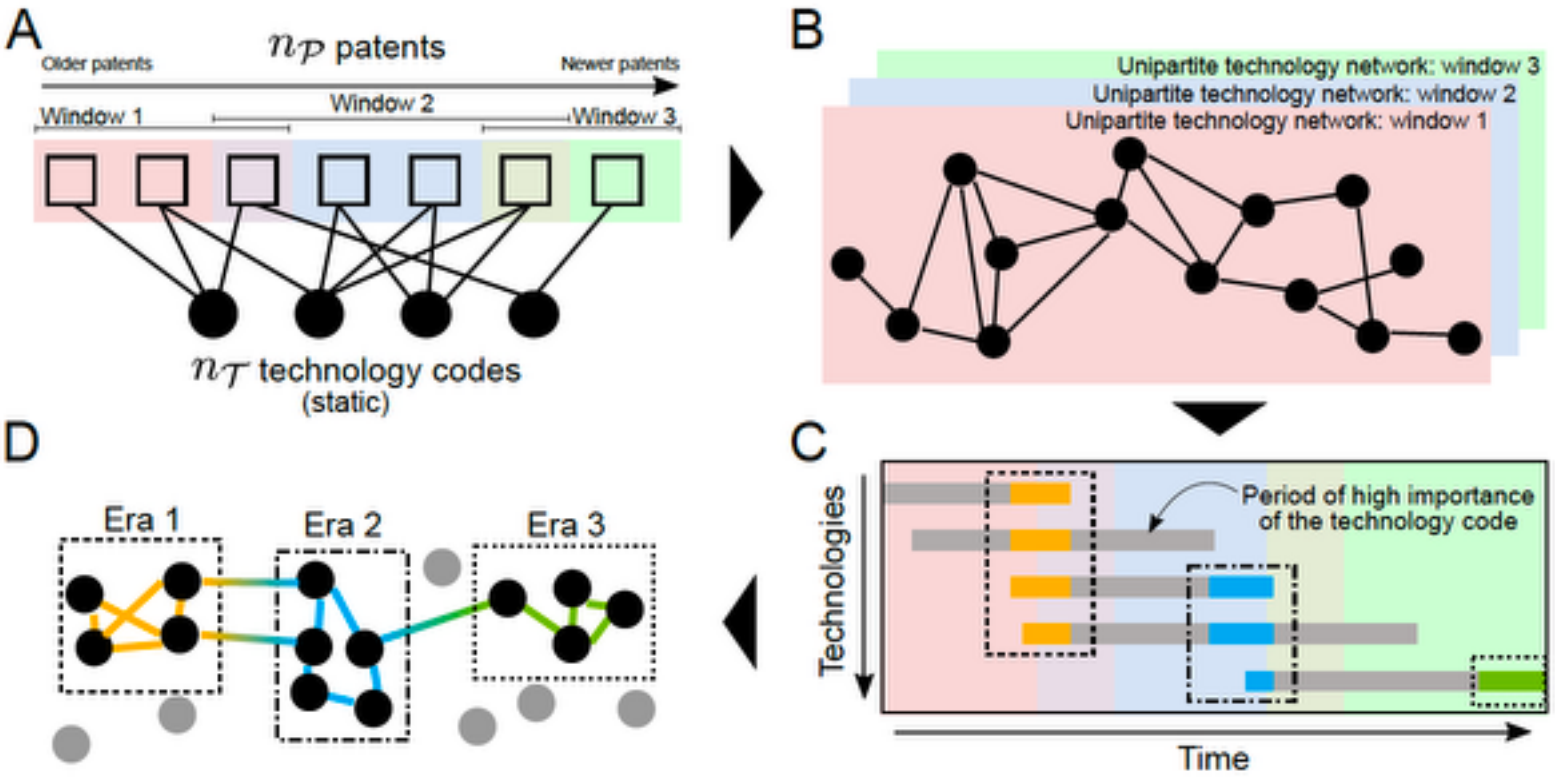
- All pre 1899 patents have been reclassified
- 40% of 1976 patents have been reclassified



- Reclassification network is dense
- Reclassification is not contained within high level (1 digit) categories

Long-run dynamics of technological change

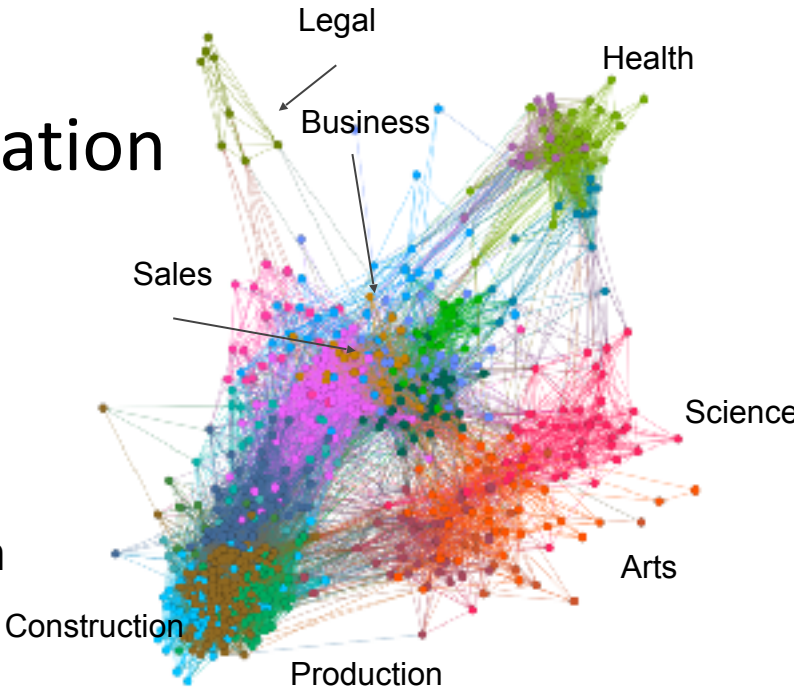
- Asano, Vary, Farmer, Lafond, Beguerisse, **Uncovering technological eras using patent classification networks**, *in progress*
  - Define technological eras based on co-importance of technologies during a time period
  - Data-driven reconstruction of the “natural history” of technologies
  - Newly available data on on old US patents (1836-1976)

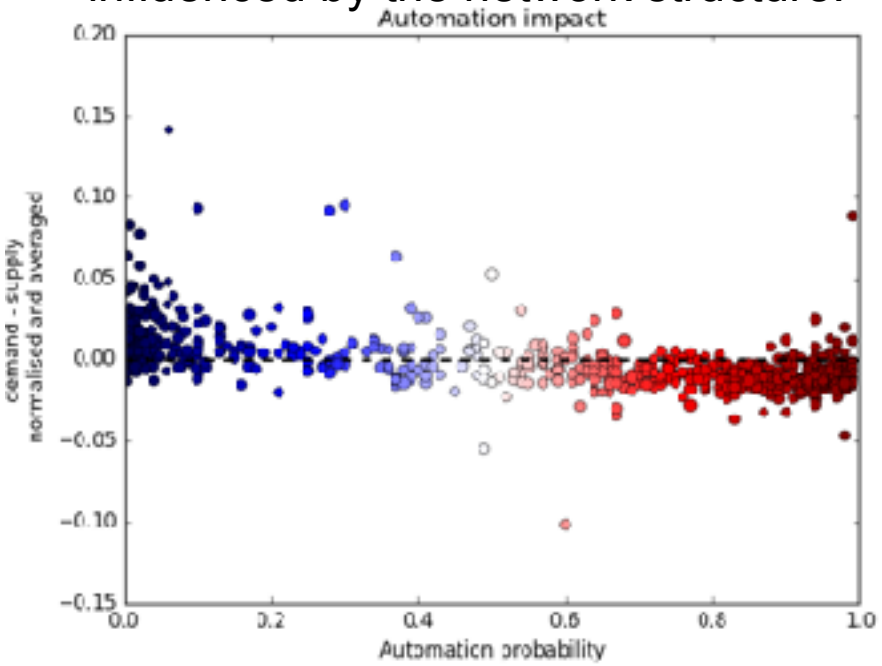


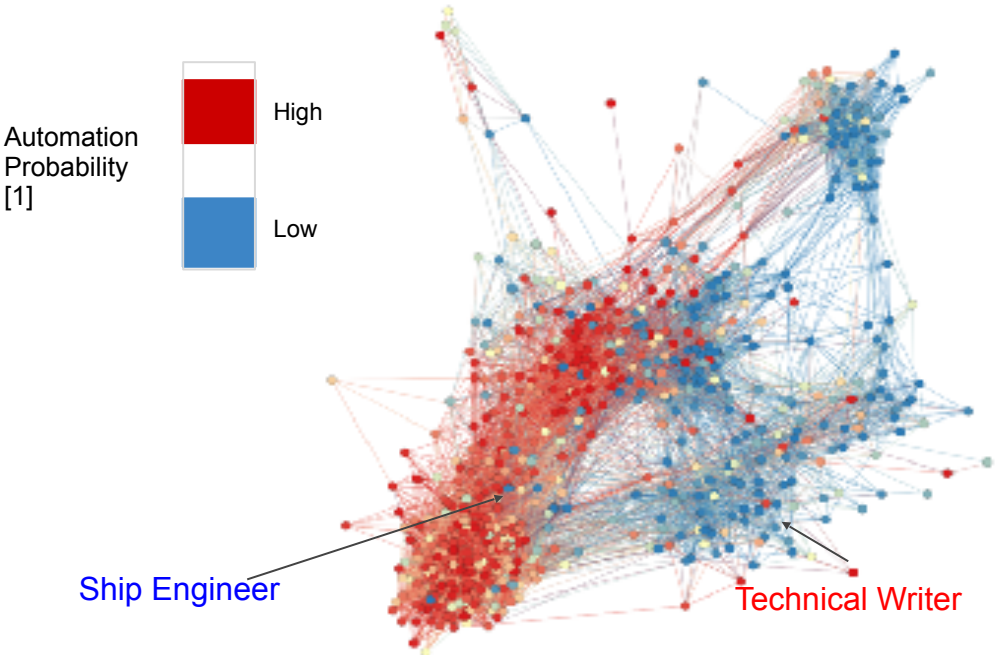
Maria and Penny
The Jobs Space and Labor Automation

Prediction of job transitions: the job space predicts job transitions better than O*NET's benchmark.

Labor Automation: the impact of automation on employment is different for each occupation and influenced by the network structure.







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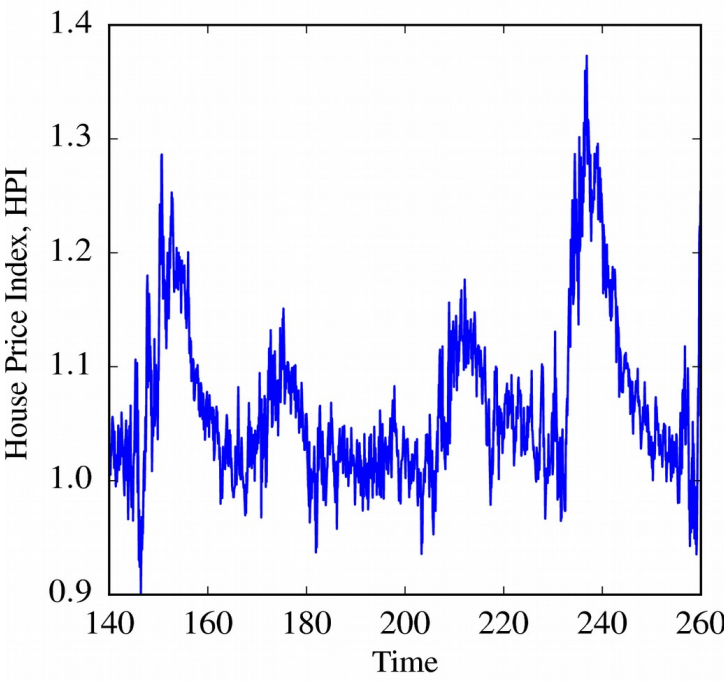
Agent-based modelling of housing markets

Non-spatial model

- Explore main drivers of house price cycles
- Explore effects of different **macro-prudential policy** schemes (e.g, mortgage lending regulatory frameworks)

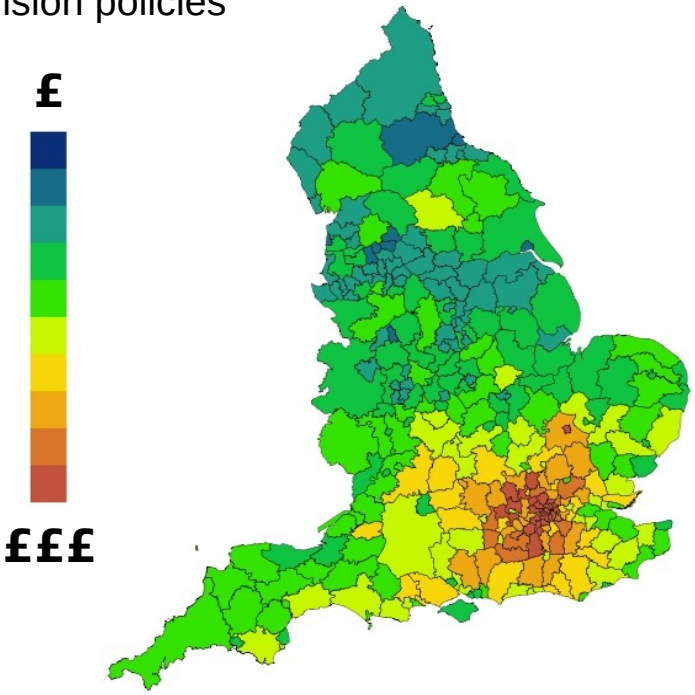


Data hungry

Highly disaggregate results

Spatial model

- Reproduce **spatial patterns of prices**
- Identify main mechanisms by which **transport infrastructure** affects housing prices
- Explore effects of different infrastructure provision policies



A Macroprudential Stress Test of Central Clearing Parties

J. Doyne Farmer, Alissa Kleinnijenhuis, Maarten Scholl, Thom Wetzer & ECB Colleagues

Motivation

- **Derivatives** have been called "**weapons of financial mass destruction**" (Warren Buffet) and "**a ticking time bomb**" (Pope Francis)
- **EMIR** has recently come into force, **data gathering** on derivatives now complete
- The **ECB** has called for the development of **macroprudential stress tests for CCPs**

Approach

- Develop simulation engine and modelling framework that deals with **millions of transactions per day**
- Analyse the network of derivatives contracts on top of **proven multi-layered network approach**
- Compare different implementations of CCPs to study the **sensitivity of financial stability to institutional designs**
- Analyse network effects that current microprudential CCP stress tests miss

Goals

- We are proposing a novel method of network analysis that uses **Potential Future Exposure (PFE)** to better evaluate liquidity risk
- Capture not only **valuation shocks** but also describe the role of **collateralisation** and **liquidity shocks** in a financial system
- Development of a **macroprudential stress test for CCPs**
- Generate recommendation on the **design of market infrastructure**

Collaboration with the ECB

Next steps

- Extend the analysis to include **other contractual layers** to make the stress test truly '**system-wide**'

First-Order Liquidation Networks

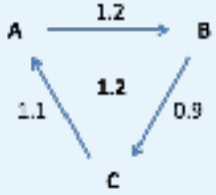
J. Doyne Farmer, Alissa Kleinnijenhuis, Thom Wetzer & Garbrand Wiersema (Working Paper)

Motivation

- Financial networks are **multi-layered**
- Multi-layered networks are **hard to characterise** in terms of **inherent stability**
- Need to develop a model that **captures multiple contagion channels** in a **monoplex network** with a single liquidation dynamic

Approach

- We model how each contagion mechanism forces institutions to **liquidate assets**
- Collapse various contract layers onto a **monoplex "First-Order Liquidation Network" (FOLN)** based on liquidation **pecking order**: captures first-instance shock dynamics
- Study a network's stability based on the **largest eigenvalue**
- Study **amplifying cycles**



Results

- Develop a **methodology** to study inherent (in)stability characteristics of a multi-layered network

- Focusing on a **single network layer underestimates** or **overestimates** network stability
- **Leverage** is a **dominant force of amplification**
- **Funding contagion** is not amplified by leverage
- **Overlapping portfolio contagion** is (singly) amplified by leverage of the security holder
- **Counter party contagion** is doubly amplified, both by debtor and creditor leverage
- Having **short-term loans** to withdraw stabilises, whereas **debtors' leverage** and **maturity transformation** destabilises

Next steps

- Track **FOLN through crises**
- Include **nonlinear contagion mechanisms**
- **Calibrate** to specific shock sizes, order layer thickness, and a real-life financial system (EU, South Africa)

Handbook on Financial Stress Tests

J. Doyne Farmer, Alissa Kleinnijenhuis, Til Schuermann & Thom Wetzer (Editors) (Cambridge University Press, 2020)

Motivation

- Financial stress tests have become a **key regulatory tool** to evaluate and enhance financial stability
- Relevant for **academics**, **private sector practitioners**, and **policymakers** - but they rarely interface and exchange views
- Need to create **macroprudential** agenda

Topics Covered

- What are the **objectives** of stress tests?
- How do we design suitable **scenarios**?
- What is the state of the art in **microprudential stress testing** for various types of institutions?
- How do regulators design and use **macroprudential stress tests**, and how could these be (fundamentally) improved?
- How do we ensure that stress tests are **credible**, and **perceived as credible**?

Contributors

- We bring together **high-calibre experts** from **public policy**, **private practice**, and **academia** and encourage them to actively engage with each other

Key policymakers (eg BoE, ECB, Fed, IMF)

Expert practitioners (eg GS, AIG, Barclays)

Top-tier, multidisciplinary academics (including a nobel laureate)

Two former US Treasury Secretaries

Next steps

- Get first draft of **chapters** (outlines are finished and reviewed)
- Organise a **conference** to bring all contributors together to **reflect** on the topics covered in the book

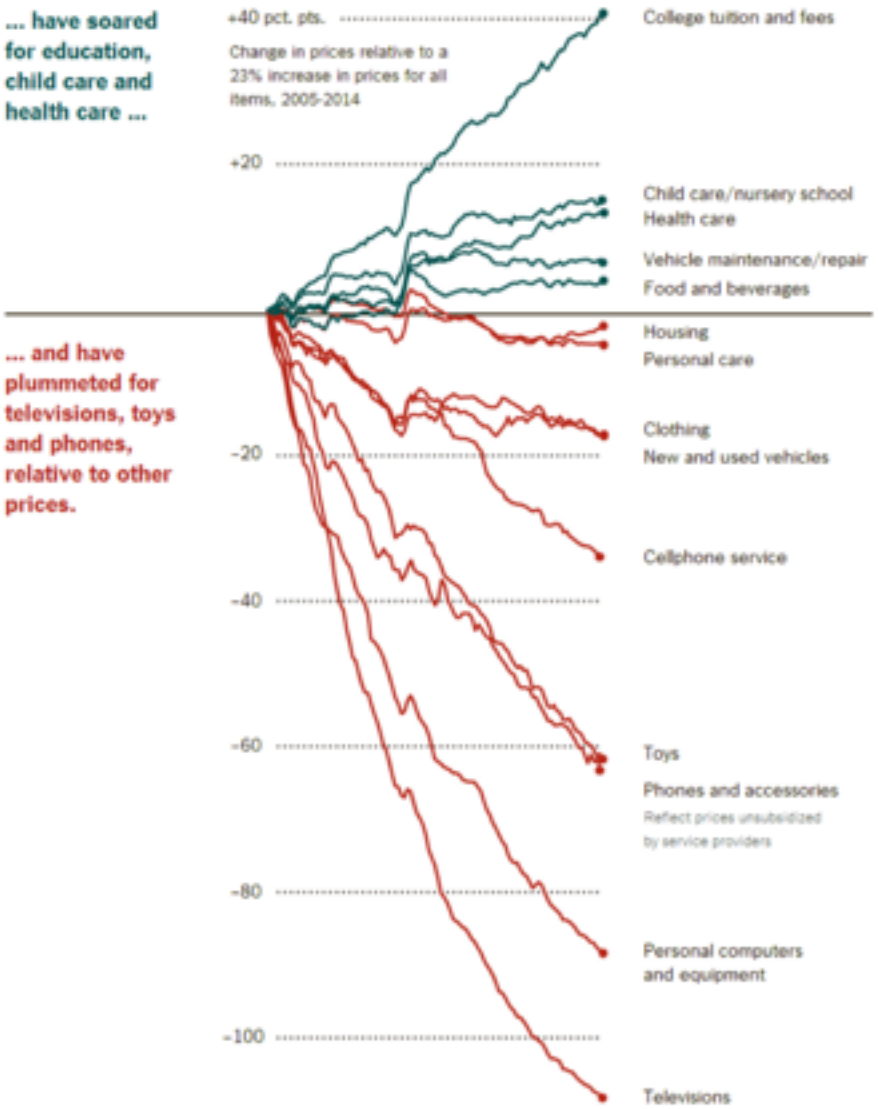
Long range plan

- Build a better model of the economy from the ground up using fine-grained data
- Gather data and build model for eight layers
  - production network
  - finance and lending
  - ownership and control
  - innovation
  - households
  - media & social networks
  - government
  - physical and environmental impacts

Costs for Americans ...

... have soared for education, child care and health care ...

... and have plummeted for televisions, toys and phones, relative to other prices.



Best reply structure and equilibrium convergence in generic games

INET Oxford Summer Research Update, 11/06/2018

Marco Pangallo[*,1,2], T. Heinrich [1,2], J. D. Farmer[1,2,3,4]

1 Institute for New Economic Thinking at the Oxford Martin School
2 Mathematical Institute, University of Oxford
3 Computer Science Department, University of Oxford
4 Santa Fe Institute

Background

- Equilibrium assumption cornerstone of economic theory
- Underpins *laissez-faire* economics (Kirman, *JEL*, 2016). To justify public intervention we need to specify market *imperfections*.
- Key point about complexity economics is non-equilibrium models
- When is equilibrium a reasonable assumption?

Does learning converge to equilibrium in games?

Does learning converge to equilibrium in games?

Robinson 1951; **Arrow** and **Hurwick** 1960; **Shapley** 1964; Crawford 1974; Stahl 1988; Milgrom and Roberts 1991; **Selten** 1991; Conlisk 1993; Fudenberg and Kreps 1993; Kalai and Lehrer 1993; Young 1993; Monderer and **Shapley** 1996; Van Huyck, Cook, Battalio 1997; Foster and Young 2001; Hofbauer and Sandholm 2002; Hopkins 2002; Hart and Mas-Colell 2003; Arieli and Young 2016

Specific classes of games

Econometrica, Vol. 84, No. 2 (March, 2016), 627–676

STOCHASTIC LEARNING DYNAMICS AND SPEED OF CONVERGENCE IN POPULATION GAMES

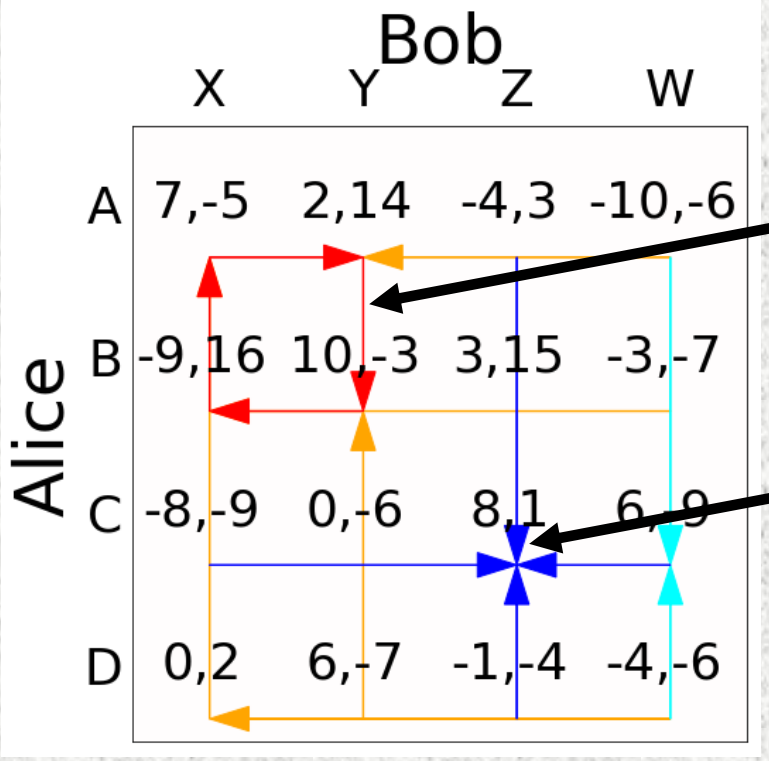
BY ITAI ARIELI AND H. PEYTON YOUNG[1]

We study how long it takes for large populations of interacting agents to come close to Nash equilibrium when they adapt their behavior using a stochastic better reply dynamic. Prior work considers this question mainly for 2×2 games and potential games; here we characterize convergence times for general weakly acyclic games, including coordination games, dominance solvable games, games with strategic complementarities, potential games, and many others with applications in economics, biology, and distributed control. If players' better replies are governed by idiosyncratic shocks, the convergence time can grow exponentially in the population size; moreover, this is true even in games with very simple payoff structures. However, if their responses are suffi-

Our approach

- Unclear whether these classes of games are really representative of complex real-world scenarios
- Quantify how typical is convergence over distribution of payoff matrices generated at random (and then held fixed while the game is played)
- Null model of generic situations that can be modeled as games

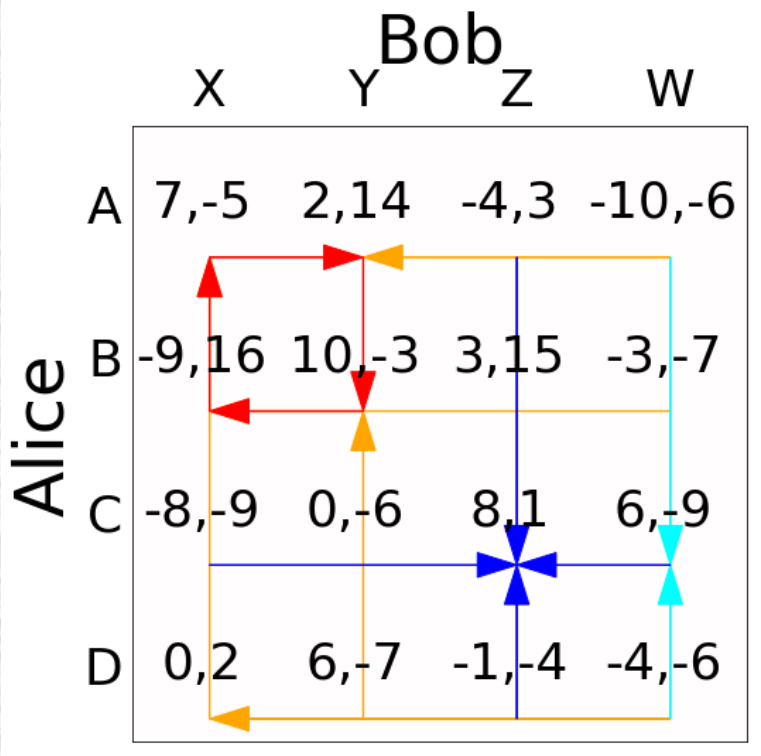
Best reply structure

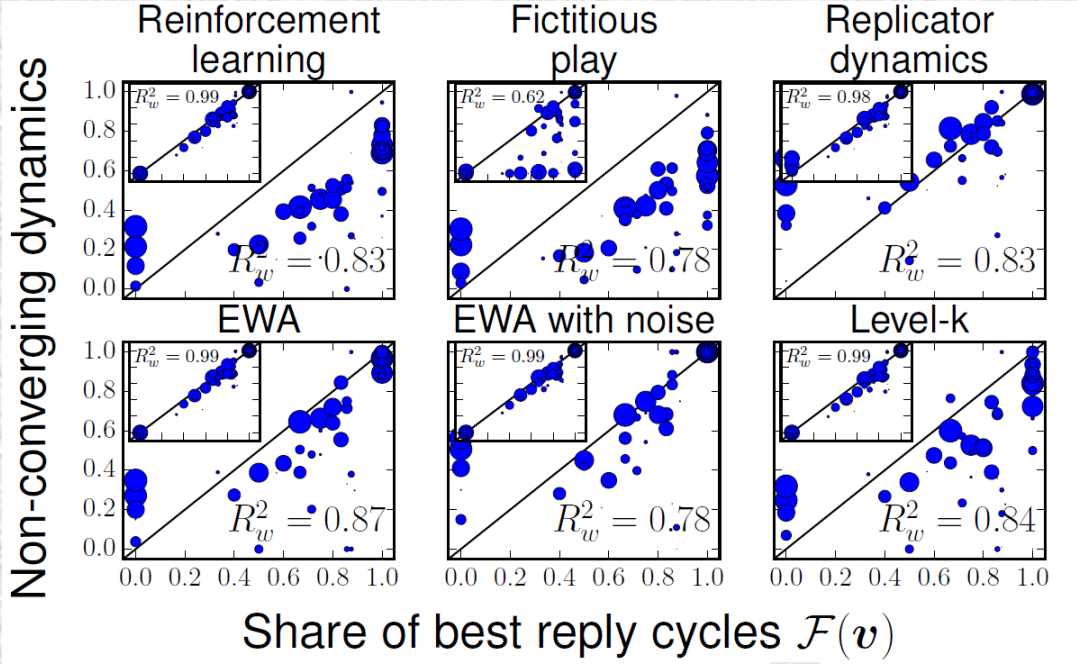


Best reply cycle

Best reply fixed point

Best reply structure

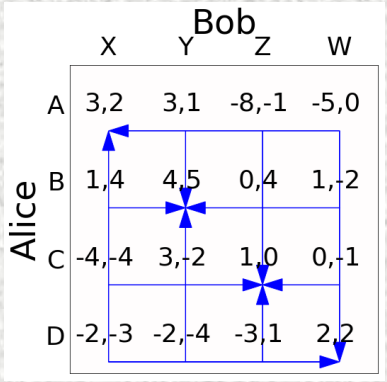




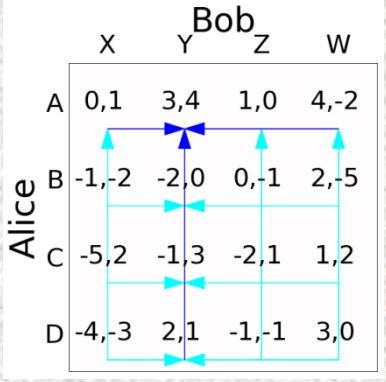
Prevalence of best reply cycles over fixed points

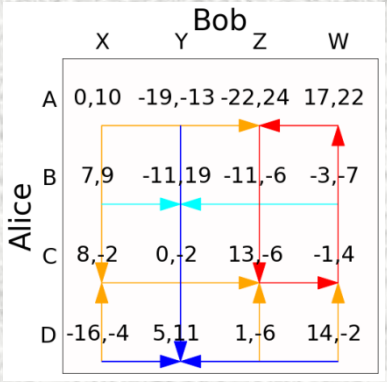
Which games are prevalent?

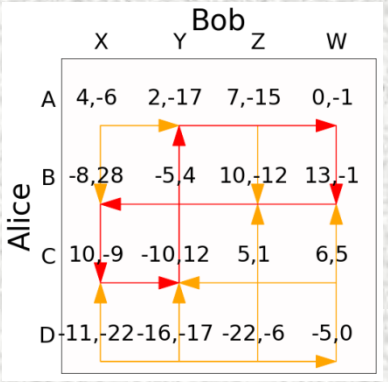
Coordination



Dominance

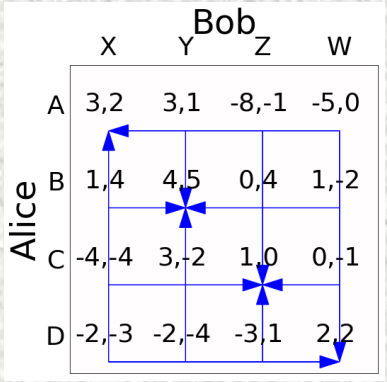




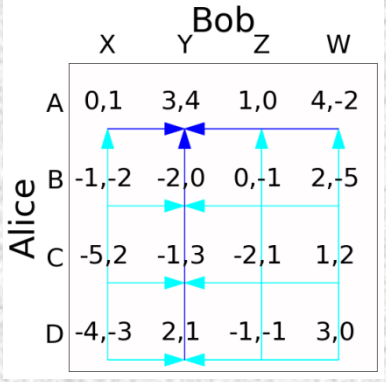


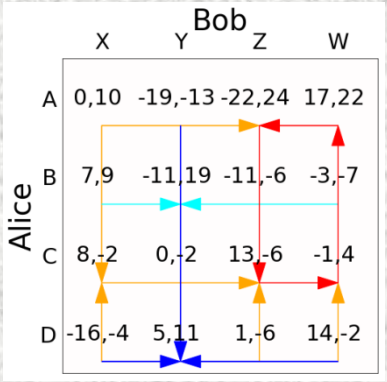
Which games are prevalent?

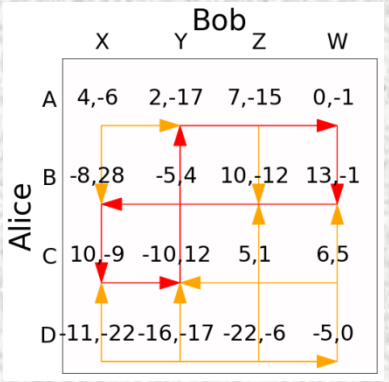
Coordination



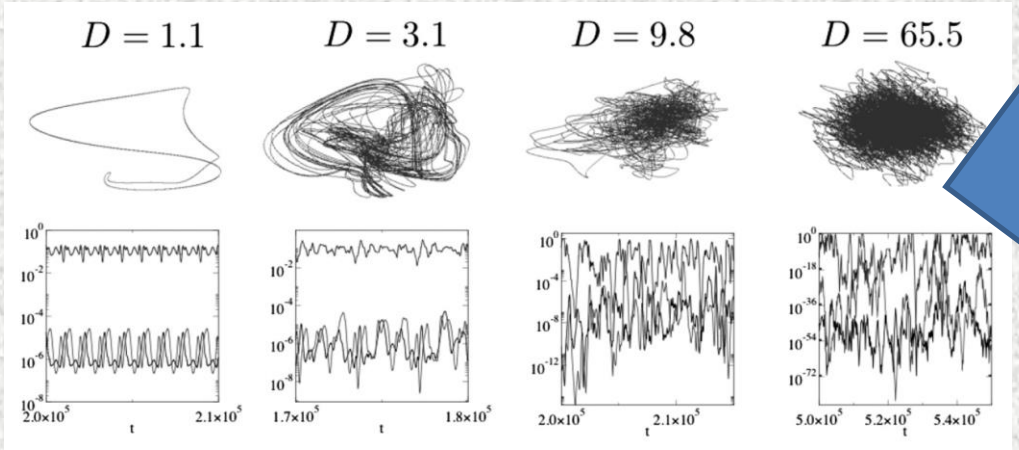
Dominance

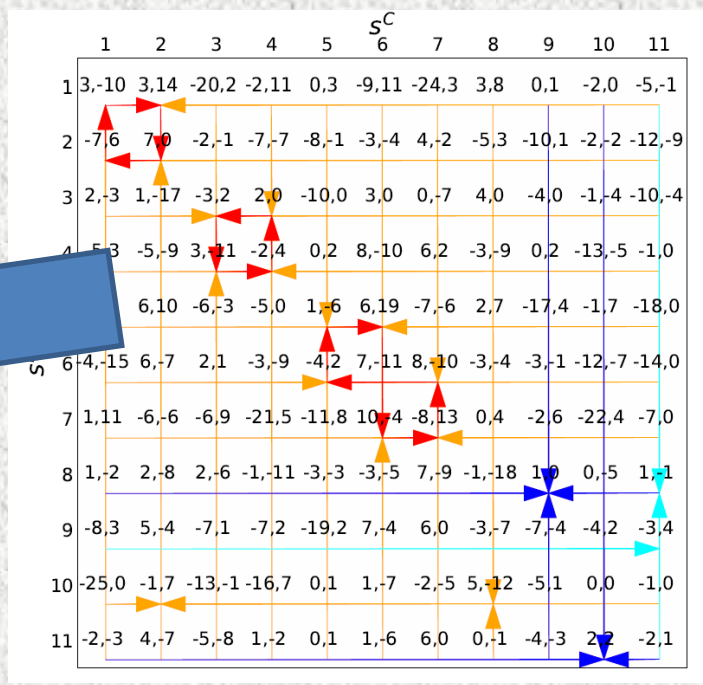






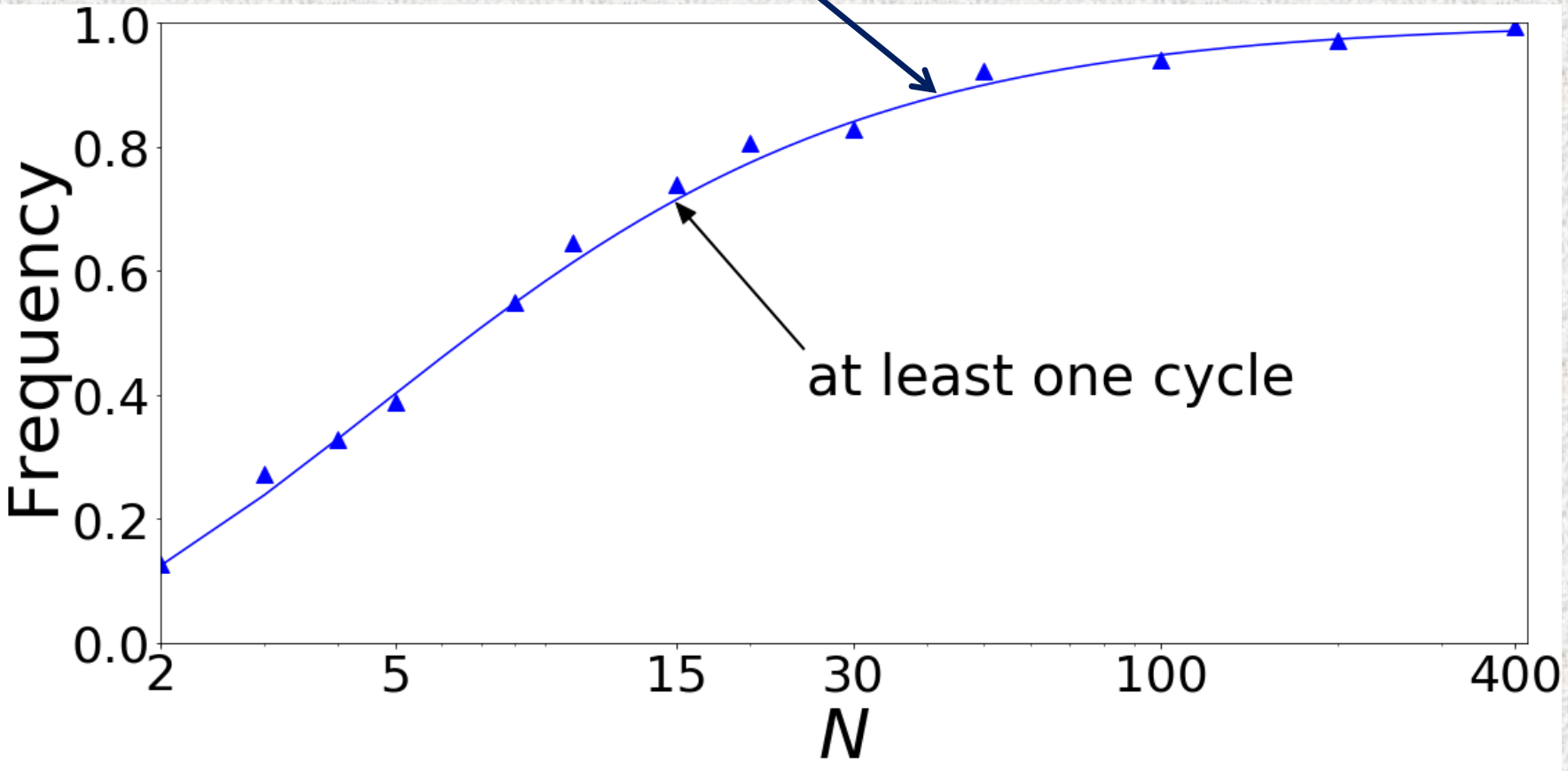
Galla and Farmer, *PNAS*, 2013



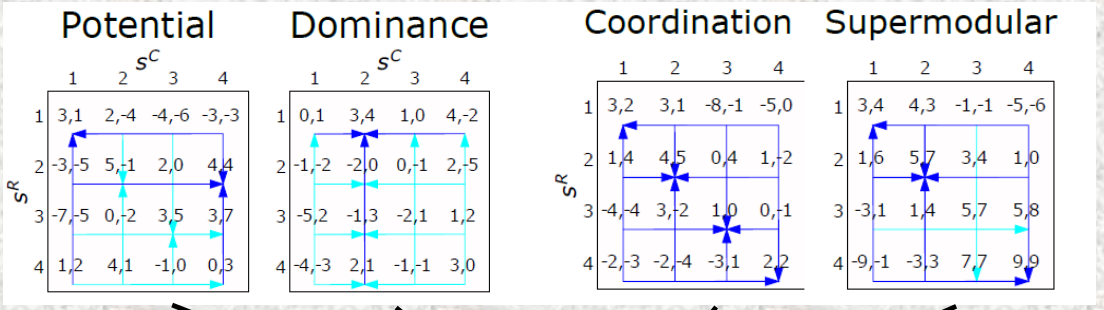


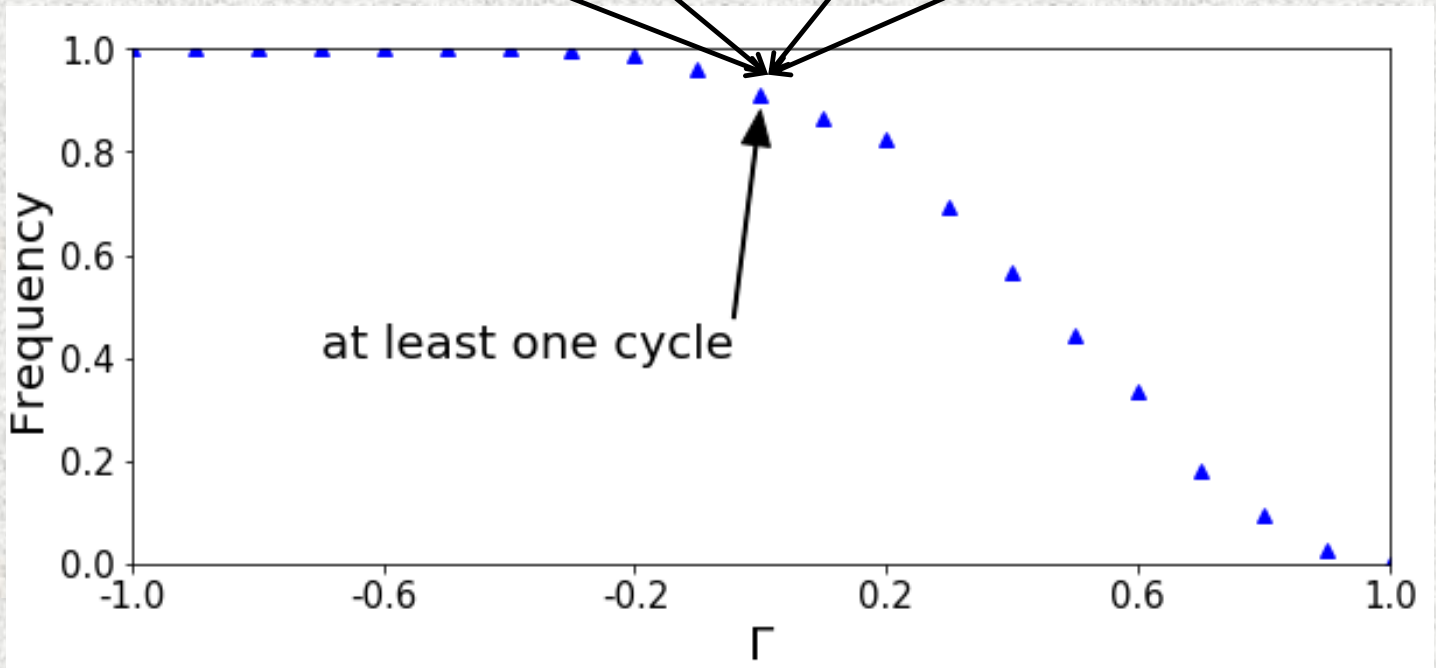
More complicated -> more cycles

$$h_N(n,k,d) = \binom{n}{k}^2 k!(k-1)! \left[N^{2(n-k)} - \frac{h_N(n-k,k,d+1)}{d+2} \right]$$



More competitive -> more cycles





Conclusion

- In complicated and competitive games equilibrium is an unrealistic assumption, and one should consider non-equilibrium models
- *If* real games are somewhat represented by the distribution we study here
- If “real” games are acyclic, why is this so?
- Extensions: multiplayer games (Sanders, Farmer, Galla, 2018; Luca Mungo); many others

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The curious case of a mysterious measure:

Penny Mealy
INET Summer
Research Update 2018

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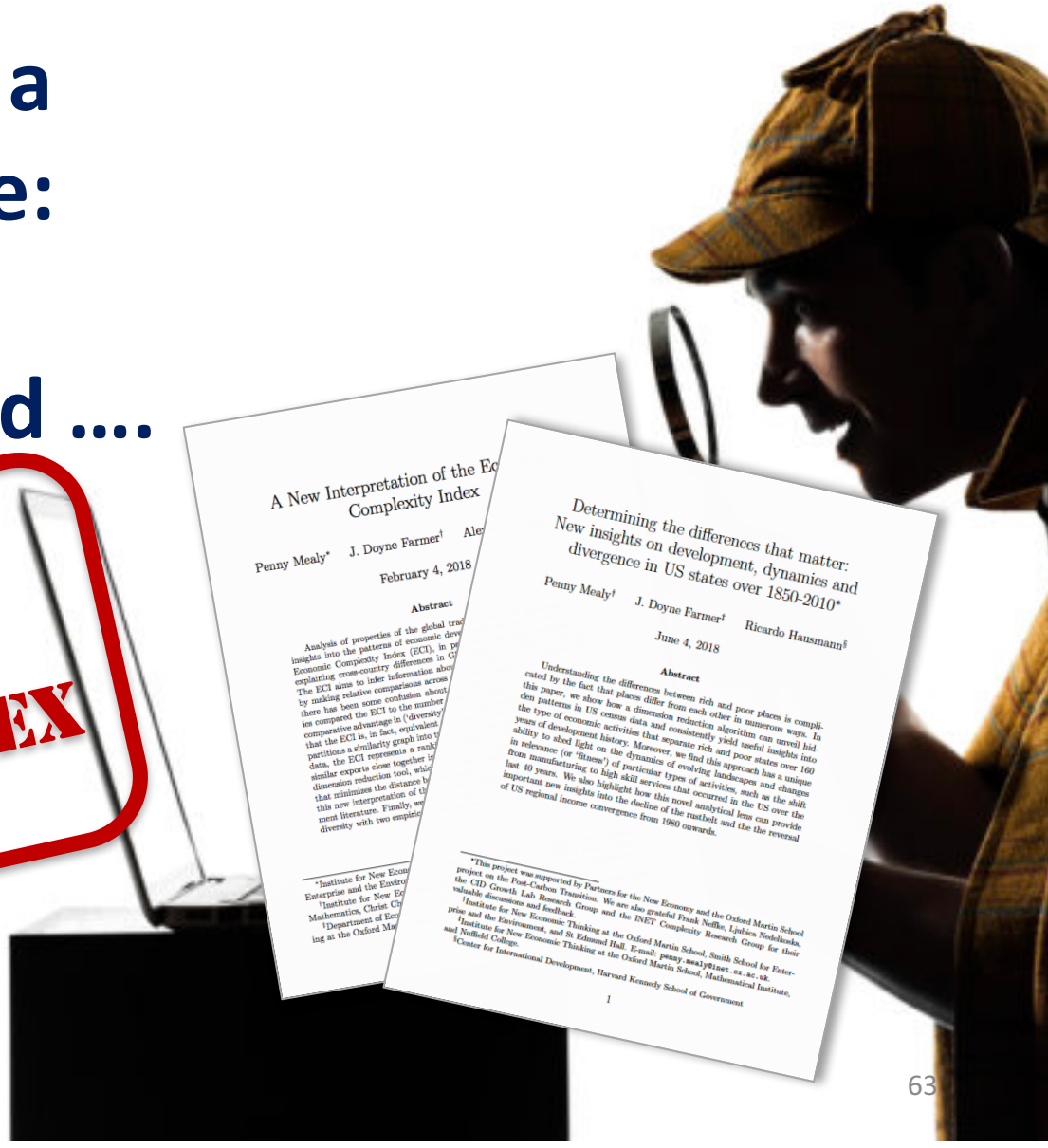
The curious case of a mysterious measure:

to be continued ….

THE ECONOMIC COMPLEXITY INDEX



Extracts from 'The future of macroeconomics'

John Muellbauer, INET@Oxford.

ECB colloquium held in honour of
Vítor Constâncio:
'The Future of Central Banking'
May 16 2018

NK Dynamic, Stochastic, GE: that would have been nice!

New Keynesian Dynamic Stochastic General Equilibrium models

- Not new, based on outdated ideas made redundant by the asymmetric information revolution of Stiglitz, Akerlof, Spence.
- Not Keynesian, ignoring co-ordination failures, especially between real economy and finance, hence useless for understanding financial stability.
- Not dynamic enough, misleading on real world lag structures.
- Hardly stochastic (statistical distributions), missing both radical uncertainty (time dimension) and heterogeneity (cross-section dimension) of distributions.
- Hardly GE, missing most of system feedbacks.
- Rational expectations and inter-temporal optimization need reformulation when structural breaks and radical uncertainty are endemic, Hendry & Mizon, VOXEU 2014.

The role of evidence

- Empirical evidence vs. New Keynesian DSGE models:
- 1) Failure of aggregate consumption Euler equation;
- 2) Mountains of new **micro-evidence** on heterogeneity, credit constraints, buffer stock behaviour, influence of house prices on consumption in liberal credit economies.
- 3) Evidence against NK-Phillips curve, micro and macro.
- Macro-evidence is seldom allowed to 'speak' in top journals: pincer movement between Lucas (1976) critique and Sims (1980) 'incredible restrictions critique' led to ban on macro-evidence outside DSGE and Bayesian VARs, where compromised by strong priors and calibration, see Hendry and Muellbauer (2018, OXREP).
- Presentation highlighted role of evidence in better understanding the macroeconomics of financial stability and of inflation.

4. New insights into US core inflation

- 4 key insights from Aron and Muellbauer (2013) forecasting PCE inflation in US:
- 1. Inflation is partly a process of relative price adjustment: long run solution determines relative prices, see Sargan (1964) paper on wages and prices in the UK, which introduced 'equilibrium correction', and Hendry (2001).
- 2. Unit labour costs, international prices and exchange rate and house prices are key elements of long-run solution.
- 3. Including union density, a measure of labour market power, improves relevance of the unemployment rate.
- Curse of dimensionality is a problem for VARs and reduced form forecasting equations: poor trade-off between number of variables vs. lag length.

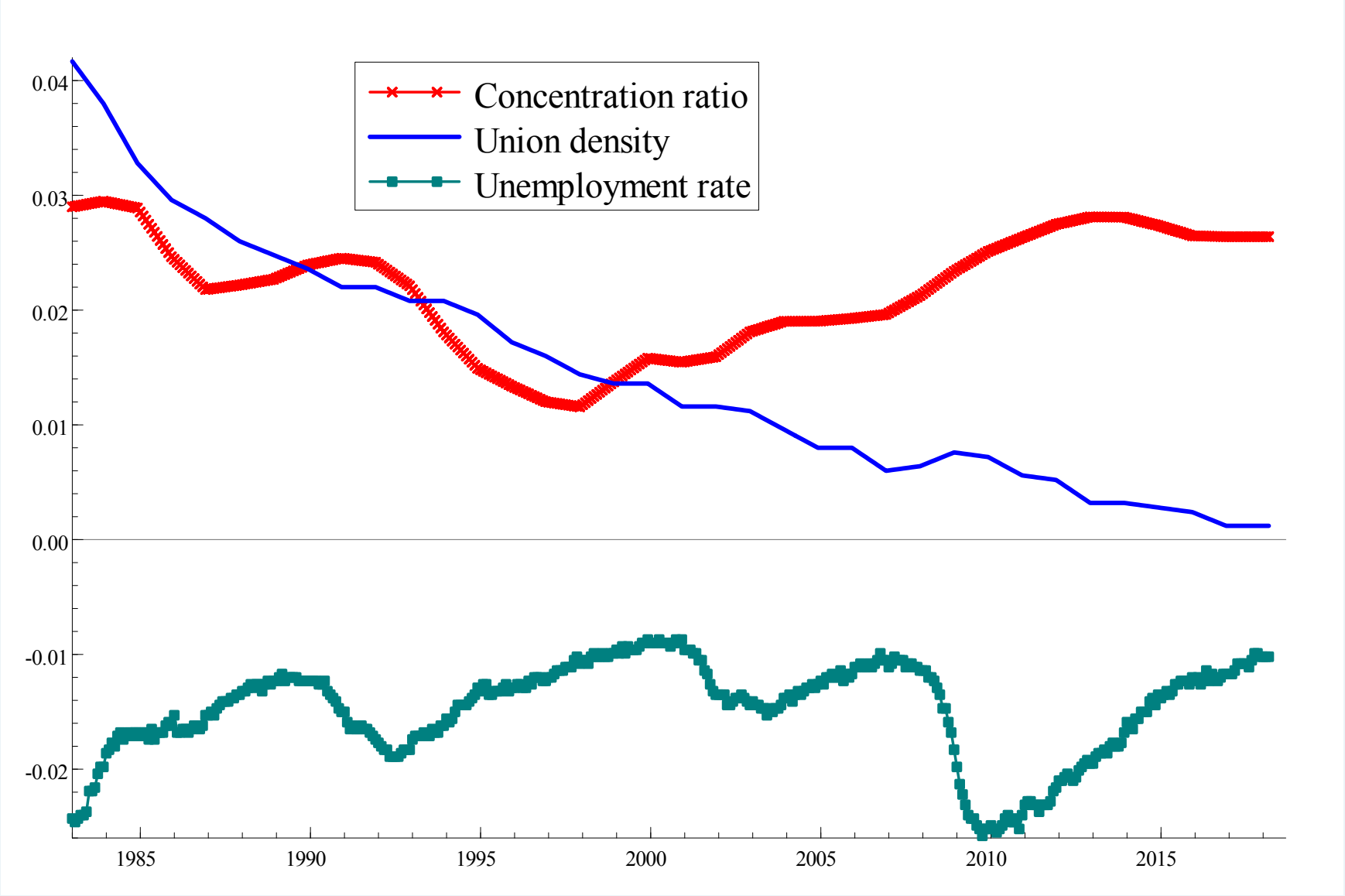
Key insights from Aron and Muellbauer (2013)

- 4. Parsimonious Longer Lags (PLL) allow better trade-off. Key intuition: impulse response functions become fuzzier as lag-length rises, but do NOT ignore longer lags.
- Monthly version: no restrictions on Dx(t), Dx(t-1), Dx(t-2), then D3x(t-3), D6x(t-6), D12x(t-12): 6 parameters instead of 24, still allows *some* role for longer lags.
- We showed that for *every information set considered*, PLL beats BIC applied to the unrestricted equation.
- Aron & Muellbauer (2018) examine pseudo-out of sample *post-crisis* performance of alternative models of US *core* inflation over various horizons. PLL usually helps.

Improved pseudo-out of sample performance

- We add a 5th insight: pricing power of firms matters for price setting along with union power for wage setting.
- Grullon et al (2017): profits related to firm concentration.
- Their Herfindahl-Hirschman index (HHI) of US firm concentration is highly significant in our forecasting models, improving in-sample parameter stability and out of sample forecasting performance.
- Key long-run drivers of core US PCE deflator: union density and unemployment rate, foreign prices, house prices and HHI.
- Union density and unemployment rate seem to be picking up unit labour costs.
- Implied Sargan-Phillips curve is stable: *after 3 years of crisis are omitted, conditional relationship is similar to before*.

Scaled effects on core price index of HHI, union density and unemployment



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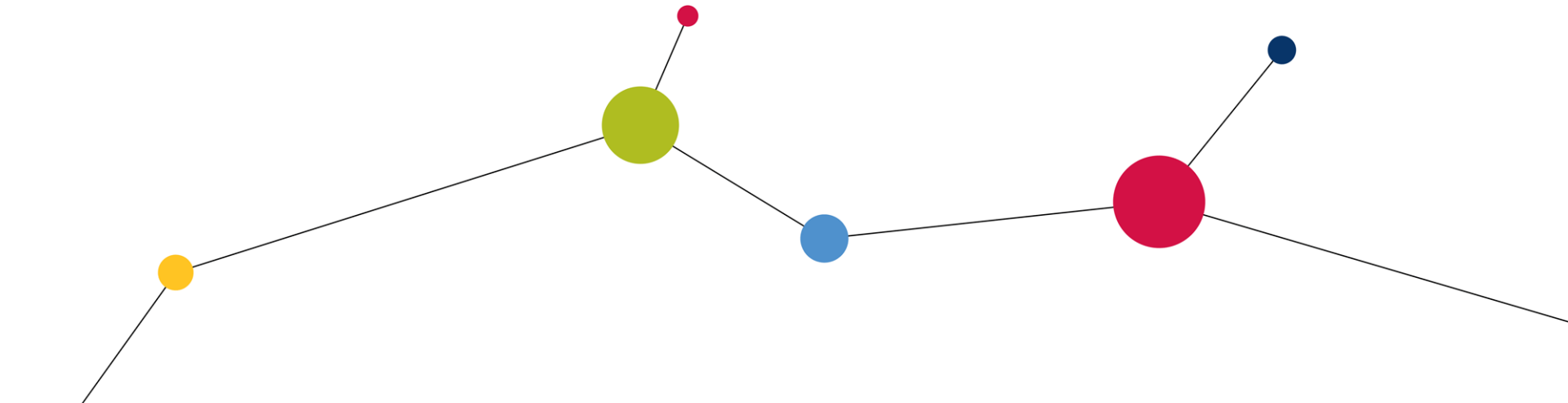
Employment, Equity and Growth Programme

11 June 2018



The RF Programme

Partnership between INET, Department of Social Policy and Intervention, and the Resolution Foundation 2014-2017

Team: ROs Marii Paskov, Stefan Thewissen, Max Roser, Andrea Geraci, DPhils Tahnee Ooms and Chloe Touzet, affiliated Oxford academics Tony Atkinson, John Muellbauer, Craig Holmes, Erzsébet Bukodi and external collaborators Salvatore Morelli, Holly Sutherland Philippe Van Kerm

Output:

30 journal papers, an edited book, 13 book chapters, 30 working papers/reports, and 2 volumes about to be published by Oxford University Press

Inequality and Inclusive Growth in Rich Countries

Chapter 1 Introduction — *Brian Nolan*

Chapter 2 Inequality and Living Standards: Key Trends and Drivers — *Michael Förster and Brian Nolan*

Chapter 3 Left Behind? Inequality and Inclusive Growth - Assessing the Australian experience — *Peter Whiteford and Daniel Nethery*

Chapter 4 Belgium, a poster child for inclusive growth? — *Ive Marx and Gerlinde Verbist*

Chapter 5 Canada's Middle Class – Forever Further Behind? — *Lars Osberg*

Chapter 6 France: rising precariousness supported by the welfare state — *Philippe Askenazy and Bruno Palier*

Chapter 7 Understanding Rising Income Inequality and Stagnating Ordinary Living Standards in Germany — *Gerhard Bosch and Thorsten Kalina*

Chapter 8 Inequality Amid Stagnation: Italy Over the Last Quarter of a Century — *Andrea Brandolini, Romina Gambacorta and Alfonso Rosolia*

Chapter 9 How has the middle fared in the Netherlands? A tale of stagnation and population shifts — *Wiemer Salverda and Stefan Thewissen*

Chapter 10: The driving forces of rising inequality in Spain and low income households' living standards — *Luis Ayala and Olga Cantó*

Chapter 11 Inequality and inclusive growth: the case of the UK — *Damian Grimshaw, Anthony Rafferty and Matt Whittaker*

Chapter 12 America's Great Decoupling — *Lane Kenworthy*

Chapter 13 Conclusions and Implications — *Brian Nolan*

Generating Prosperity for Working Families in Affluent Countries

Chapter 1 Introduction — *Brian Nolan*

Chapter 2 The Evolution of Living Standards for Middle and Lower Income Households in OECD Countries — *Brian Nolan and Stefan Thewissen*

Chapter 3 Inequality and Ordinary Living Standards in OECD Countries — *Brian Nolan and Stefan Thewissen*

Chapter 4 Median Household Income and GDP — *Brian Nolan, Max Roser and Stefan Thewissen*

Chapter 5 Sources of Household Income Growth in Rich Countries — *Brian Nolan, Stefan Thewissen and Alice Lazzati*

Chapter 6 Evolution of Median and Lower Incomes across Countries: The Role of Institutions and Growth 'Models' — *Brian Nolan and Chloé Touzet*

Chapter 7 The Labour Market: Wage Inequality, Occupations and Mobility — *Craig Holmes*

Chapter 8 8 Sifting through the ASHE: Job Polarisation and Earnings Inequality in the UK, 1975-2015 — *Annalisa Cristini, Andrea Geraci and John Muellbauer*

Chapter 9 Minimum Wages and Supporting Wage Growth — *Brian Nolan*

Chapter 10 Strengthening Redistribution — *Brian Nolan, Chrysa Leventi, Holly Sutherland and Iva Tasseva*

Chapter 11 Middle and below living standards: what can we learn from beyond income measures of economic wellbeing? — *Marii Paskov, Joan Madia and Tim Goedemé*

Chapter 12 Wealth Inequality — *Salvatore Morelli, Brian Nolan and Philippe Van Kerm*

Chapter 13 Income inequality, living standards and intergenerational social mobility — *Erzsébet Bukodi and Marii Paskov*

Chapter 14 Conclusions and Implications — *Brian Nolan*

Some Key Messages

US extreme case in terms of increase in inequality and stagnation in ordinary living standards over decades, so hazardous to generalise from its experience as in current 'grand narratives'

Some weak association across countries between rising income inequality and stagnation in middle and lower incomes, but inequality accounts for little of variation in income growth

growth in GDP per head has detached from ordinary household incomes in US, but the extent of that divergence and the factors driving it vary widely across other rich countries

Outside US, real wages of primary earner as well as increases in employment rates for other household members have contributed to rising real incomes

No 'best-performing model' in terms of 'varieties of capitalism' or 'welfare regimes' in generating real income growth for middle and below

Some Key Messages

Globalisation and technological change seen as common external forces 'hollowing out' middle jobs, but changes in occupational structure and distribution of earnings have varied widely across rich countries

For UK, different patterns in occupational change between regions, time-periods and genders, with significant occupational upgrading for women

Raising the minimum wage has impact on middle as well as lower household incomes; other tools to enhance wage growth include supporting collective bargaining and trade unions, regulating precarious employment, pay policies for public sector, competition and regulation policies re market power, fiscal and monetary policies

Changes in the redistributive impact of direct taxes and cash transfers have been central to how much income inequality has risen across countries

Partial basic income for all adults, with more progressive direct taxes and major increase in child-related transfers. would reduce poverty and inequality in UK, though some low-income households would lose out

Some Key Messages

Impact of the Great Recession on household incomes and non-monetary indicators of living standards dramatically different across rich countries, with policy responses being a key contributor

Wealth is much more unequally distributed than income but inequality has risen much more sharply in some countries than others, with relatively limited increase in UK due to impact of rising house values

Extent of social class mobility across generations is quite similar across most European countries, UK is not distinctive

Stagnating living standards and rising inequality are not inexorable products of external forces such as globalisation and technology, instead institutions and policies can be better framed to support inclusive growth; includes scope to strengthen broadly-based wage growth and increase effectiveness of tax/transfer systems in underpinning middle and lower incomes

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OMS Citi Programme

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Oxford Martin Programme on Inequality and Prosperity

5-year programme from Sept. 2016, as part of the Oxford Martin School's research partnership with Citi

Aims to advance understanding of the drivers of increasing inequality and its effects, and identify a coherent set of responses aimed at promoting inclusive growth and prosperity

Team: Matteo Richiardi, Luis Valenzuela

Initial output: *Inequality and Prosperity in the Industrialized World: Addressing a Growing Challenge*, Citi Global Perspectives and Solutions series, Oct. 2017

Main current research strands:

- untangling the drivers of rising income inequality in rich countries
- exploring firm effects on wage dispersion and the productivity-pay gap
- building a dynamic simulation model to study tax/transfer reforms
- identifying the role of rising inequality in political behaviours and outcomes
    - David Weisstanner (political science, Zurich) joining next month

Intergenerational Wealth Transfers

New project funded by Nuffield Foundation

Aim is to compare patterns of transmission of wealth *inter vivos* and via inheritance in rich countries, assess its role in wealth accumulation and if/how that has been changing, and see if effects of different tax regimes can be identified with lessons for improving their design

Juan Palomino (economics, Madrid) joining next month

Strongly related to Marii Paskov's research funded by British Academy Postdoctoral Fellowship including broader role of parental wealth in influencing socio-economic outcomes

The labour share in the UK

Research question:

What is the role of firm heterogeneity in recent developments of the labour share in the UK?

For example: higher dispersion of TFP, market power, or wages between firms? Does firm size matter?

Both a theoretical and empirical contribution (using firm-level data for UK).

Spin-off research:

- Capital distribution across firms
- Product and factor market power effect on firm wages

Microsimulation project

Research question(s):

What are the short-, medium- and long-term consequences of changes in

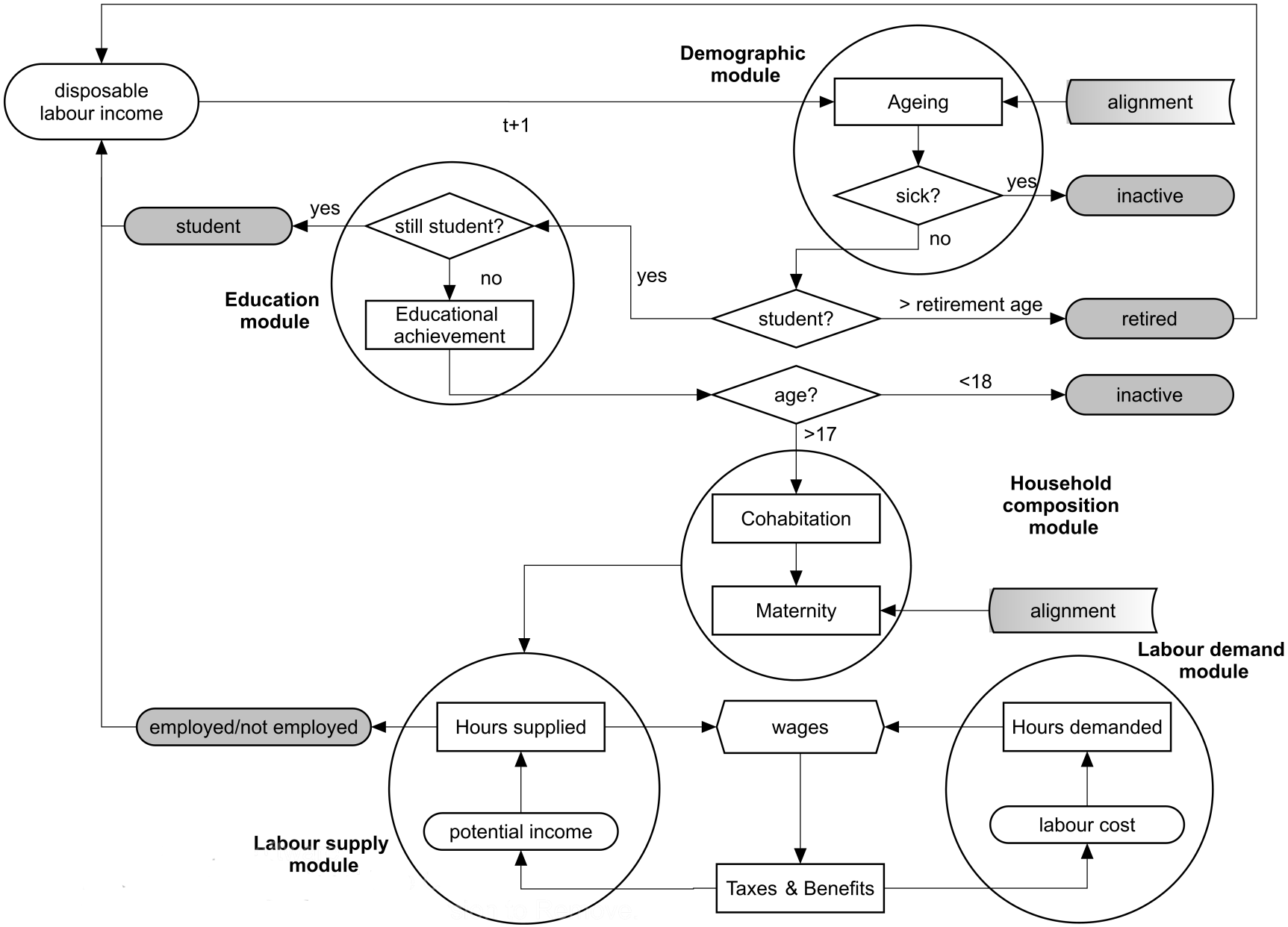
- Population structure (life expectancy, immigration flows)
- Household structure (fertility, cohabitation status)
- Educational achievements
- Labour supply behaviour
- Fiscal and retirement policies
- Technical change

on individual and household employment, poverty, inequality, insecurity?

Dynamic microsimulation model with behavioural responses and endogenous wages, applied to UK (and beyond?)

A tool for economic and policy evaluation, with embedded tax & benefit calculator (EUROMOD)

Microsimulation project



Tea Break

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ECONOMICS OF SUSTAINABILITY

Francois Cohen, Cameron Hepburn, Linus Mattauch, Jacquelyn Pless, and Alexander Teytelboym

June 11th 2018


Growth &
wealth


Climate

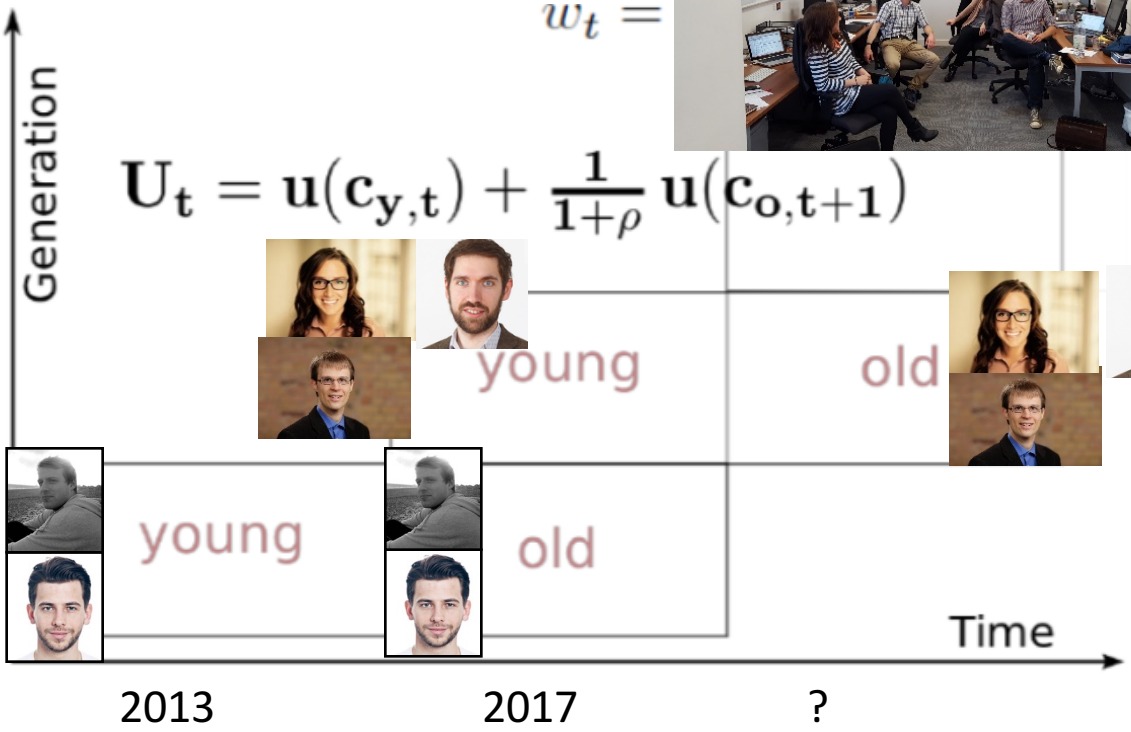

Energy


Natural capital

2017: the year of generational turnover in EoS...

$$w_t =$$

$$\mathbf{U_t} = \mathbf{u}(\mathbf{c_{y,t}}) + \frac{1}{1+\rho}\mathbf{u}(\mathbf{c_{o,t+1}})$$



Free market solution:

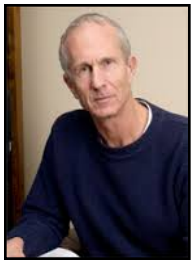
...results in a pleasingly non-trivial inter-temporal welfare optimisation problems for the social planner:

Leadership

Cameron Hepburn (Programme Director)

Alexander Teytelboym (Deputy Director)

Eric Beinhocker



Doyne Farmer

Research Fellows

Matthew Ives

Jacquelyn Pless

Niall Farrell is now Marie Curie Fellow at PIK

Linus Mattauch

Doctoral Candidates and RAs

Alex Pfeiffer is now at McKinsey

Lucas Kruitwagen

Ahmad Al Sayed

Ryan Rafaty

Penny Mealy is now an Oxbridge postdoc

Francois Cohen

Rupert Way

Francois Lafond

Yangsiyu Lu

Andrea Bacilieri

Anton Pichler

Sugandha Srivistav

Frank Sperling

Collaborators & Visiting Fellows (among others)

Andreas Loeschel

Kirk Hamilton

Paul Lehmann

Nicholas Stern

Myles Allen

Joe Stiglitz

Total chaos elimination

Gemma Lenik

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Clean Energy Innovation

Jacquelyn Pless

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How can policy steer the direction of innovation?

Volume 12, Issue 1
Winter 2018

Policy Brief—Encouraging Innovation that Protects Environmental Systems: Five Policy Proposals

Cameron Hepburn, Jacquelyn Pless, David Popp

Review of Environmental Economics and Policy, Volume 12, Issue 1, 1 February 2018, Pages 154–169, https://doi.org/10.1093/reep/rex024
Published: 19 January 2018

1. Put a price on natural capital
2. Support environmentally-friendly R&D
3. Judiciously support early-stage deployment
4. Support collaborative R&D arrangements
5. Reduce barriers to private sector financing

Ongoing research

Energy Innovation

- Are grants and tax credits complements or substitutes?
- Horizon 2020 and Technological Change (with Ralf Martin, Imperial, and Myra Mohnen, Essex)

Other

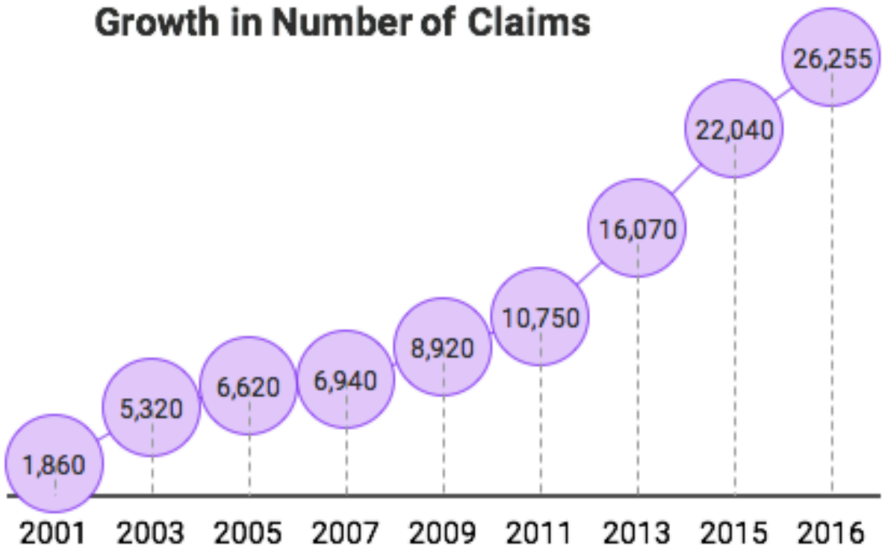
- How do information and uncertainty impact solar self-consumption? (with Eoghan McKenna, UCL)
- What is the impact of environmental regulation on labour? (Yangsiyu's DPhil work)

Government launches £102m fund for clean energy research

25 May 2018, source edie newsroom

The UK Government has launched a £102.5m investment programme in a bid to tackle the challenges the UK faces as the renewables revolution continues, suggesting that the nation's energy sector could soon be poised to take clean power sources mainstream.

Source: https://www.edie.net/news/6/Government-launches--102m-fund-for-clean-energy-research/



Source: https://rndtax.co.uk/hmrc-rd-tax-credit-statistics-2017/

Other activities – enabling robust study of public innovation spending effectiveness

Image borrowed from John List's website

We have been meeting with HMT to discuss embedding experiments into the ways in which public innovation funds are allocated

Public finance of climate change mitigation

Linus Mattauch

(with RAs 2017/18: Franziska Funke, Matthias Roesti, Fiona Spuler, Simona Sulikova)

University of Oxford
Institute for New Economic Thinking
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Further activities:

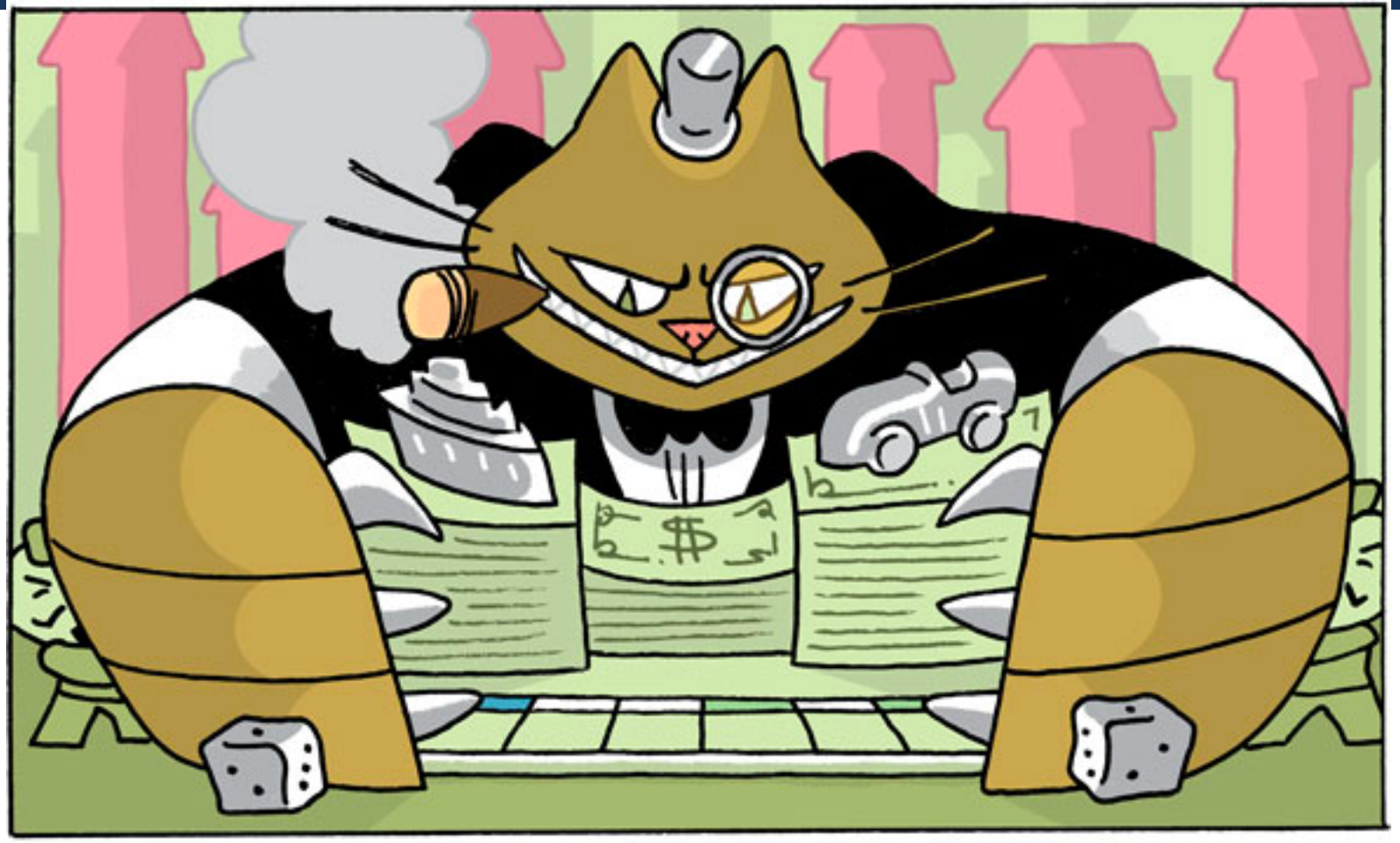
- **Endogeneous preferences:** does regulation align with our identities?
- **Demand-side solutions** to environmental sustainability in economics.
- **Rents:** Appropriating the climate rent increases economic growth.
- **Wealth inequality:** can it be overcome by capital taxes that finance public investment?
- **Health benefits** from active travel: How to evaluate in urban policy? (Simona's MPhil)
- **Policy work:**
  - *European Economic Review* Special Issue on Carbon Pricing
- **As of September: Lecturer for the Environmental Change Institute**

Creutzig, F. et al. (2018). Towards demand-side solutions for mitigating climate change. Nature Climate Change 8:260-271.

Mattauch, L., C. Hepburn, N. Stern (2018). Pigou changes his preferences, in preparation, mimeo.

Mattauch, L., D. Klenert, J. Stiglitz, O. Edenhofer (2018). Overcoming wealth inequality by capital taxes that finance public investment. *mimeo*

Siegmeler, J., L. Mattauch, O. Edenhofer (2018). Capital beats coal: how collecting the climate rent increases aggregate investment. Journal of Environmental Economics and Management, 88:366--378.



Market imperfections and climate solutions

Francois Cohen

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How do the markets for energy efficiency perform?

European Economic Review
Volume 93, 2017

Consumer myopia, imperfect competition and the energy efficiency gap: Evidence from the UK refrigerator market

François Cohen[a], Matthieu Glachant[b,*], Magnus Söderberg[c]

[a] *London School of Economics and Political Science, Grantham Research Institute of Climate Change and the Environment and Centre for Climate Change Economics and Policy, London, UK*
[b] *MINES ParisTech, PSL Research University, CNRS, i3-CERNA, 60, boulevard St Michel, 75006 Paris, France*
[c] *University of Gothenburg, Department of Business, Gothenburg, Sweden*

1. Consumers undervalue energy costs by 45% and buy inefficient goods.
2. Do manufacturers price appliances differently because of this?
3. Yes. Inefficient and larger appliances look better than they are and are over-priced.
4. Consumers therefore buy less of them.
5. This effect reduces energy consumption.

New research with

Barriers to investment in sustainable agricultural practices

- Rely on the lessons learnt from barriers to investments in energy efficiency
- Take into account the specificities of the agricultural sector

Mix of market and regulatory failures

- Imperfect information and information asymmetries
- Market structure and vertical integration
- Split incentives
- Regulatory barriers (size of vegetables regulated!)

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Generously supported by The Nature Conservancy

Peer-to-peer electricity trading

Alexander Teytelboym

(joint work with Thomas Morstyn and Malcolm McCulloch)

University of Oxford
Institute for New Economic Thinking
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OXFORD MARTIN PROGRAMME ON INTEGRATING RENEWABLE ELECTRICITY

THE FUTURE OF ELECTRICITY:

MARKETS, REGULATION, & DEVELOPMENT

ST ANNE'S COLLEGE | UNIVERSITY OF OXFORD

2 JULY, 2018 | 9:30 - 16:45

OXFORD MARTIN SCHOOL

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ssee

Featuring:

Frank Wolak

Andreas Loeschel

Mar Reguant

Cedric Philibert

Dan Kammen

James Bushnell

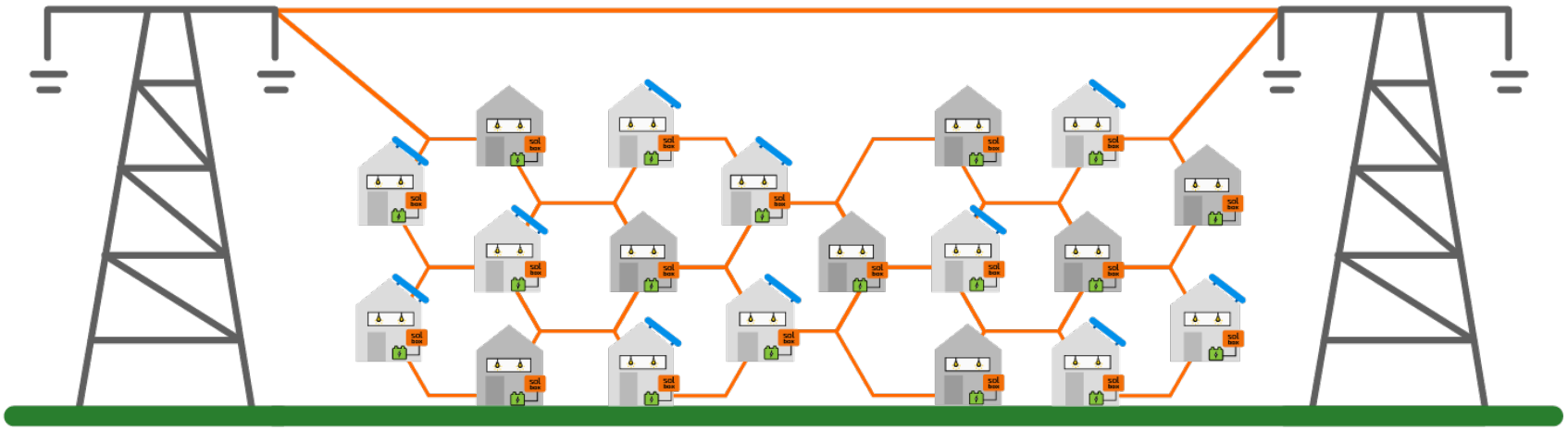
Catherine Wolfram

Richard Green

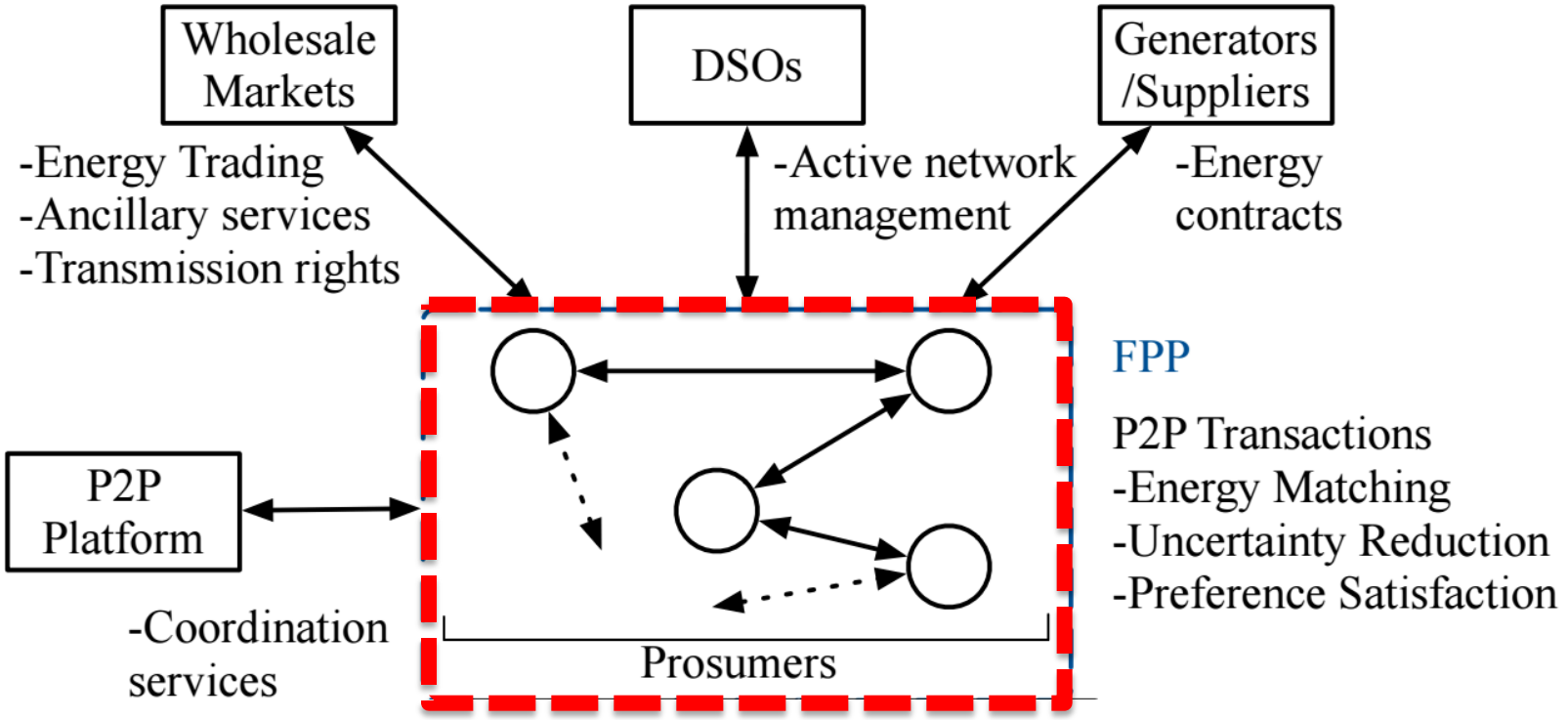
Peter Cramton

Peer-to-peer electricity trading

Peer-to-peer electricity trading



Peer-to-peer electricity trading



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Peer-to-peer electricity trading

Bilateral Contract Networks for Peer-to-Peer Energy Trading

Thomas Morstyn, *Member, IEEE*, Alexander Teytelboym, and Malcolm D. McCulloch, *Senior Member, IEEE*

***Abstract*—This paper proposes bilateral contract networks as a new scalable market design for peer-to-peer energy trading. Coordinating small-scale distributed energy resources to shape overall demand could offer significant value to power systems, by alleviating the need for investments in upstream generation and transmission infrastructure, increasing network efficiency and increasing energy security. However, incentivising coordination between the owners of large-scale and small-scale energy resources at different levels of the power system remains an unsolved challenge. This paper introduces real-time and forward markets, consisting of energy contracts offered between generators with fuel-based sources, suppliers acting as intermediaries and consumers with inflexible loads, time-coupled flexible loads and/or renewable sources. For each type of agent, utility-maximising preferences for real-time contracts and forward contracts are derived. It is shown that these preferences satisfy full substitutability conditions essential for establishing the existence of a stable outcome – an agreed network of contracts specifying energy trades and prices, which agents do not wish to mutually deviate from. Important characteristics of energy trading are incorporated, including upstream-downstream energy balance and forward market uncertainty. Full substitutability ensures a distributed price-adjustment process can be used, which only requires local agent decisions and agent-to-agent communication between trading partners.**

***Index Terms*—Bilateral contracts, energy trading, electricity markets, game theory, market design, matching markets, microgrids, peer-to-peer trading, prosumers, smart grid, trading networks, transactive energy.**

Ψ_m^*	Selected trades at a competitive equilibrium
Ω_m	Trades in market m
Ω_{mi}^B	Agent i's potential upstream trades
Ω_{mi}^S	Agent i's potential downstream trades
$\mathcal{A}$	Set of agents
$a(\cdot)$	Set of agents associated with a set of contracts
$b(\cdot)$	Buyer of a trade or contract
$C_{mi}(\cdot)$	Agent i's choice correspondence
$C_{mi}^B(\cdot)$	Agent i's chosen upstream contracts
$C_{mi}^S(\cdot)$	Agent i's chosen downstream contracts
c'_y	Net upstream trades
c'_z	Net downstream trades
c_{g1i}	Generator i's linear cost coefficient
c_{g2i}	Generator i's quadratic cost coefficient
c_{t1i}	Supplier i's linear cost coefficient
d_{fi}	Prosumer i's net flexible demand
d'_{fi}	d_{fi}, adjusted for the time-coupled flexible load
$\bar{d}_{fi}$	Prosumer i's flexible load power limit
$D_{fi}(t)$	Remaining time-coupled flexible load
d_{ri}	Prosumer i's net inflexible demand
d'_{ri}	d_{ri}, adjusted for the time-coupled flexible load
$\mathbb{E}[\cdot]$	Expectation operator
g_i	Generator i's unconstrained optimal output
$\bar{g}_i$	Generator i's maximum capacity
$\mathcal{G}$	Set of generator agents

Matching Markets with Contracts for Electric Vehicle Smart Charging

Thomas Morstyn*, Alexander Teytelboym† and Malcolm D. McCulloch*
* Department of Engineering Science, The University of Oxford, Parks Road, Oxford OX1 2JD, United Kingdom {thomas.morstyn, malcolm.mcculloch}@eng.ox.ac.uk
† Department of Economics, The University of Oxford, Manor Road, Oxford, OX1 3UQ, United Kingdom, alexander.teytelboym@inet.ox.ac.uk

***Abstract*—This paper proposes the novel application of matching markets with contracts for electric vehicle smart charging. The flexibility inherent in electric vehicle charging presents the new opportunity for automation and coordination to shape overall demand. Mechanisms that incentivise coordination are a promising approach for integrating the individual preferences and energy requirements of electric vehicle owners. However, these mechanisms require careful design, since they directly influence power system operation. This paper proposes a new ma design, allowing owners of electric vehicles and agg competitively negotiate charging contracts s and price of charging at discrete pow the agents' preferences over substitutability, establish an agreed set of deviate f**

not directly applicable when electric vehicles b owners, since the owners need to be inc a coordinated manner.

Time-of-use energy pri charging during limitati

s pa ma

U nifica increa arrive h

ent n in

ere is a central ystem cost. Finally, the ctric vehicle chargers capable of tinuously controllable range of charging he electric vehicles tend to converge towards a ion normalised profile, with significant time spent at low charging power levels.

In [10], it is noted existing electric vehicle battery charging standards do not provide for continuously controllable charging power levels, and instead are only able to vary between a discrete set of values. In addition, a coordination strategy that primarily adjusts vehicle charging powers, rather than charging times, tends to result in vehicles operating at low power levels for significant periods. However, this can increase losses, due to power converters having low efficiency when operated at low power levels [11]. Discrete optimisation strategies have been proposed to address this issue for electric vehicle fleets with a single owner [12], [13].

Recently, there have been significant developments in the theory of matching markets with contracts, which analyses agent-to-agent negotiation mechanisms, where agents have competing interests and trade non-homogeneous goods [14]–[16]. Key considerations are the existence of stable outcomes –

Best conference paper at Power & Energy Society Meetings

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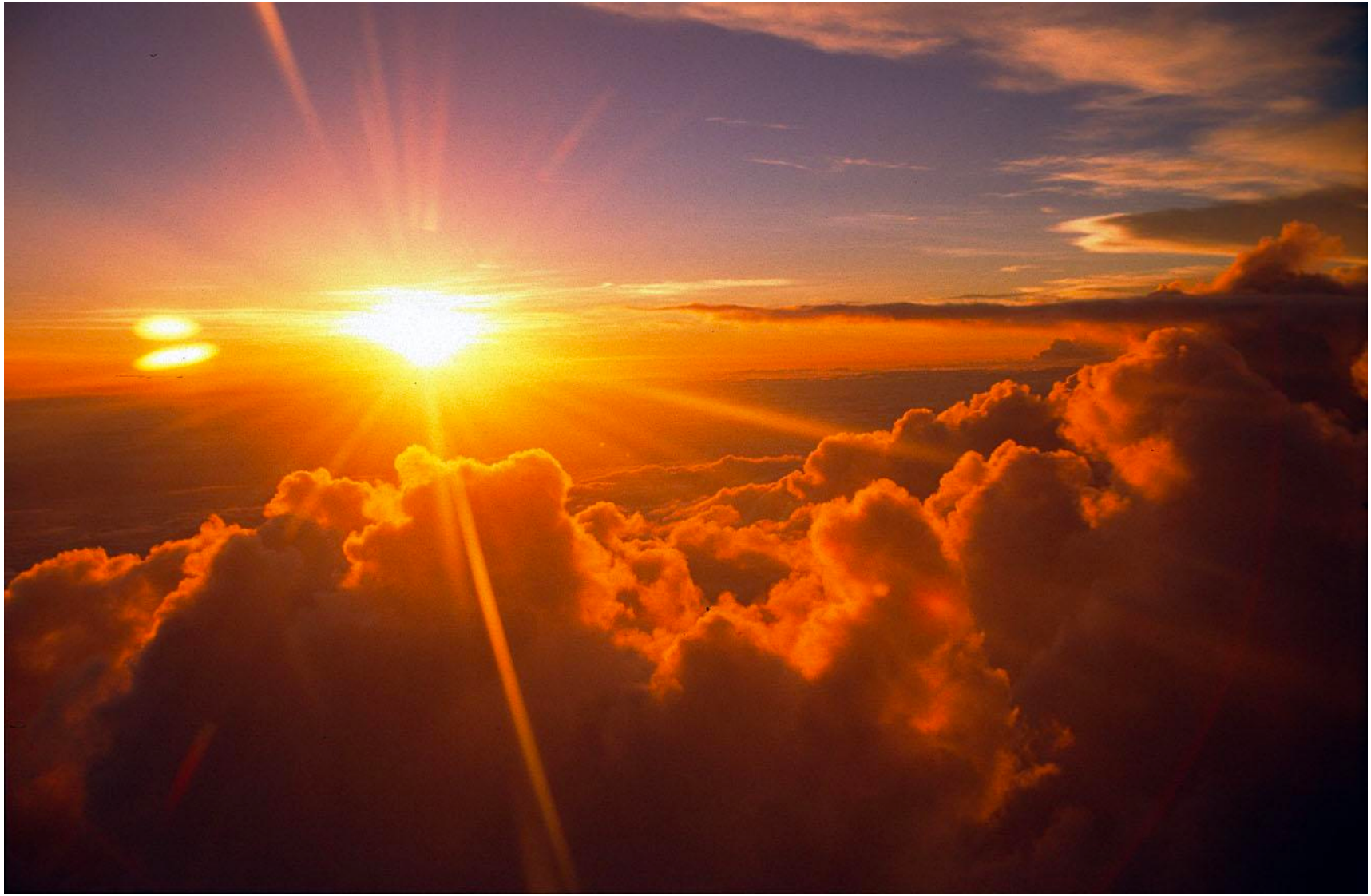

Research and policy highlights

Cameron Hepburn

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We provided investors with more clarity over strategies and their 2°C compatibility

We published investment principles (cover of *Nature Climate Change* in Jan) to guide investors on the risks and returns of investment in fossil fuel focused companies.

- The three principles are:

1. **Commitment to net-zero emissions:** When (year or temperature) does the company plan to hit net zero emissions?

2. **Profitable net-zero business model:** What does it's business plan look like in an NZE world?

3. **Quantitative mid-term targets:** How will the company measure progress?

Source: Millar et al. (2018, *NCC*)

EoS team examining substitutability of natural capital called for better pricing & governance

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The wealth of nature

Increasing national wealth and reducing risk by measuring and managing natural capital

Author team: François Cohen, Kirk Hamilton, Cameron Hepburn, Frank Sperling, Alexander Teytelboym

green economy coalition

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The UK government wants to put a price on nature – but that will destroy it

George Monbiot

'capital' is morally wrong, counter-productive

● George Monbiot says trying to account for the value of nature will inevitably lead to its commodification and destruction. But our global economic system already places economic values on the natural world - and has done so for centuries. The problem is that the price placed on ecosystems and biodiversity is effectively zero. Our economies see these things as worthless because we have failed to measure, understand and account for the true value of nature's riches. Markets remain largely blind to these benefits, and thus we consume them to the point of destruction.

Monbiot is incorrect when he says that "price represents an expectation of payment, in accordance with market rates". In fact, price represents the attribution of economic value. Natural capital does not prepare nature for sale; it calls attention to the worth of what is lost. We have argued that all human prosperity rests on nature, and Monbiot is correct to point out that many natural resources are irreplaceable. Unfortunately, until we place a proper value on natural capital, the global economic system will continue to merrily saw away at the branch we're all sitting on. Decades of well-intentioned conservation have done little; a new approach is required. Properly valuing the huge, irreplaceable natural contributions that we all depend on is a good place to start.

Cameron Hepburn *Professor of environmental economics, Smith School, University of Oxford, and director of economics of sustainability, INET, Oxford Martin School*, **Alex Teytelboym** *Associate professor, Department of Economics, University of Oxford*, **Francois Cohen** *Senior research officer, INET Oxford Martin*, **Kirk Hamilton** *Visiting professor, Department of Geography and Environment, LSE*
Green Economy Coalition

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Electricity markets are being reformed, creating new market opportunities

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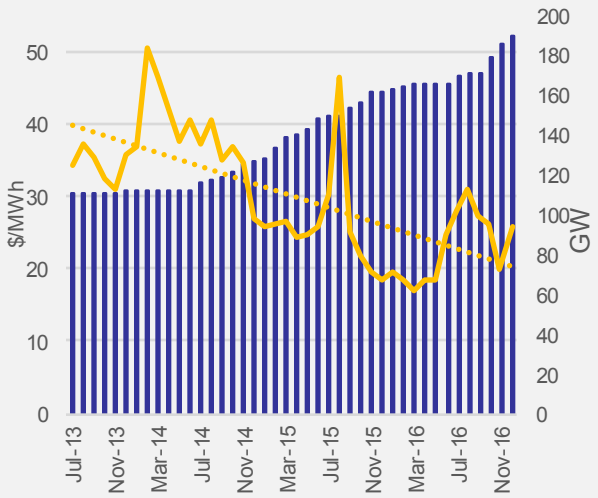
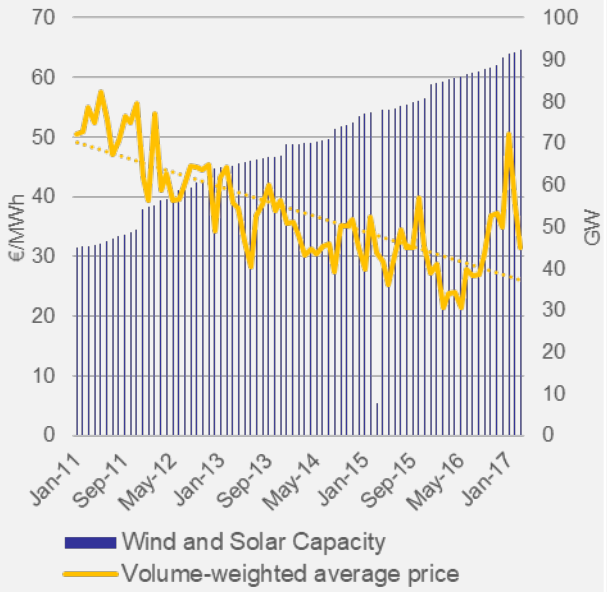
- Balancing services are being explicitly priced
- Competitive auctions are being used to procure capacity
- New markets are opening for demand side response and batteries

More renewables (blue) → lower wholesale electricity prices (yellow)

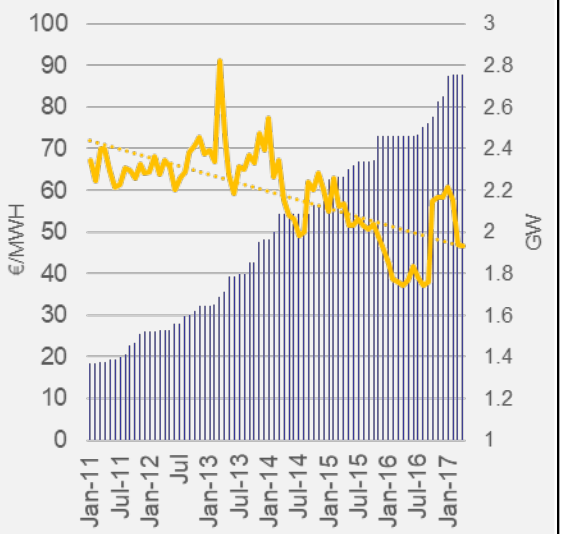
Texas



Germany



Ireland



Source: Farrell et al (forthcoming, *OxREP*) Is this the end of conventional wholesale electricity markets?

Inertia is strong, existing capacity not compatible with Paris; pipeline even worse

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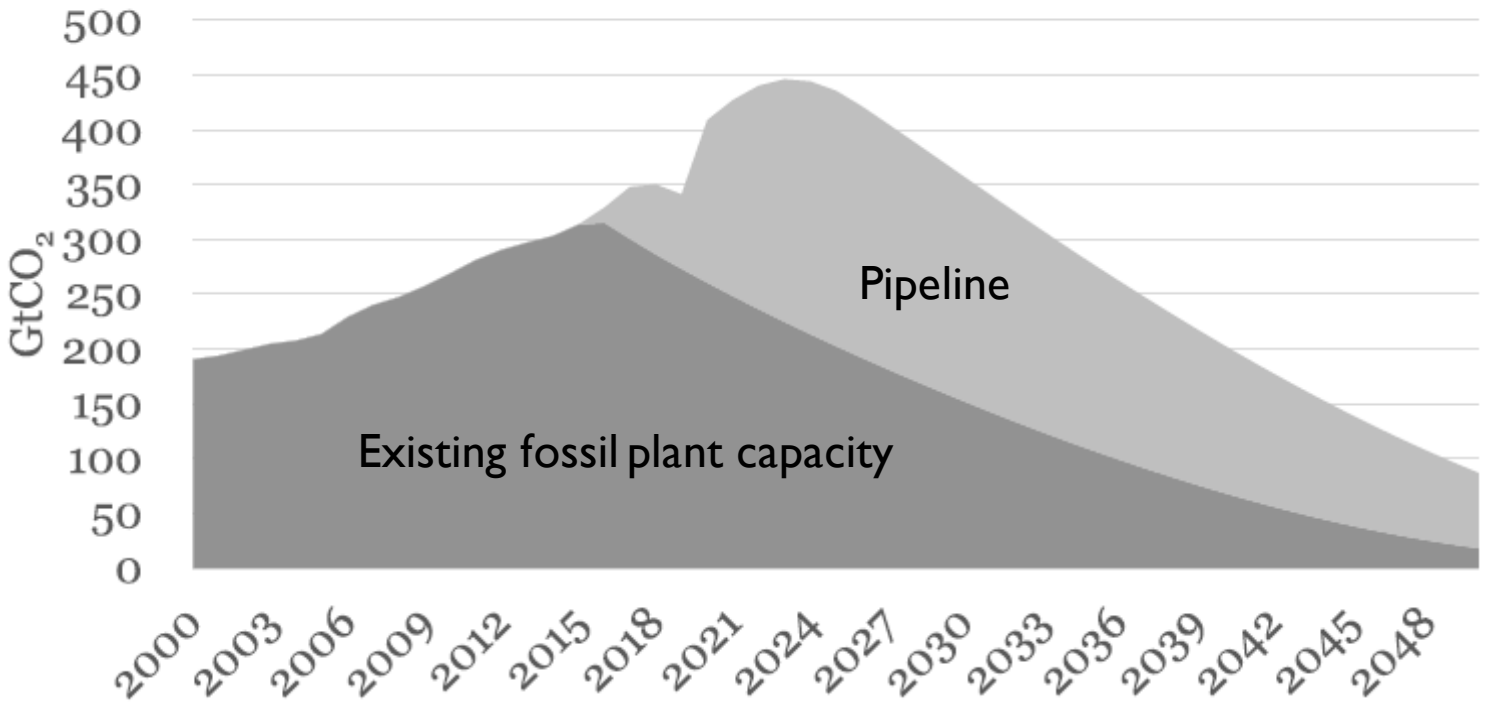
- Remaining budget for Paris is ~240GtCO$_2$ for the power sector
- Existing assets imply future 'committed' emissions of ~300GtCO$_2$
- Pipeline implies an additional committed emissions of ~270GtCO$_2$

'Committed emissions' (GtCO$_2$) to 2050



Source: Pfeiffer et al (2018, *ERL*) Committed emissions from existing and planned power plants

Government promises and action are not enough

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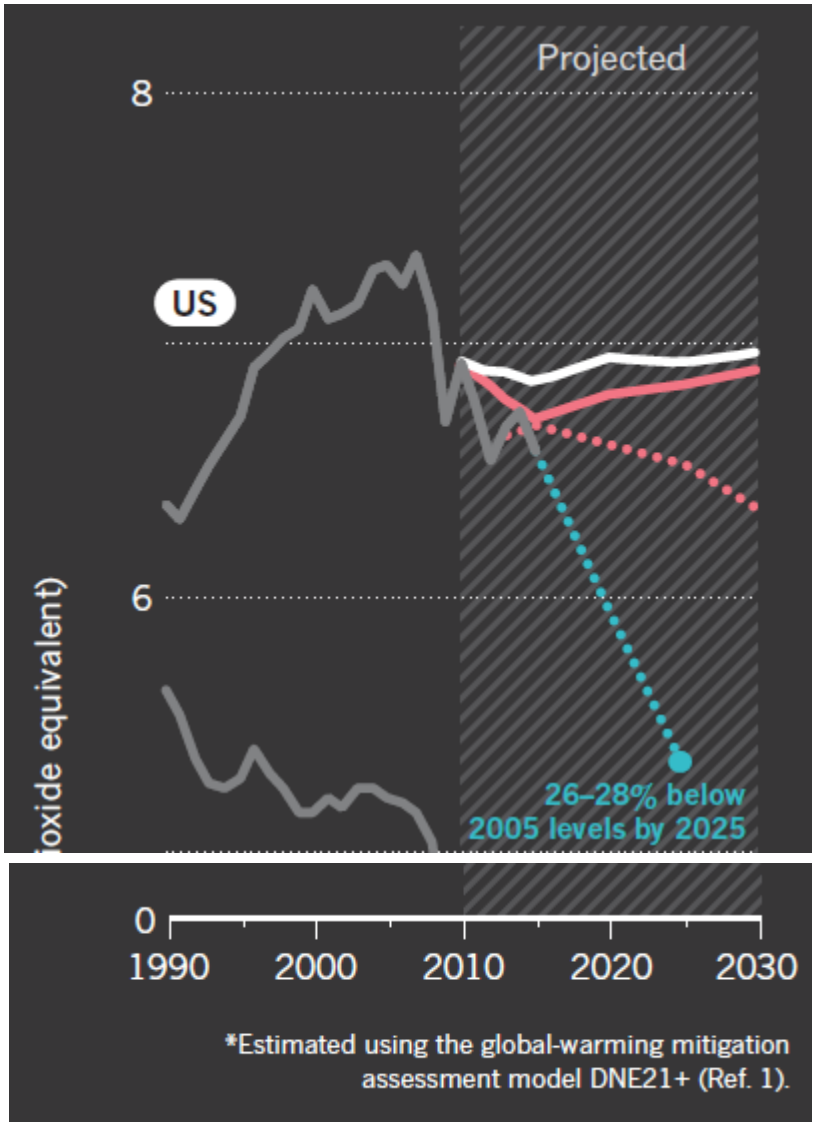
CLIMATE SHORTFALL

Emissions trajectories for three advanced industrialized regions show that enacted and pledged policies will be unable to deliver the ambitious cuts to emissions agreed under the 2015 Paris framework.

- Historical emissions
- Business as usual*
- Enacted policies*
- Pledged policies (reported)
- Target emissions (nationally determined contributions)



Source: Victor et al. (2017, *Nature*) Prove Paris more than Paper Promises

The PCT programme kicked off and is heeding Nick Stern's call for a new generation of models

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Climate Change 2014
Mitigation of Climate Change

Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Edited by

Ottmar Edenhofer
Working Group III Co-Chair
Potsdam Institute for Climate Impact Research

Ramón Pichs-Madruga
Working Group III Co-Chair
Centro de Investigaciones de la Economía Mundial

Youba Sokona
Working Group III Co-Chair
South Centre

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Scientist

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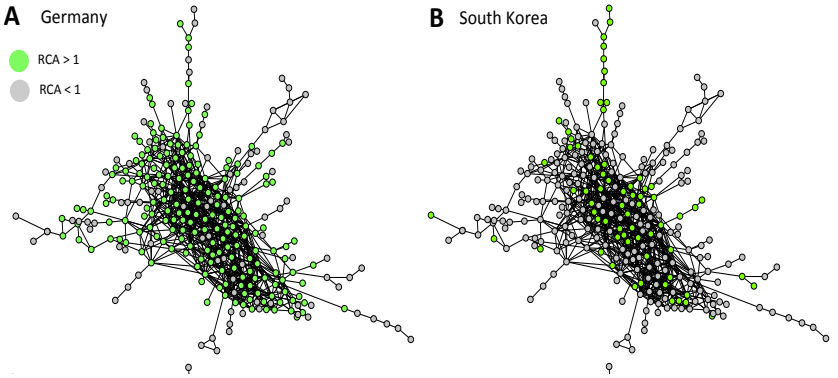
Senior Scientist

Working Group III Technical Support Unit

CAMBRIDGE UNIVERSITY PRESS

There is an urgent need for a new generation of models that give a more accurate picture.

Lord Nicholas Stern (2016)



Sources: IPCC

We are looking for sensitive intervention points that may show self-reinforcing dynamics

Some of these accelerating dynamics can already be observed:

Technology: Deployment of clean technology → costs fall through learning by doing → more deployment

Finance: Finance clean energy → financiers gain experience → interest rates fall → costs fall → more finance

Legal: Material threat of litigation for climate-related risks → directors act → corporate norms change → further litigation

Social: Cleantech adoption → neighbours more likely to adopt → increase in market size → costs fall → others are more likely to adopt the clean technology

Geopolitical: A leading economy adopts a carbon price and border carbon adjustment → other countries adopt carbon prices → a carbon club forms → more countries join

Beliefs: If key people believe the transition will happen → action → beliefs spread

Climate action and the G20

G20 Germany

Share:

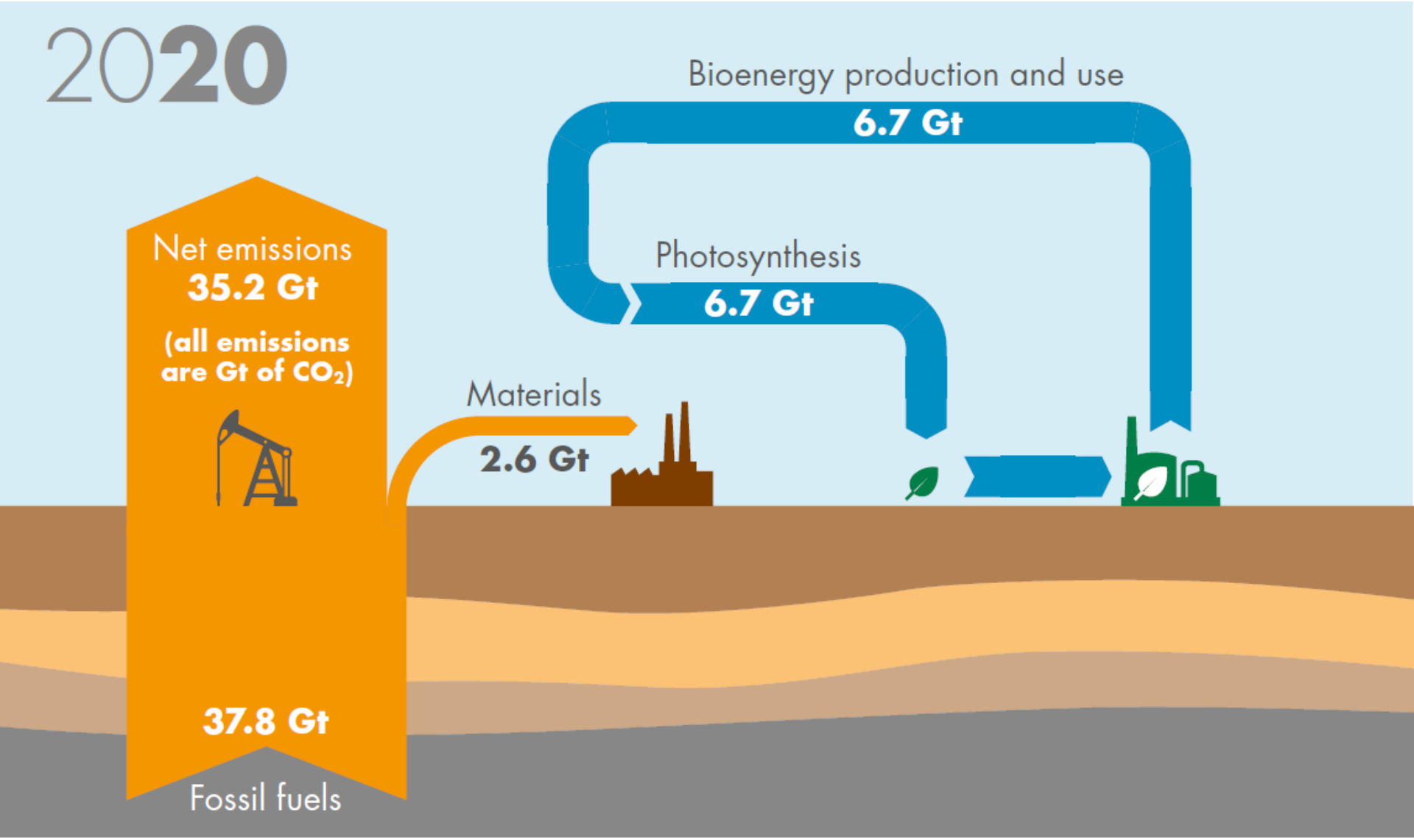
The Tipping Point: How the G20 Can Lead the Transition to a Prosperous Clean Energy Economy

Cameron Hepburn, Eric D. Beinhocker, J. Doyne Farmer

May 25, 2018 | Last updated: May 25, 2018

The world is approaching an historic tipping point. The cost of clean energy technologies such as solar, wind, and batteries are declining rapidly while their performance increases. These technologies have already become less expensive than new-build fossil fuel power generation in many regions and applications. In the coming 10-20 years it is highly likely that clean energy technologies will become less expensive than coal, oil, and gas electricity generation for almost all regions and all applications. When this tipping point is reached, clean, modern, cheap energy infrastructure will rapidly replace dirty fossil infrastructure. While this is good news,

Shell's Sky scenario (1.75°C) relies on NETs (including land-use change) to remove CO_2



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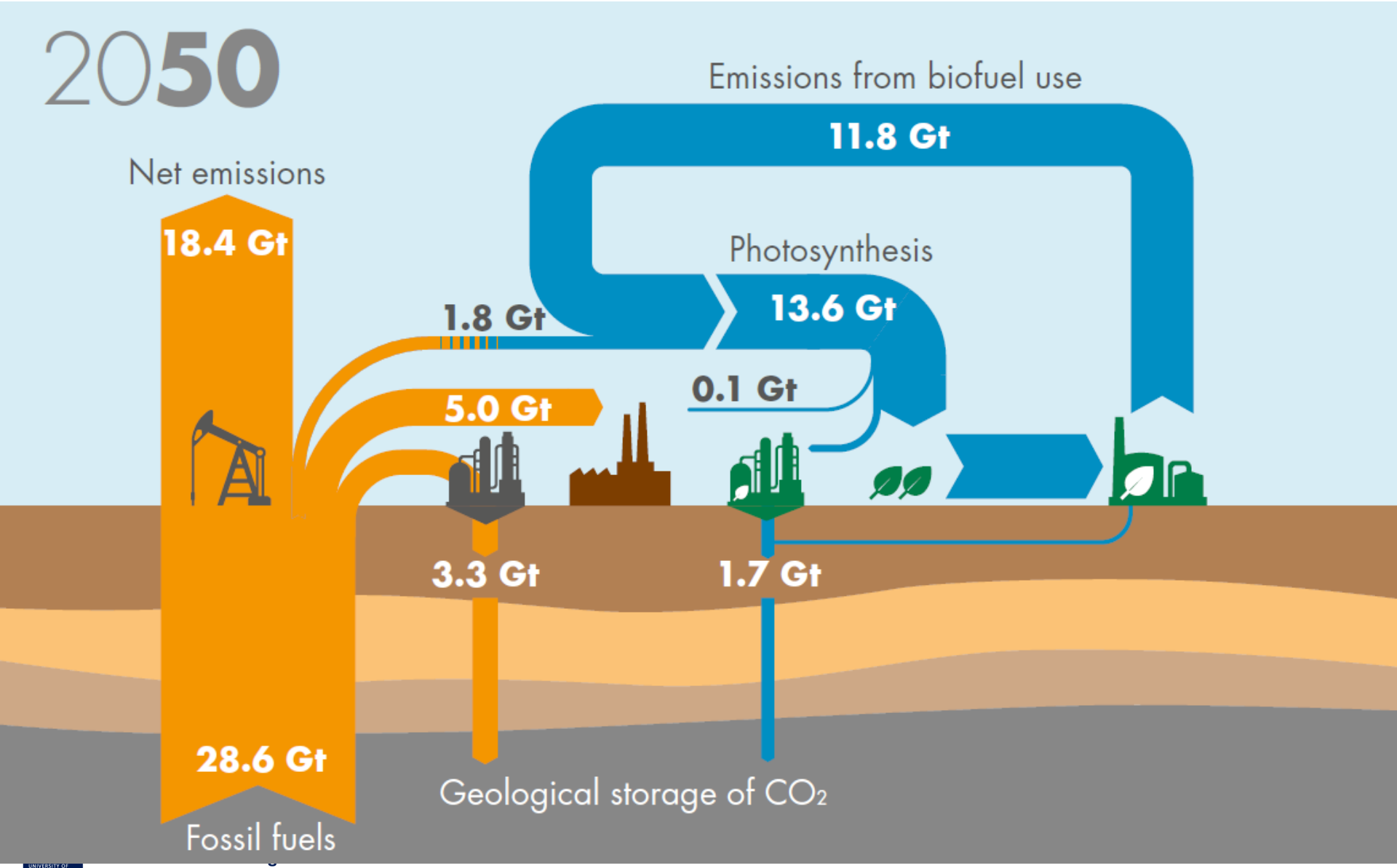

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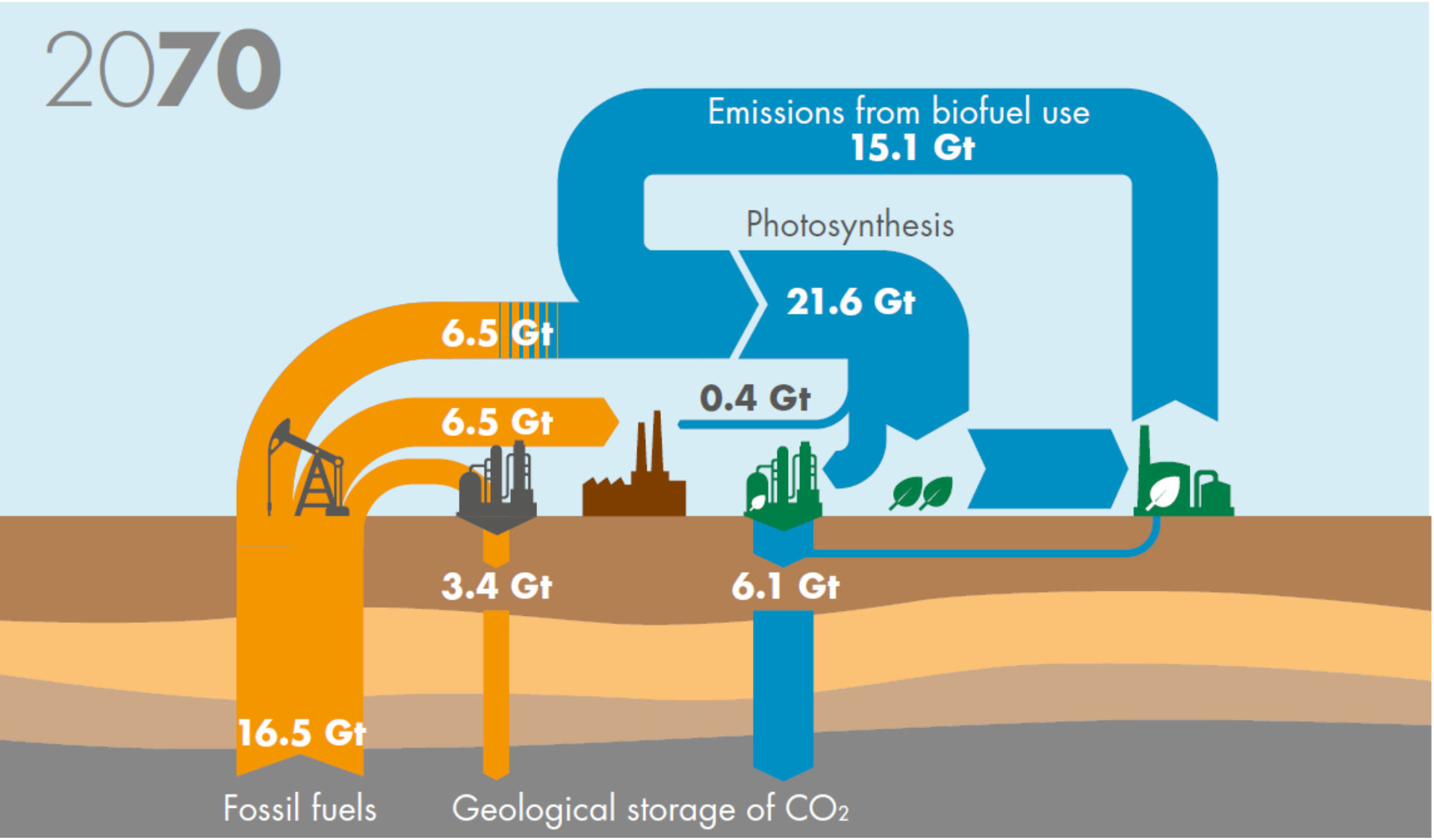

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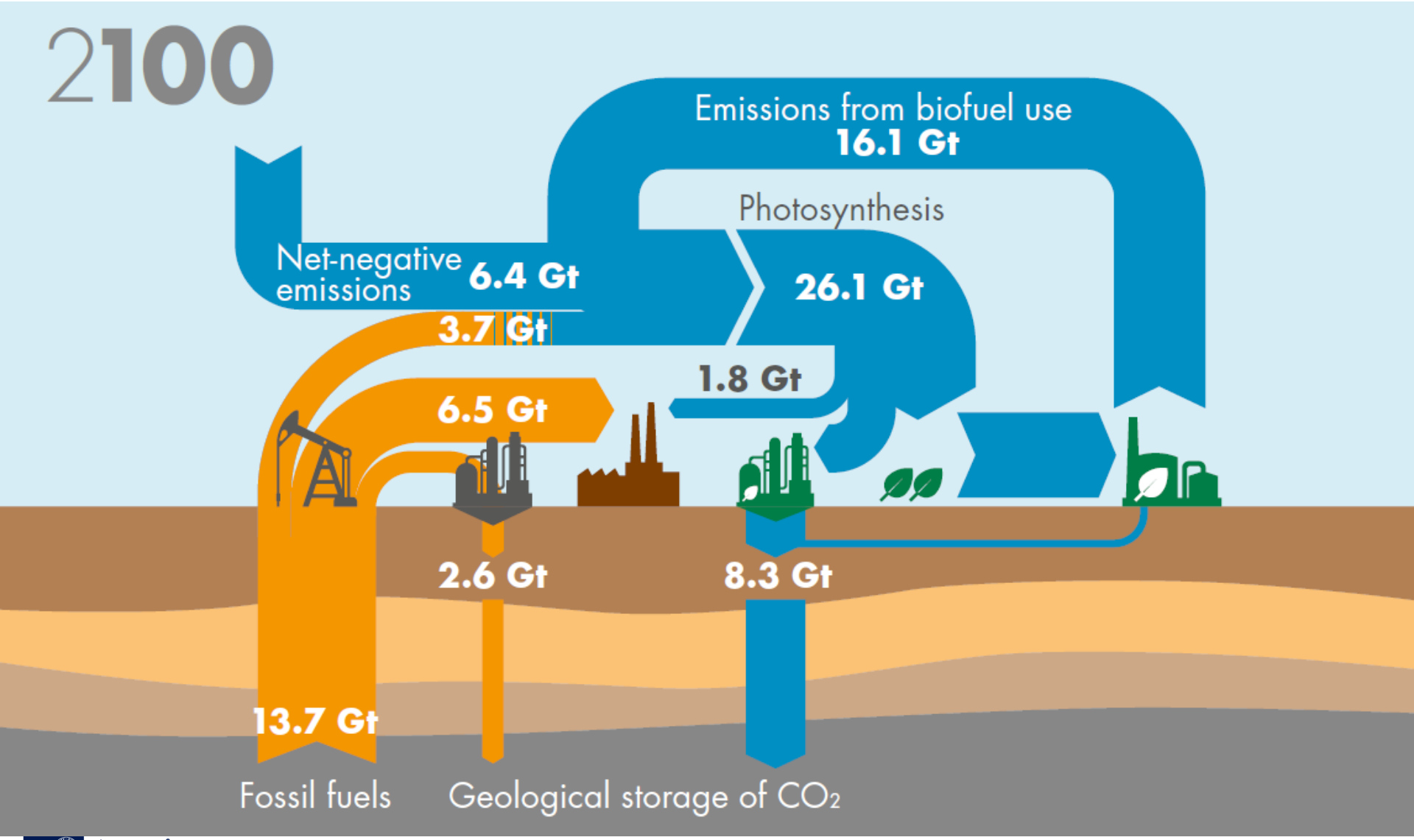
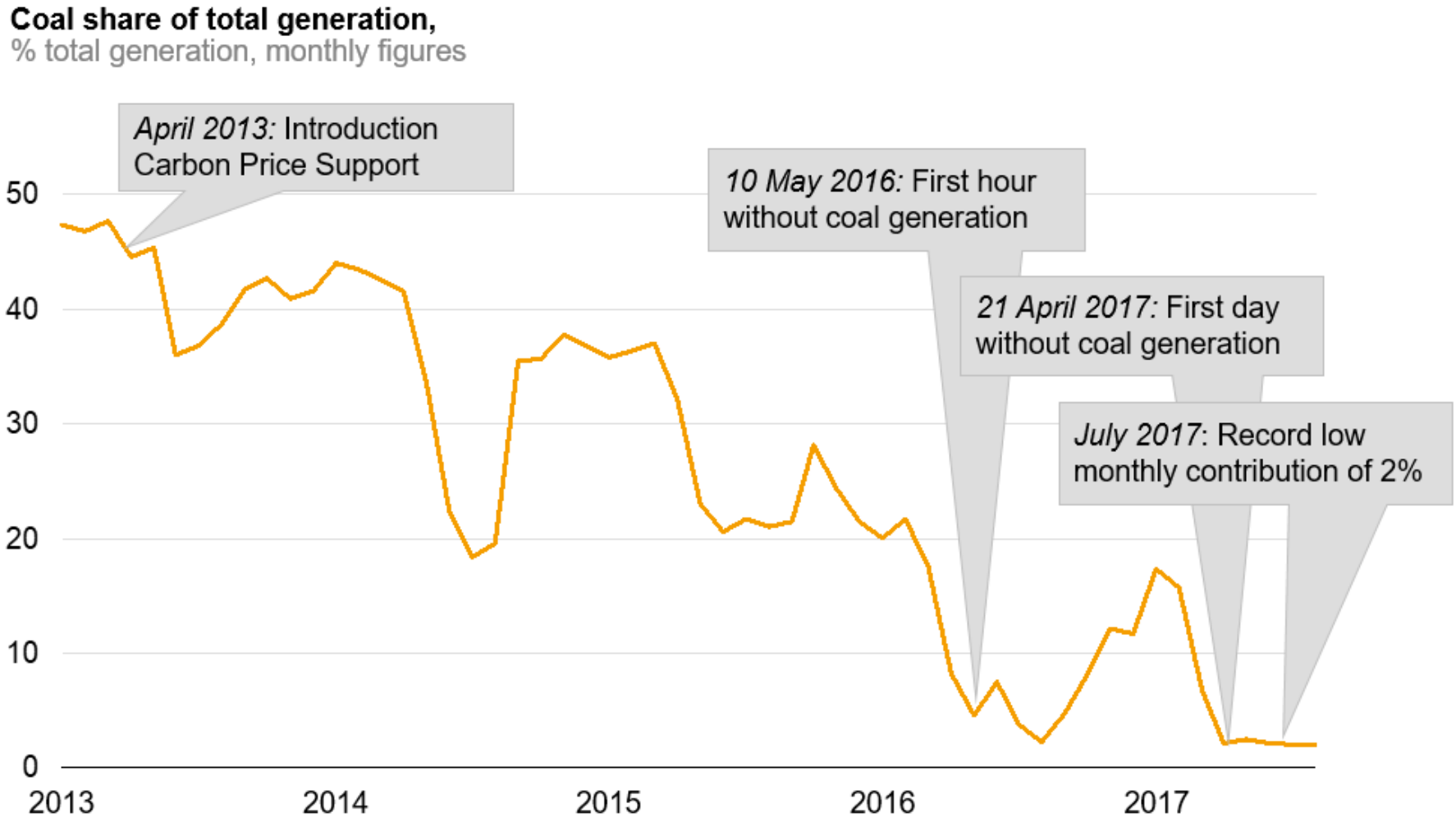


Coal in the UK has gone from nearly 50% of the power mix to under 5% of the mix in 5 years



Source: Aurora (2017)

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ECONOMIC MODELING PROGRAM AND CLIMATE ECONOMETRICS

Janine Aron, Jennifer Castle, Jurgen Doornik, David Hendry, Luke Jackson, Andrew Martinez, John Muellbauer and Felix Pretis

EMoD & Climate Econometrics teams and associates


Andrew
Forecasting


Angela
Administrator


Anna
Climate


Bent
Econometrics


David
Modelling


Felix
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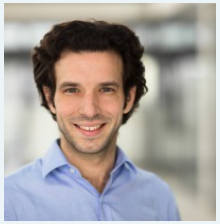
James
Econometrics


Janine
Development


Jennie
Forecasting


Jimmy
Econometrics


John
Macro


Jurgen
Computing

EMoD & Climate Econometrics teams and associates


Andrew
Forecasting


Angela
Administrator


Anna
Climate


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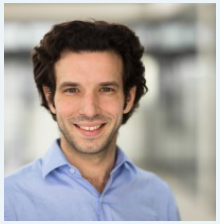
Econometrics


David
Modelling


Felix
Climate


James
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Jimmy
Econometrics


John
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Jurgen
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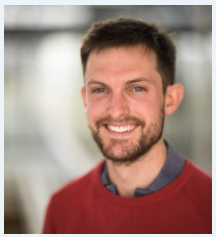

Luke
Climate


Mike
Forecasting


Moritz
Environment


Sophia
Forestry


Sophocles
Macro


Vanessa
Econometrics

Research activities

Climate change (CE)

Dynamic shifting macro systems

Modelling multiple shifts

Forecasting facing breaks

Model discovery

Flash data on economy

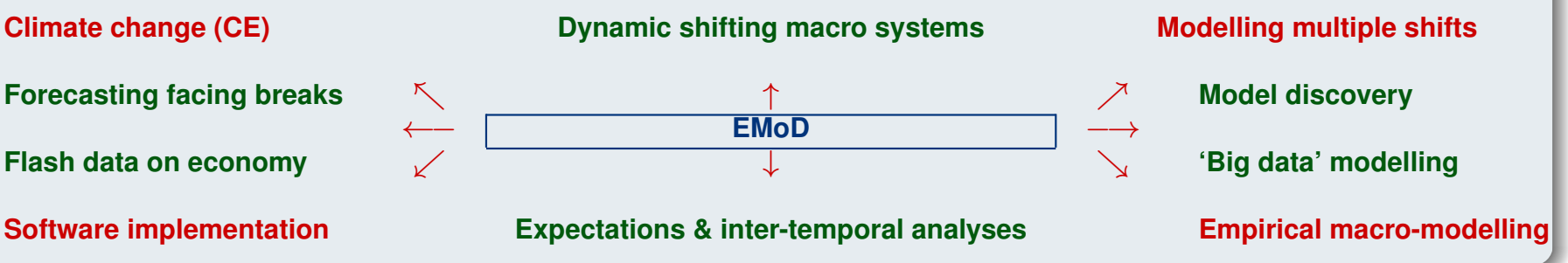
'Big data' modelling

Software implementation

Expectations & inter-temporal analyses

Empirical macro-modelling

Research activities



73 academic outputs since June 2016:
40 articles published, 7 more and a book forthcoming,
20 working papers with 3 R&R and 3 books near completion.

5 VoxEU articles, with more than 100,000 reads already,

plus several videos and opinion pieces.

New software released (OxMetrics and R).

Talks will address five of our key research areas:

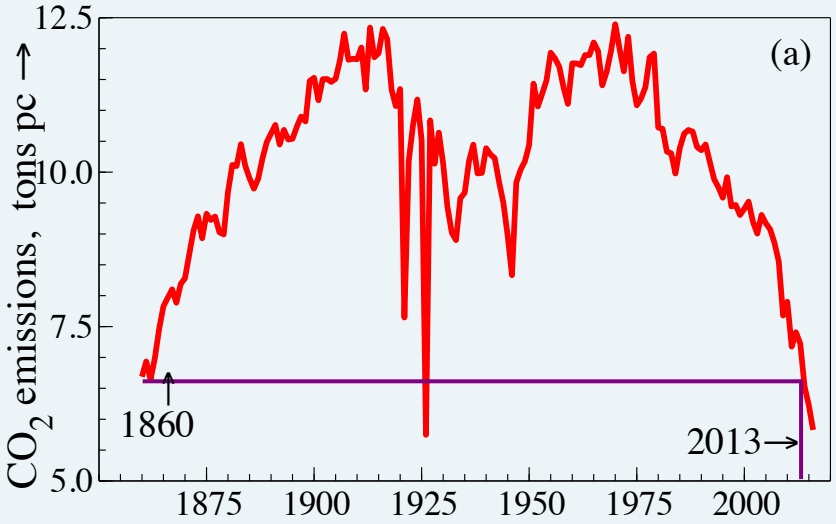
1. David: Modelling UK's CO_2 emissions.
2. David for Andrew: Uncertainty impacts from hurricanes.

Talks will address five of our key research areas:

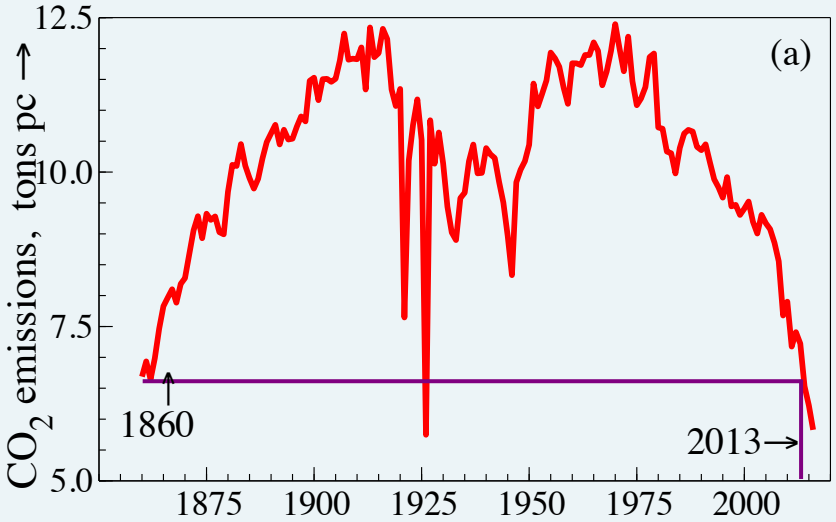
1. David: Modelling UK's CO_2 emissions.
2. David for Andrew: Uncertainty impacts from hurricanes.
3. Jurgen: New software for doubly cointegrated systems.
4. Felix: Impacts of 1.5^{o}C v 2^{o}C.
5. Luke: Future sea-level rises.

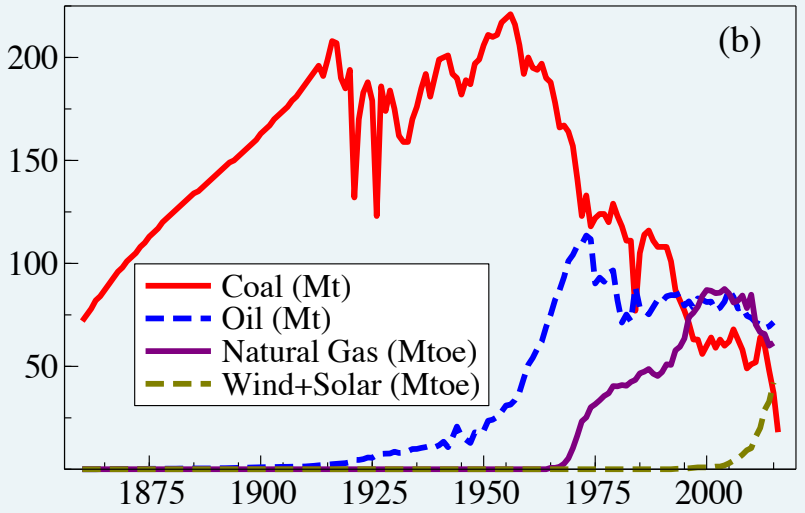
Today's Shock: Luke as Earthy!

UK CO2 emissions and fuel use

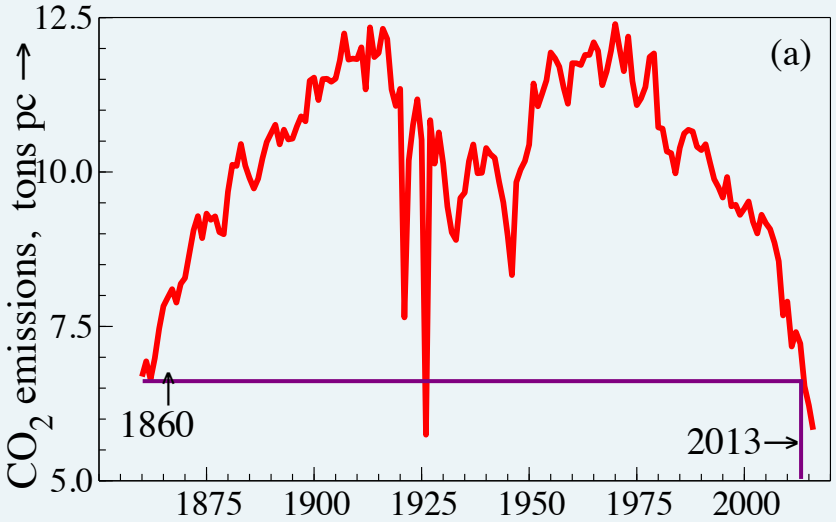


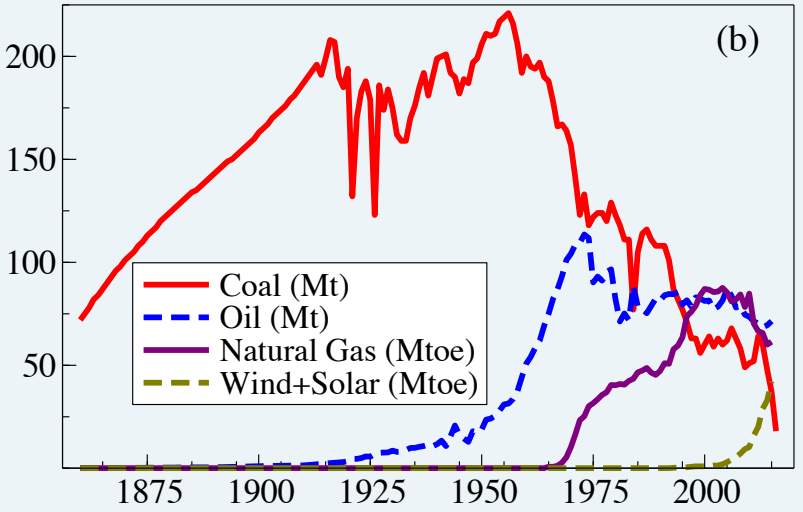
UK CO2 emissions and fuel use

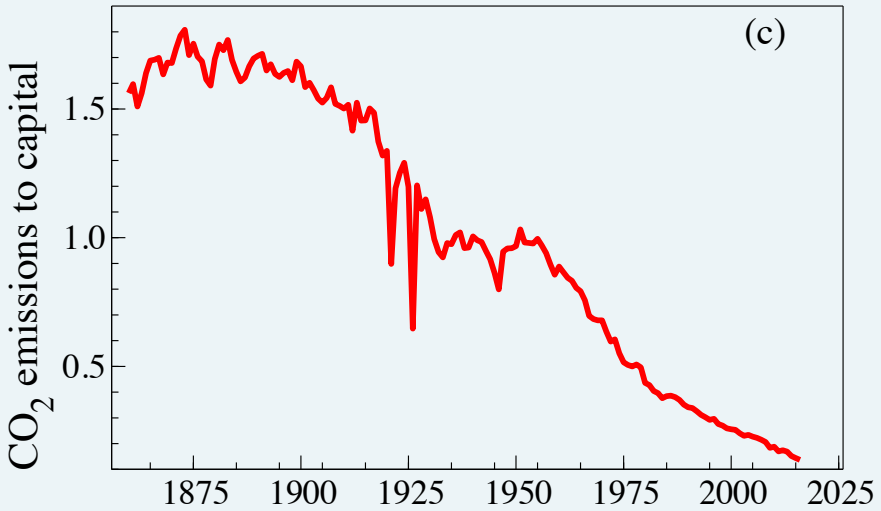




UK CO2 emissions and fuel use







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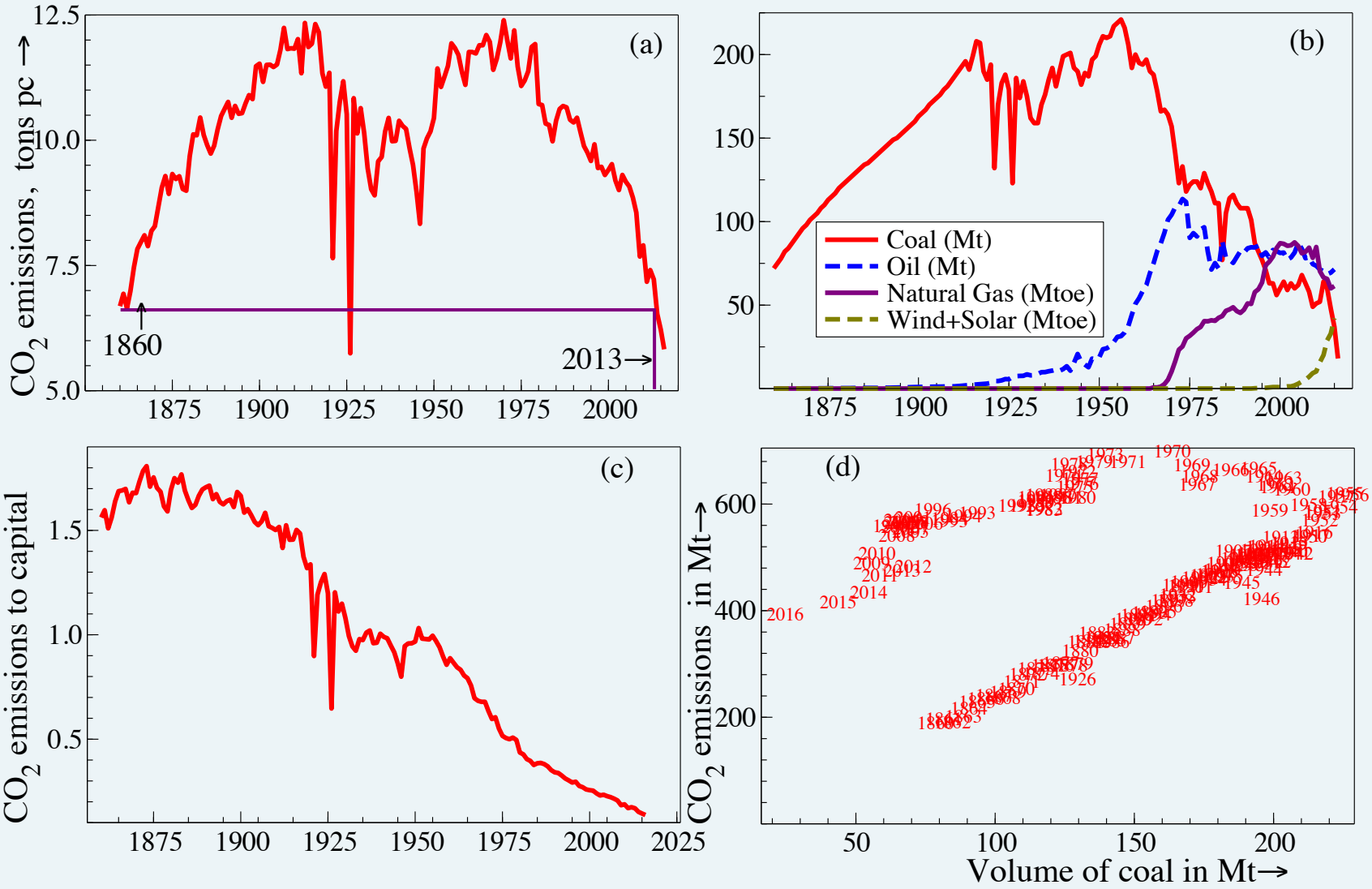
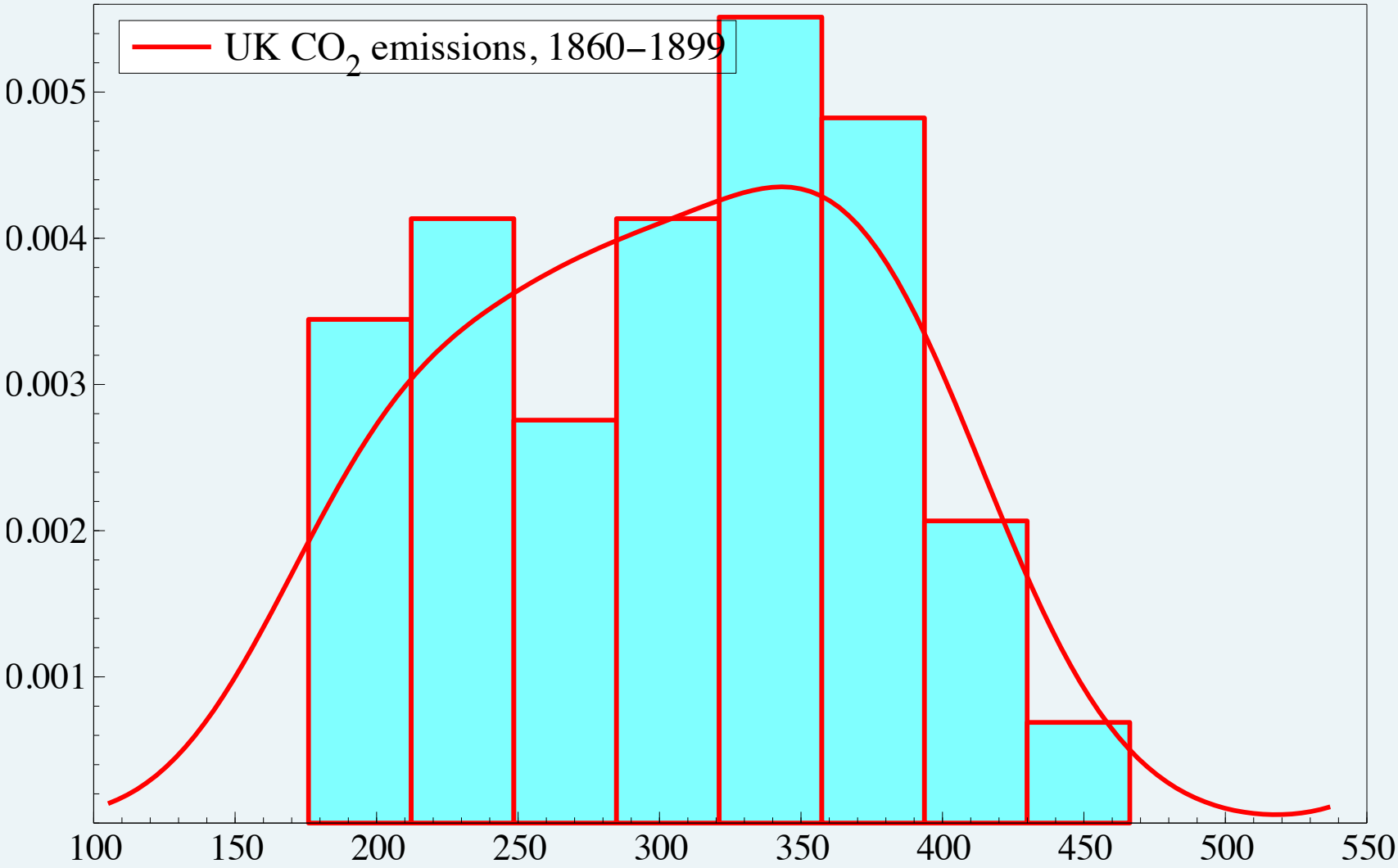


Distributional shifts of total UK CO2 emissions in Mt p.a.



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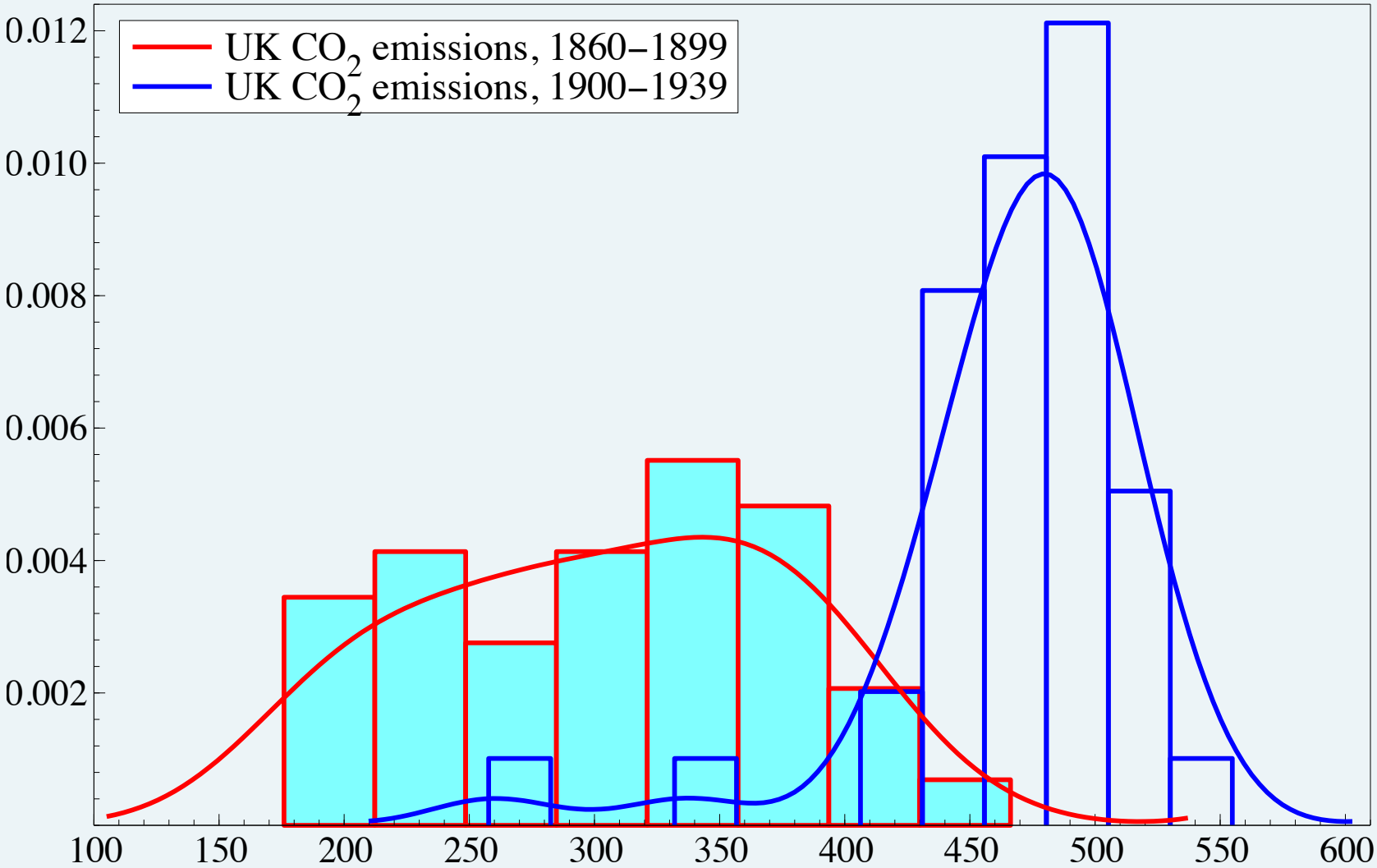

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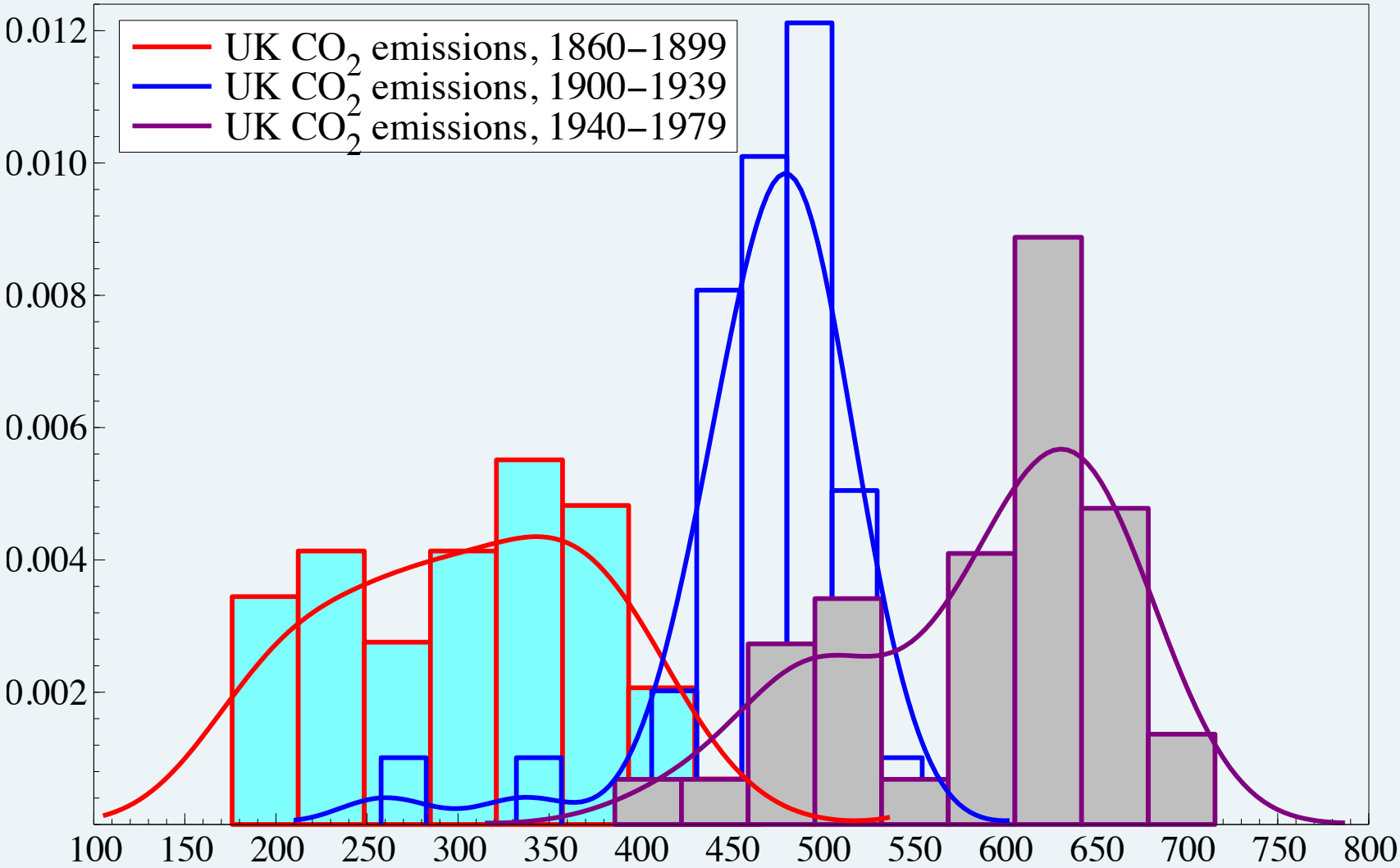

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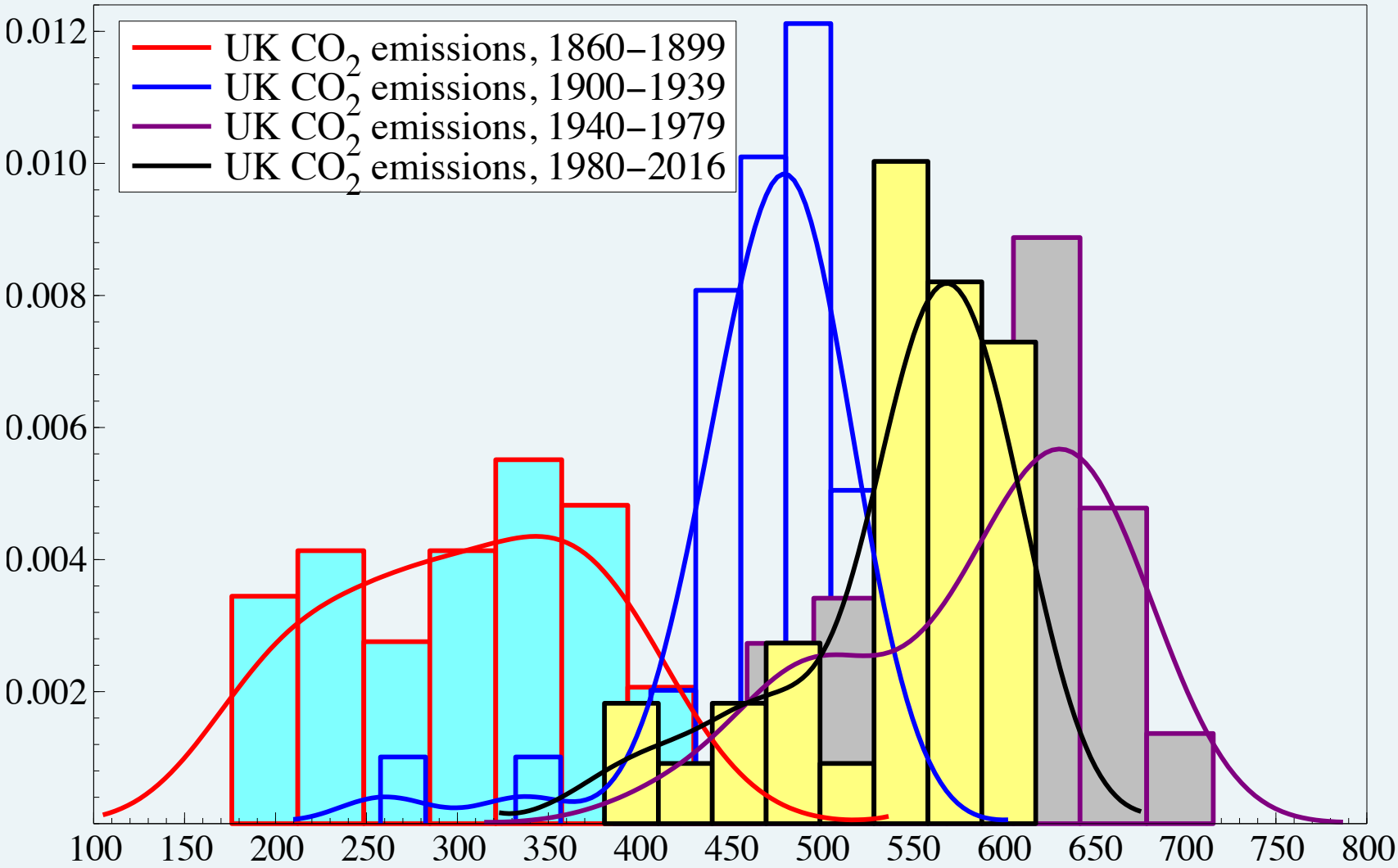

To capture changing relations, the model includes:

(a) the 2 main CO_2 emitters, **coal** and **oil**, plus **capital stock** & **GNP**;
(b) dynamics for adjustments to changes in technology, legislation and relative fuel prices;
(c) impulse indicators for outliers (e.g., from strike action);
(d) step indicators for major permanent shifts (often policy induced).

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All **4** variables matter plus **3** large step shifts, **identifiable with**:

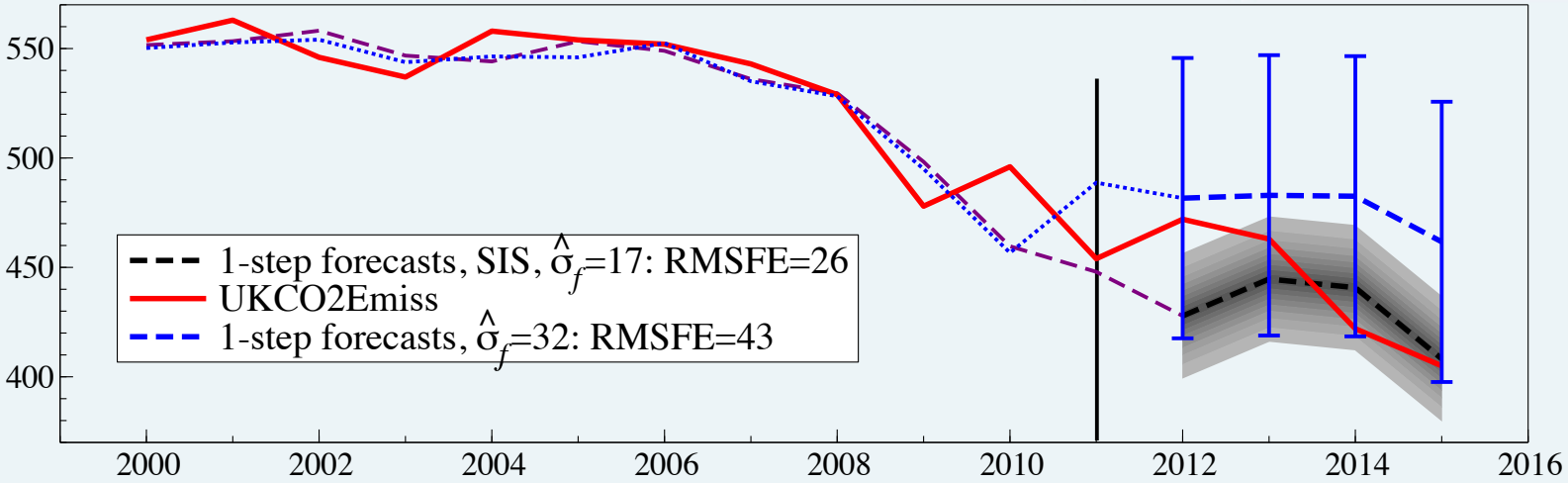
1925 Act of Parliament creating UK's nationwide electricity grid.

1969 start of **conversion** from coal gas to natural gas.

2010 follows UK's **Climate Change Act** of 2008 and EU's **renewables directive** of 2009.

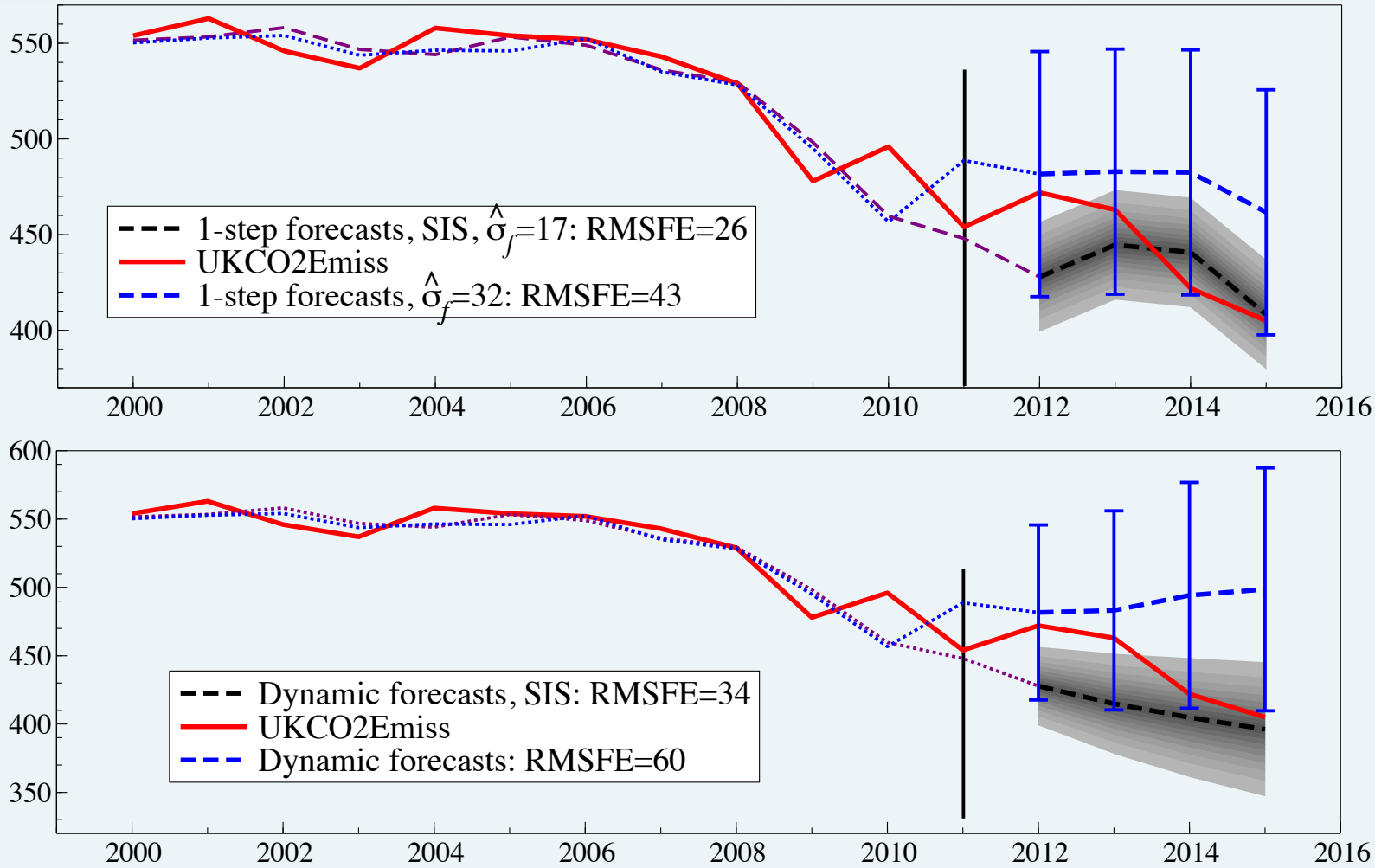
We did not impose that policies had an effect–data show they did.

Unconditional system 1-step and dynamic forecasts



(a) Outcomes fitted values, and 1-step forecasts without and with indicators, with $\pm 2\widehat{\sigma}_f$ respectively shown as bars and fans, plus RMSFEs.

Unconditional system 1-step and dynamic forecasts

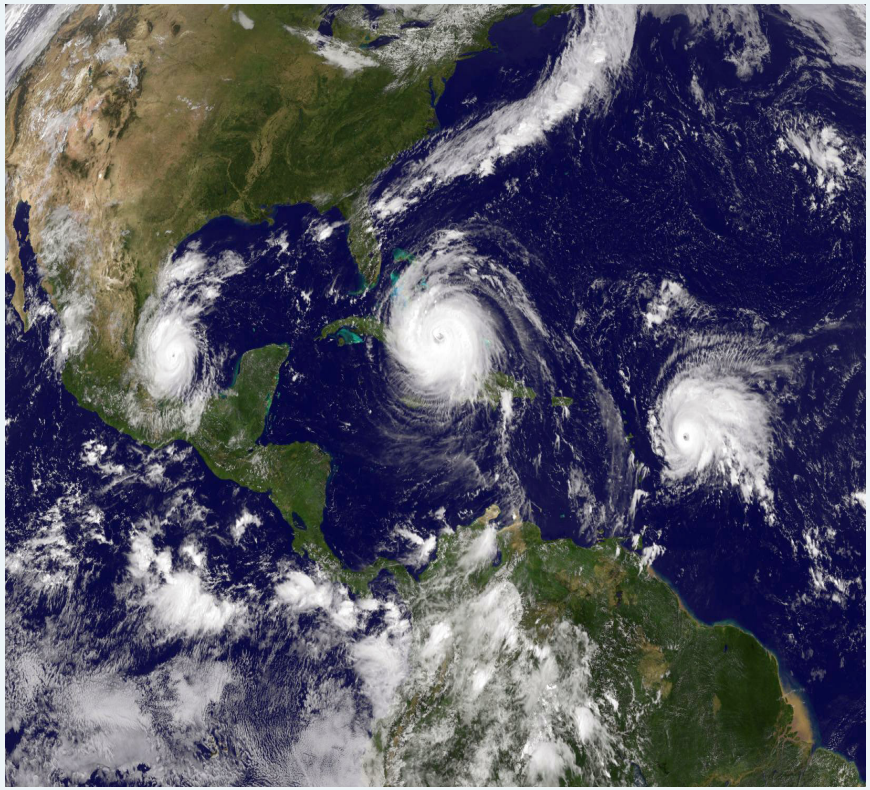


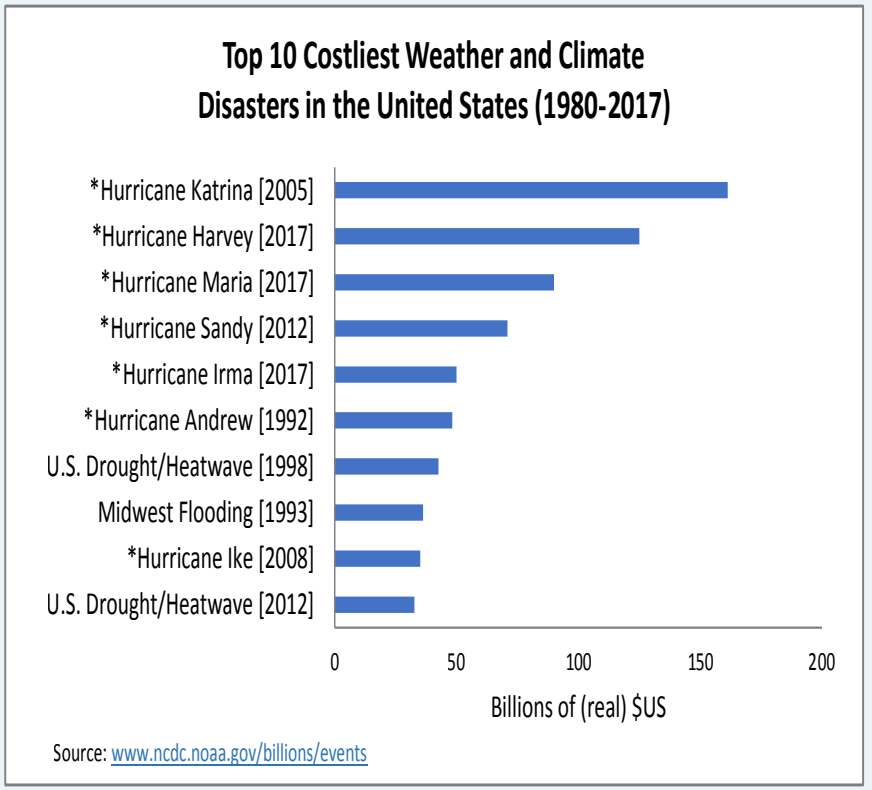
(a) Outcomes fitted values, and 1-step forecasts without and with indicators, with $\pm 2\widehat{\sigma}_f$ respectively shown as bars and fans, plus RMSFEs;

(b) Outcomes fitted values, and multi-step forecasts without and with indicators, with $\pm 2\widehat{\sigma}_f$ respectively shown as bars and fans, plus RMSFEs.

Hurricanes: frequently occurring, destructive natural events

4 of top 5 costliest US disasters from this decade's hurricanes.





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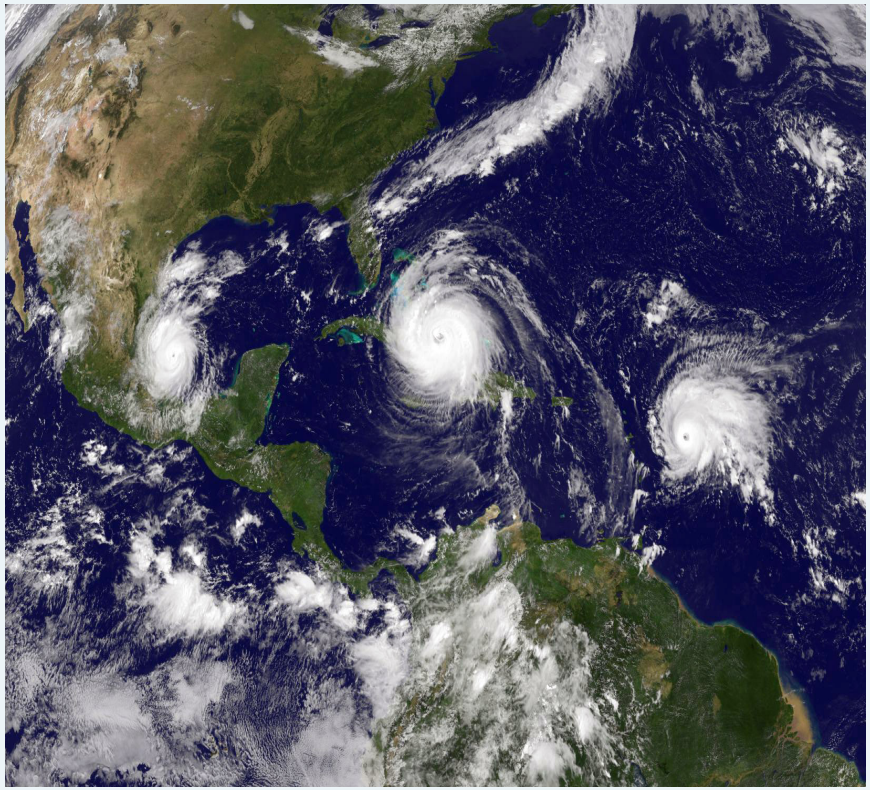
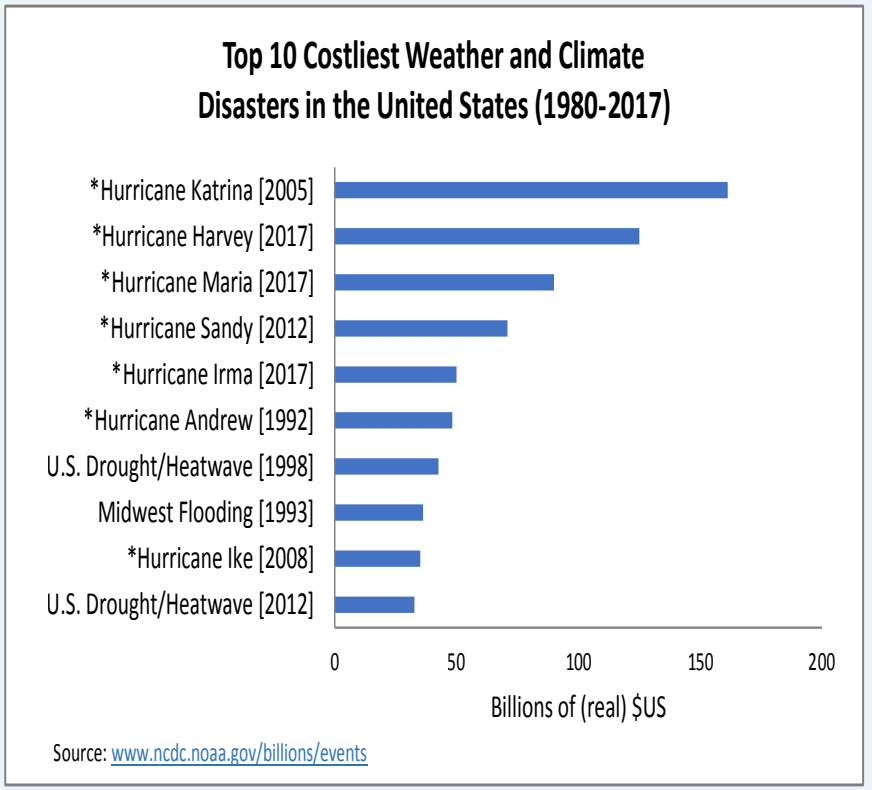




- Climate change can alter location, frequency, and intensity of such storms
- **Does forecast uncertainty impact hurricane damages?**

Research by Andrew Martinez

Embed forecast uncertainty in a general model of hurricane damages and use *Autometrics* automatic model selection:

Income

Population

Housing Units

Historical Frequency

Wind Speed/Pressure

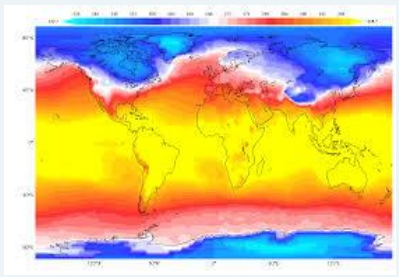
Max Storm Surge

Max Rainfall

Seasonal Cyclone Energy

Soil Moisture

Air Temperature



Forecast Uncertainty

Other

35 Additional Variables

Embed forecast uncertainty in a general model of hurricane damages and use *Autometrics* automatic model selection:

Income

Population

Housing Units

Historical Frequency

Min Pressure

Max Storm Surge

Max Rainfall

Seasonal Cyclone Energy

Soil Moisture

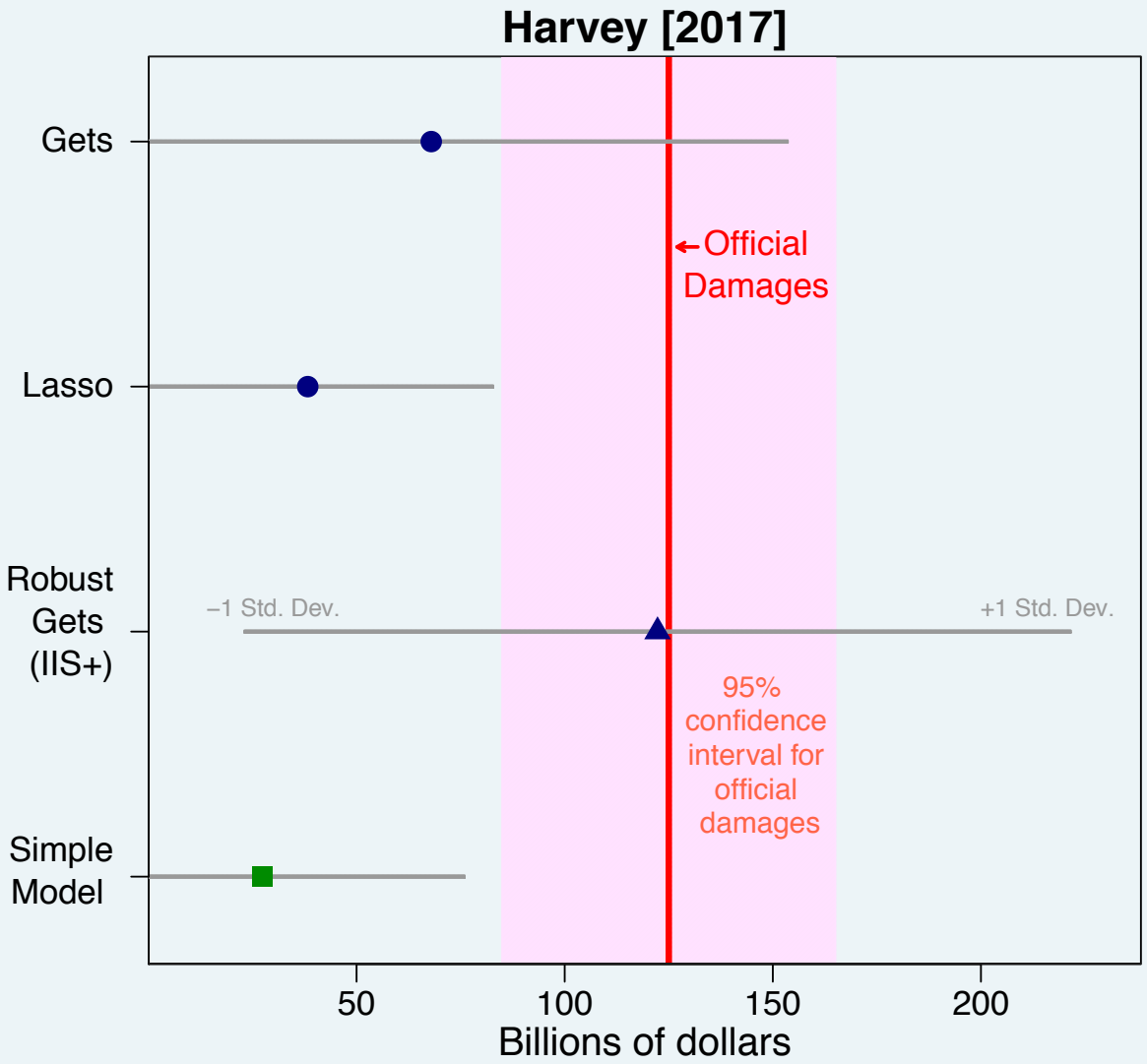
Air Temperature

Forecast Uncertainty

Other

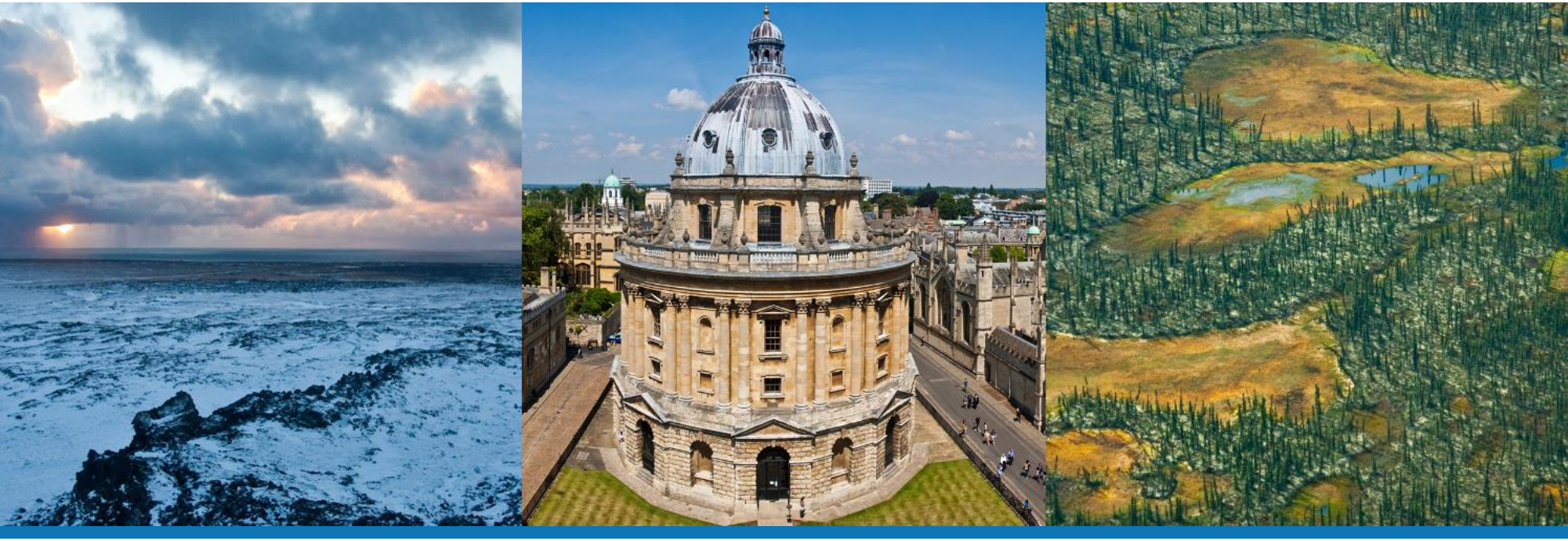
35 Additional Variables

Out of sample 'prediction' of damages by Harvey



Green box shows calculation from simple damage model; pink shading the likely range of damages; **blue triangle** from Andrew's model estimated 2 years earlier.

Climate Econometrics



COMPUTERS AND COMPUTATION: TOOLS FOR EMPIRICAL MODELLING

Jurgen A. Doornik
INET at Oxford.

Econometrics not operational without computational tools.

Tools must be

- Fast,
- Reliable,
- Robust.

Implementation requires

- Improving existing methods,
- Developing new methods,
- Algorithmic knowledge,
- Computer language(s).

New ideas need implementation to allow evaluation

computing $\Leftrightarrow$ theory

Automatic model selection

Essential to handle information overload and complexity.

New type of saturation estimators to handle outliers and breaks.

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Cointegration analysis

To models well-behaved relationships between stochastically trending variables (many small shocks).

Sophisticated mathematics to handle reduced rank restrictions: new 'triangular' representation.

Automatic model selection

Essential to handle information overload and complexity.

New type of saturation estimators to handle outliers and breaks.

Cointegration analysis

To models well-behaved relationships between stochastically trending variables (many small shocks).

Sophisticated mathematics to handle reduced rank restrictions: new 'triangular' representation.

Forecasting

is different from modelling: models occasionally unstable out-of-sample, large shocks happen.

Made submission to a forecast competition.

Detecting breaks in GPS data: real data, (unknown) breaks added.

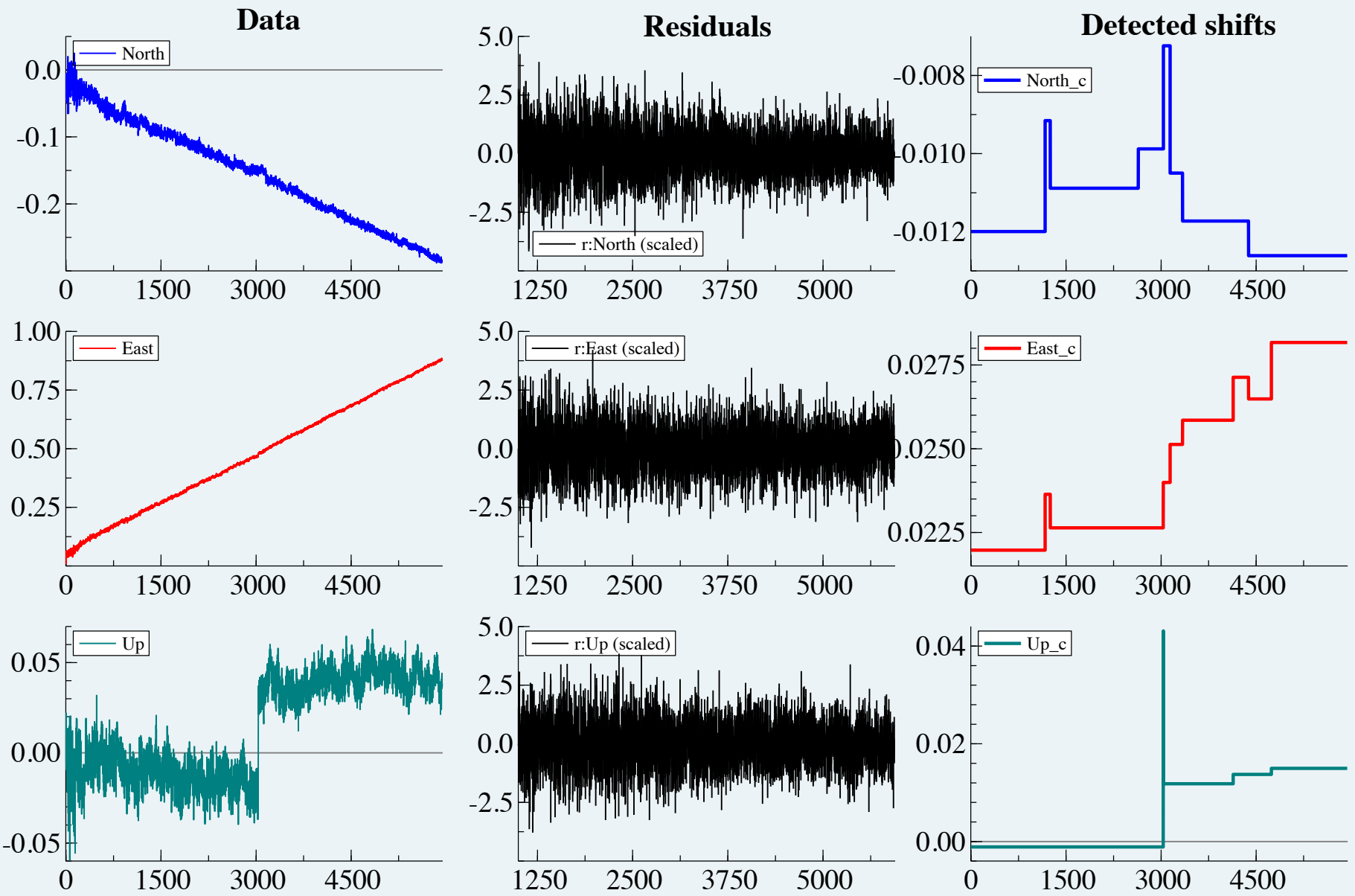
- Three directions: North, East, Up
- Basic model is a VAR(4) with intercept and trend:

$$y_t = A_1 y_{t-1} + ... + A_4 y_{t-4} + \mu_0 + \mu_1 t + \text{SIS} + \epsilon_t, \quad \epsilon_t \sim \text{IIN}(0, \Omega),$$

$$y_t = \{ \text{North}, \text{East}, \text{Up} \}.$$

- 9 moving overlapping windows: 1000 — 2000, 1500 — 2500, ..., 5000 – 5937
  VAR(4) decent approximation for shorter samples
- Multivariate SIS with Autometrics at $\alpha = 0.01\%$, fixing rest of model: 9 multivariate SIS runs.
- Collect all the change points, and run multivariate selection at 1%, allowing sparsity in each equation (and allowing only own lags). Estimation by full information maximum likelihood.

Data, residuals and change points



Many potential economic applications

- Accelerated algorithm: also applies to expectation-maximization (EM) algorithm
- New represention of doubly integrated I(2) model

Speed improvements:

- Bartlett correction: ≈ 100 times faster
- Recursive estimation: ≈ 100 times
- Restrictions on cointegrated vectors: ≈ 20 times
- I(2) estimation: $\approx 20 - 50$ times
- Ox advantage: ≈ 3 times
- Parallel bootstrap/recursive estimation: $\approx 4 - 20$ times

M4 forecast competition

Framework:

- 100 000 times series to forecast;
- Annual, quarterly, monthly weekly, daily, hourly data;
- Follows from M3 about twenty years ago (3003 series);
- Objective: smallest average forecast error (two measures).

Challenges

- Many series: cannot look at all;
- Limited information: forecast in isolation;
- Average performance: important to avoid big mistakes;
- Standard time-series models not robust: need adjusted procedures.

M4 forecast competition

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Challenges

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- Average performance: important to avoid big mistakes;
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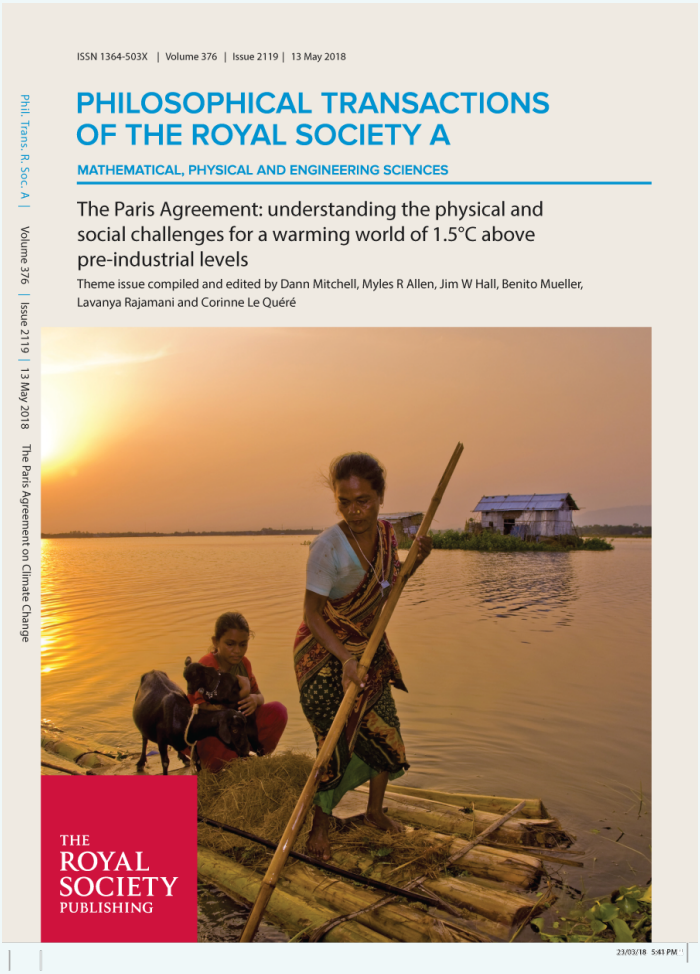
Managed to get 8.5% improvement over M3 winner Theta

This is withholding data - final result not yet known.

Could improve more if we understand what works when.

Economic Impacts of Stabilising Temperatures at 1.5C & 2C

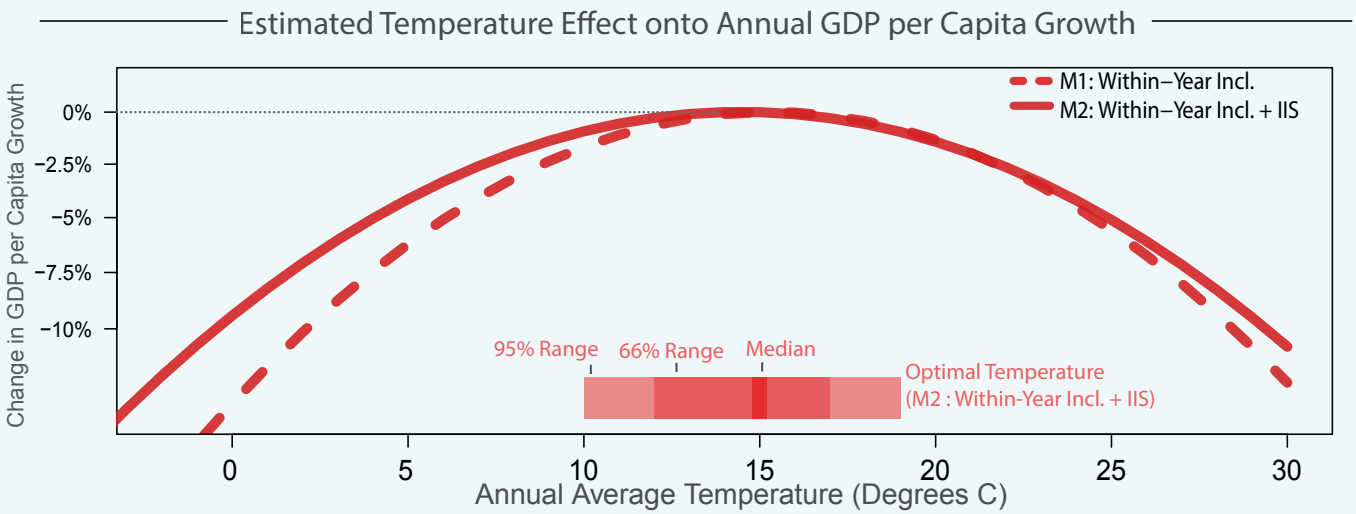


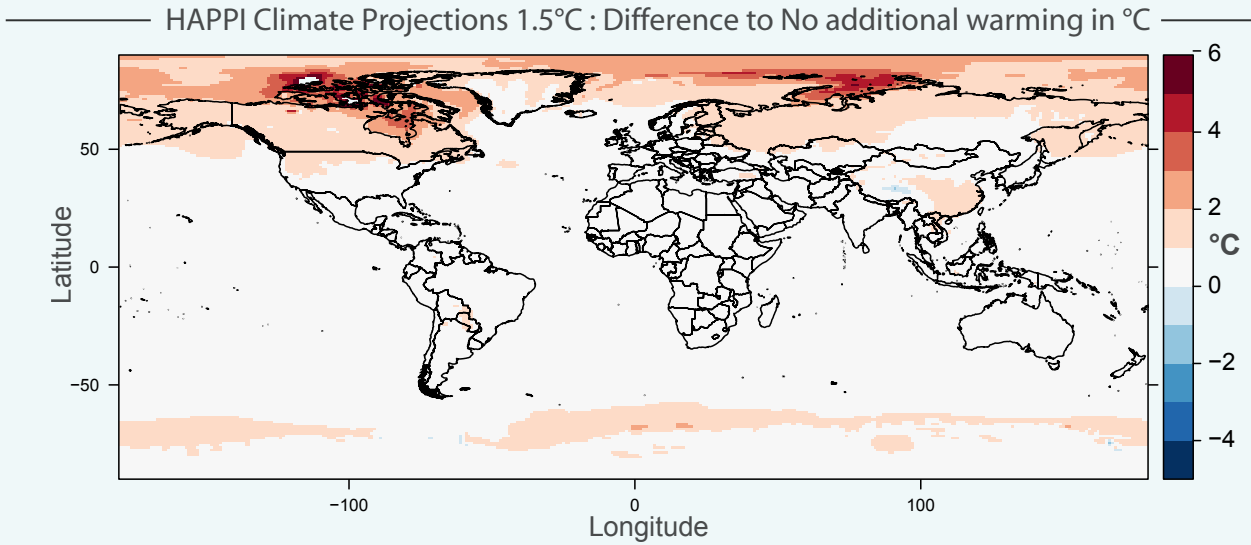
Phil. Trans. R. Soc. A on Paris Agreement:

'Uncertain impacts on economic growth when stabilizing global temperatures at 1.5C or 2C warming'

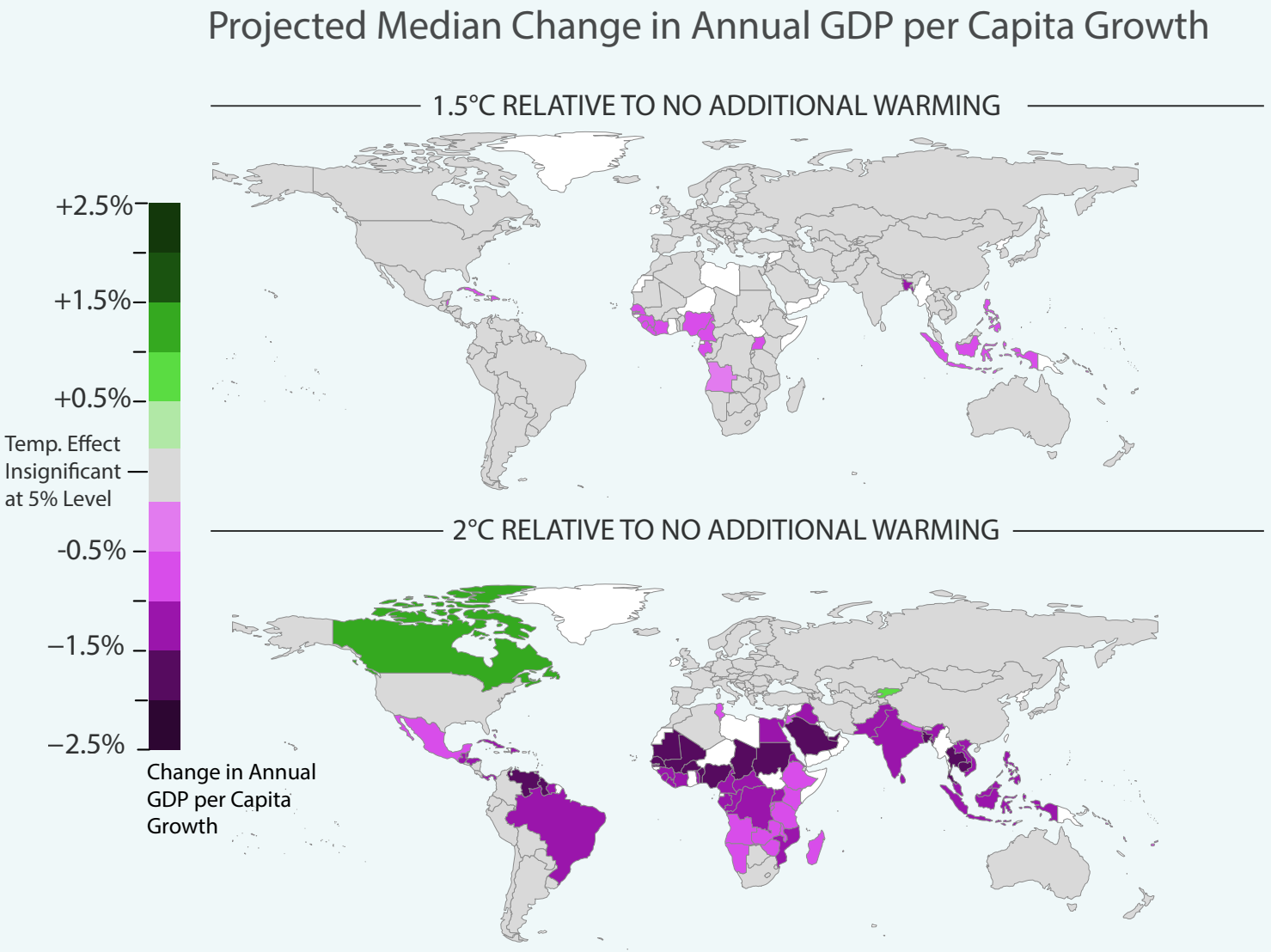
Felix Pretis, Moritz Schwarz, Kevin Tang, Karsten Haustein, & Myles Allen (2018)

Modelling and Projecting Economic Impacts of 1.5C & 2C



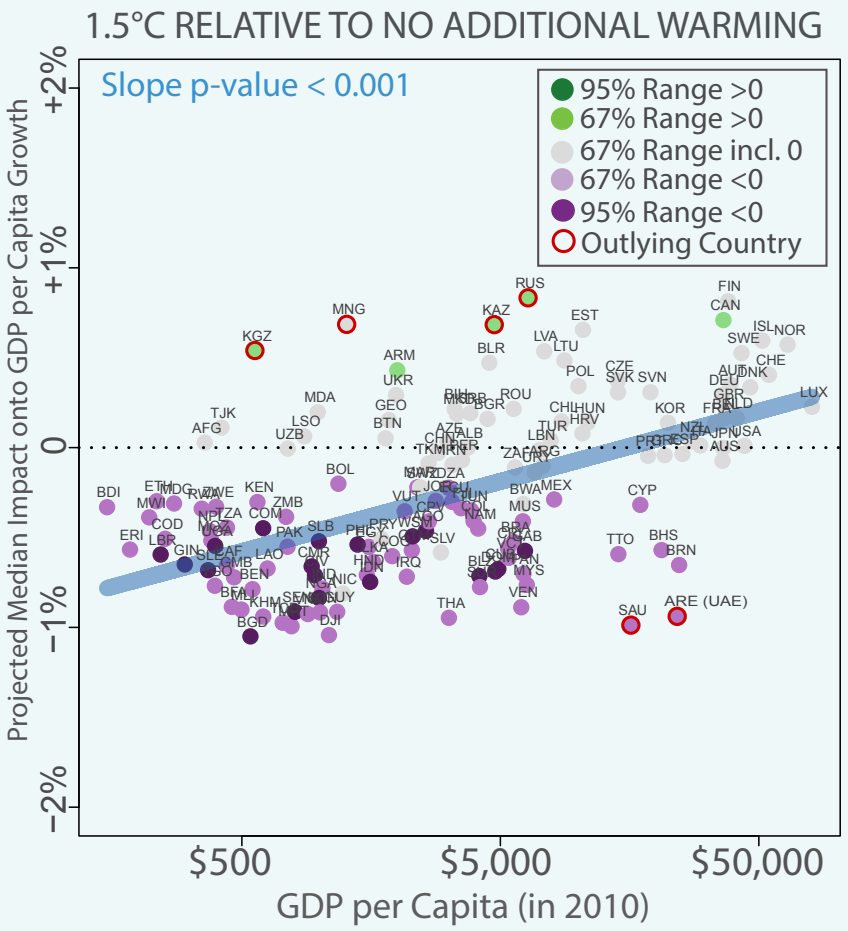


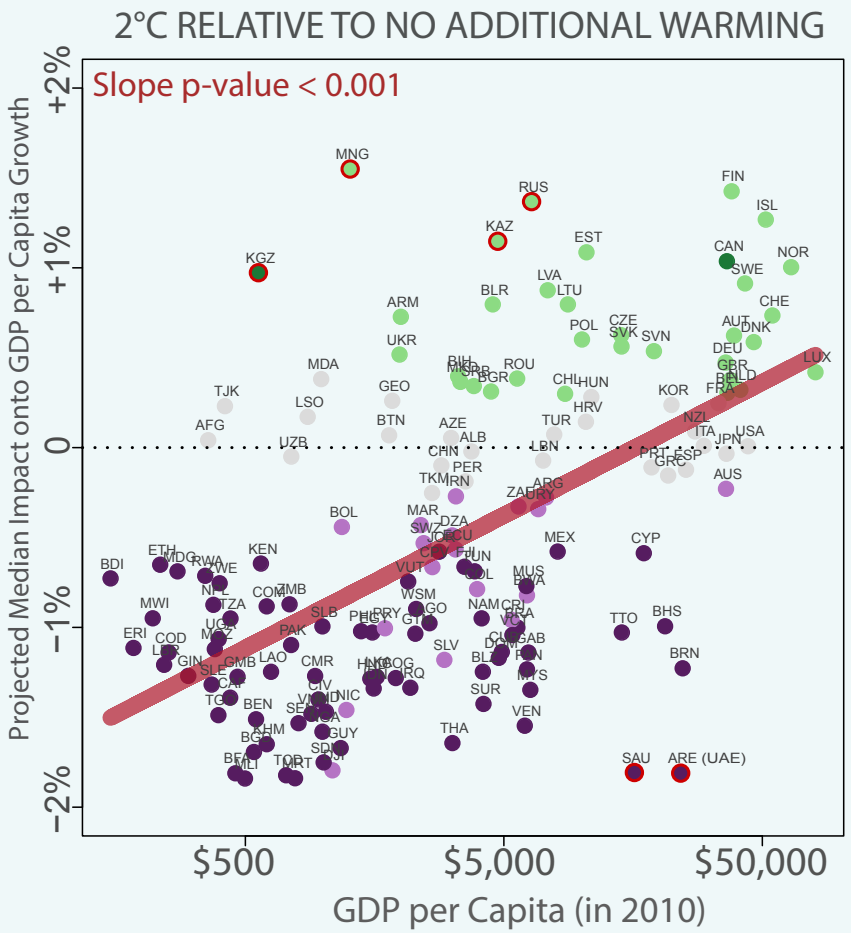
Projected Economic Impacts of 1.5C & 2C



Projected Increase in Inequality Across Countries

Median Projected Change in the Growth of GDP per Capita by GDP per Capita in 2010





Performance Dates (shows at 2pm and 3pm)
Saturday 30th June
Saturday 28th July
Thursday 2nd August*
Thursday 9th August
Thursday 16th August
Thursday 23rd August*

OXFORD UNIVERSITY MUSEUM OF NATURAL HISTORY

UK Association for Science and Discovery Centres

NATURAL HISTORY MUSEUM

dynamic earth

eden project

NERC SCIENCE OF THE ENVIRONMENT

Is mitigation really worth it?

City-based damages from future sea-level rise

Luke Jackson

INET Summer Update, 11th June 2018

BASQUE CENTRE FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

Climate Econometrics

UNIVERSITY OF OXFORD

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

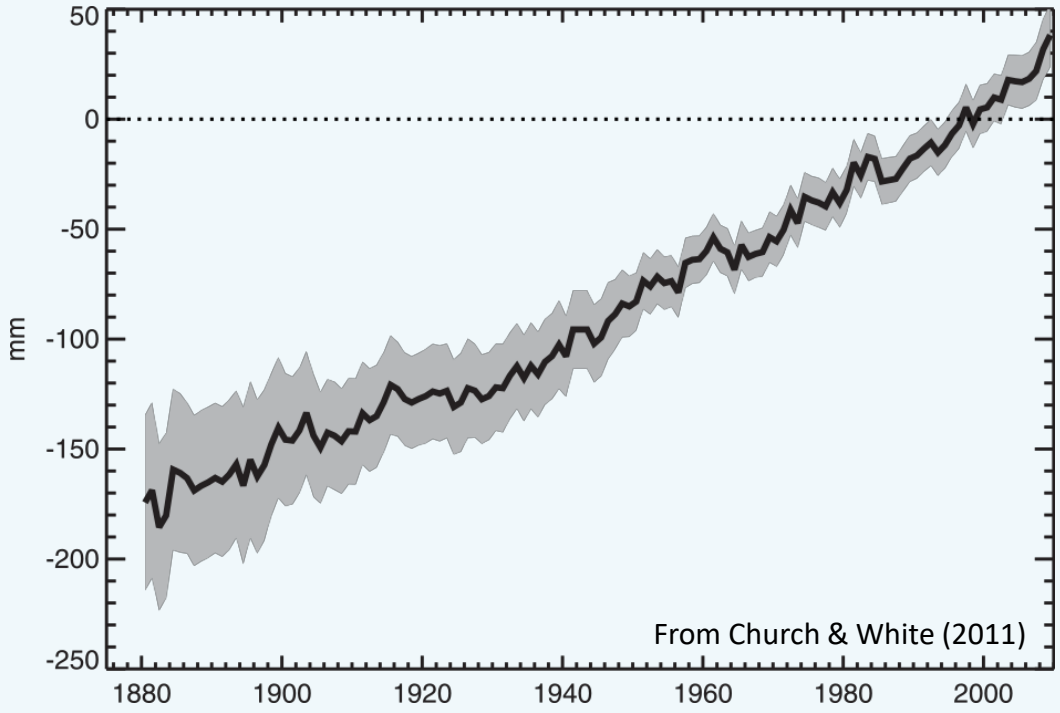
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Consensus: sea level is rising

In the historical past and present, human activity has caused warming leading to unprecedented global sea level rise

The rate of global sea level rise has increased dramatically over the past century, far exceeding the expected rates from the natural cycle

Period covered (years)	Rate of global sea-level (mm/yr)
6,000 BC – 1880 AD	0.3
1880 – 1992	1.8
1992 – 2017	3.4



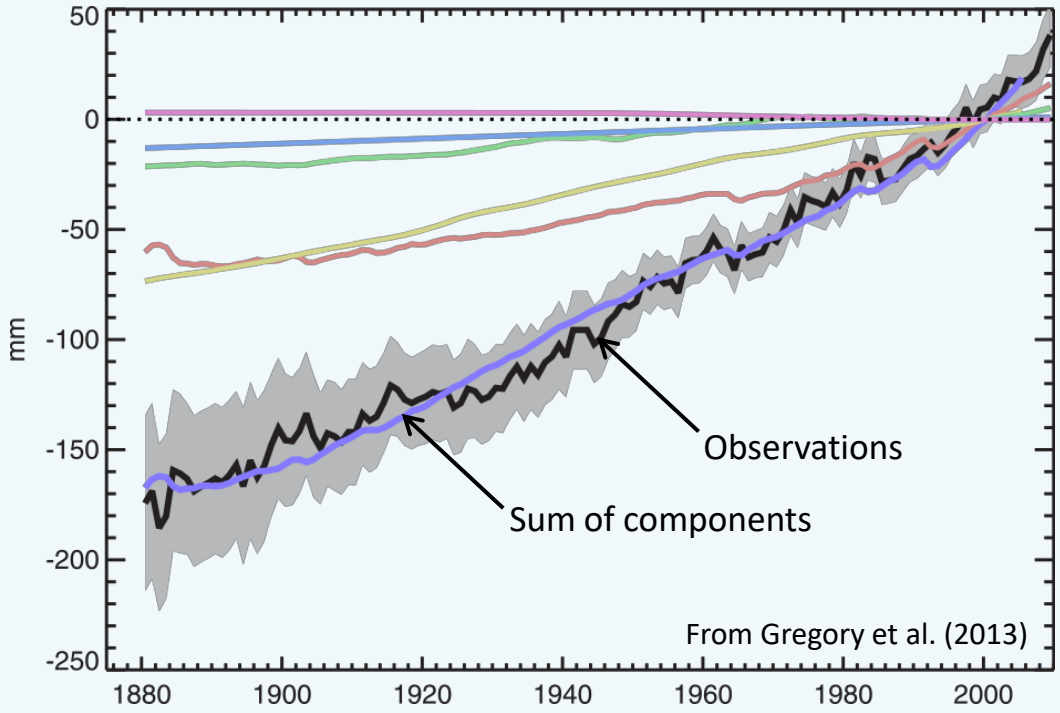
The impact of sea-level rise is already felt

Jakarta already experiences significant coastal flooding due to seasonal high-tides coupled with subsidence

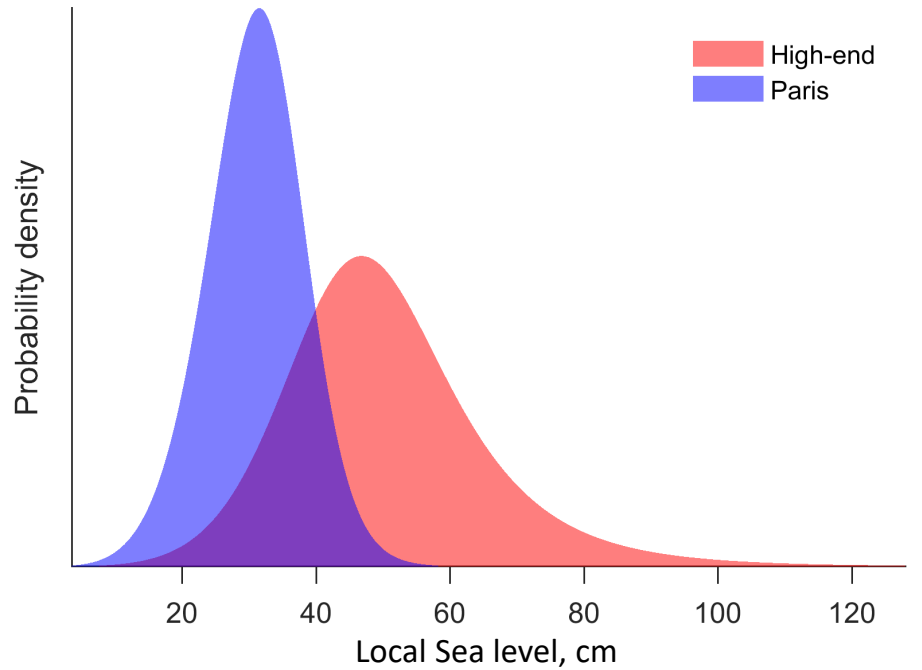
Sea level is the sum of many parts

The sea level you see anywhere in the world is the sum of a set components:

Global | Regional | Local

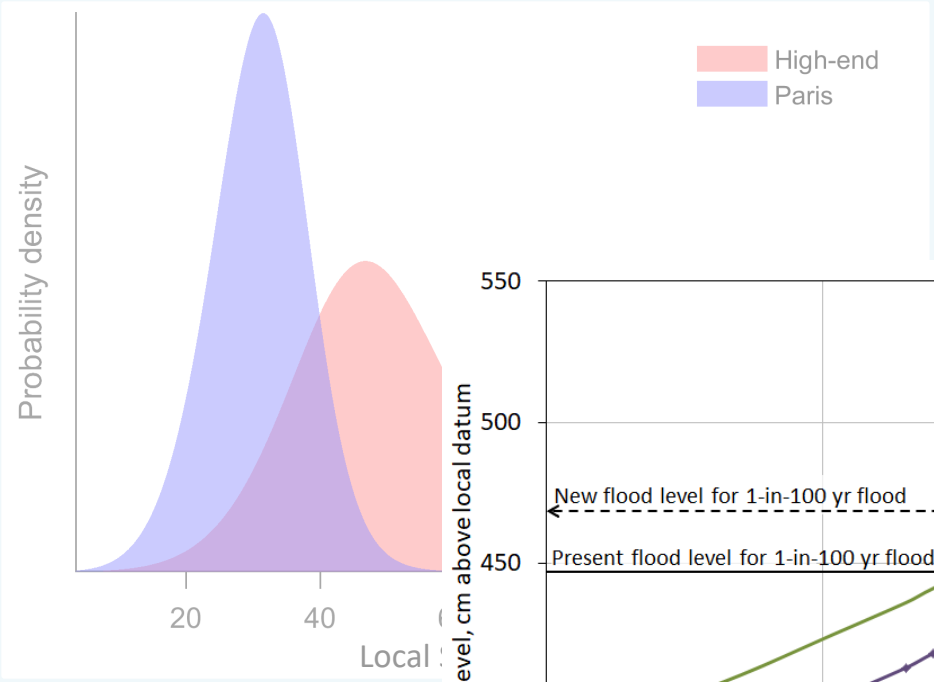


Getting from sea level to damages



Create regional sea-level projections (using probabilistic, process-based method) through time for different future climate scenarios

Getting from sea level to damages



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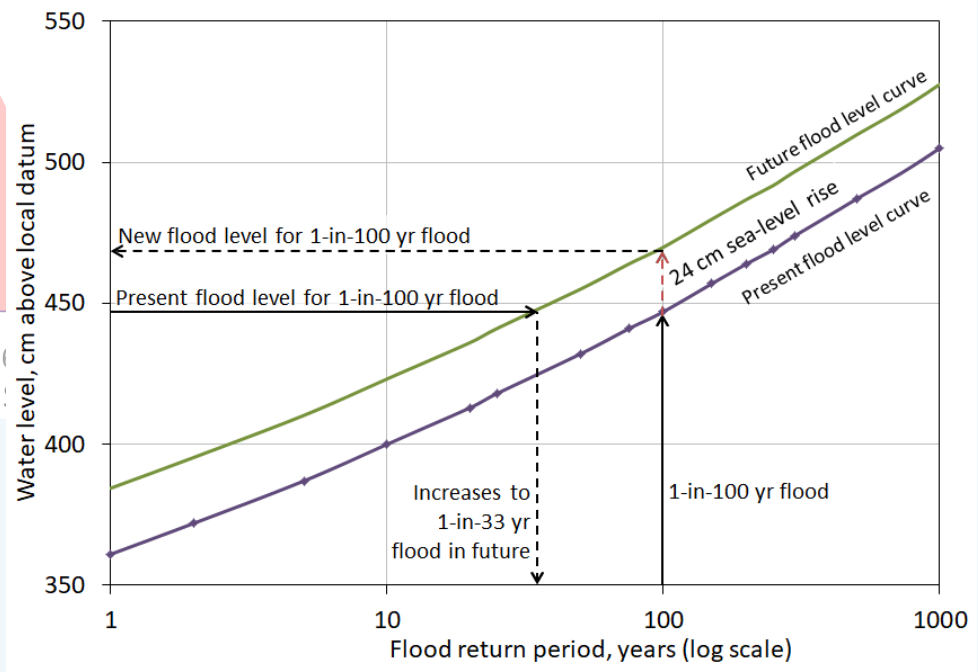
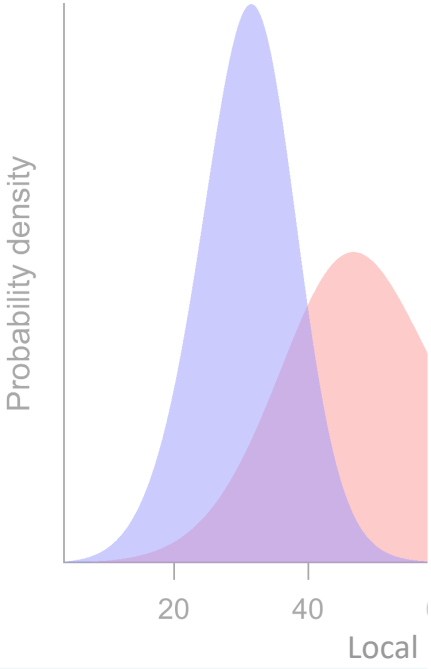


Calculate new flood level by adding local sea-level projection to present-flood return period curve

Getting from sea level to damages



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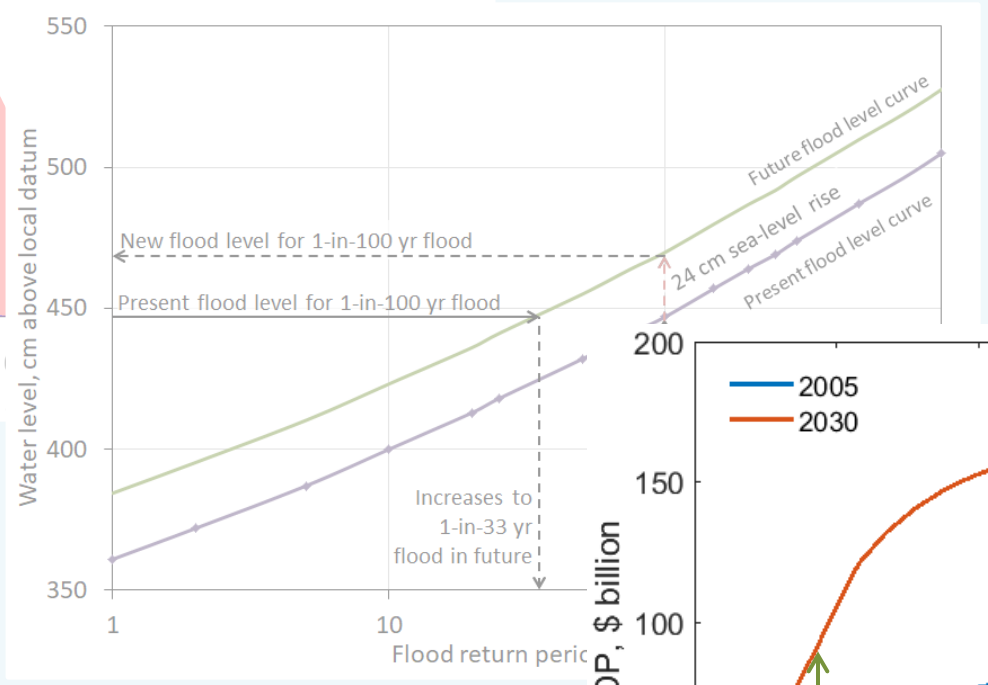

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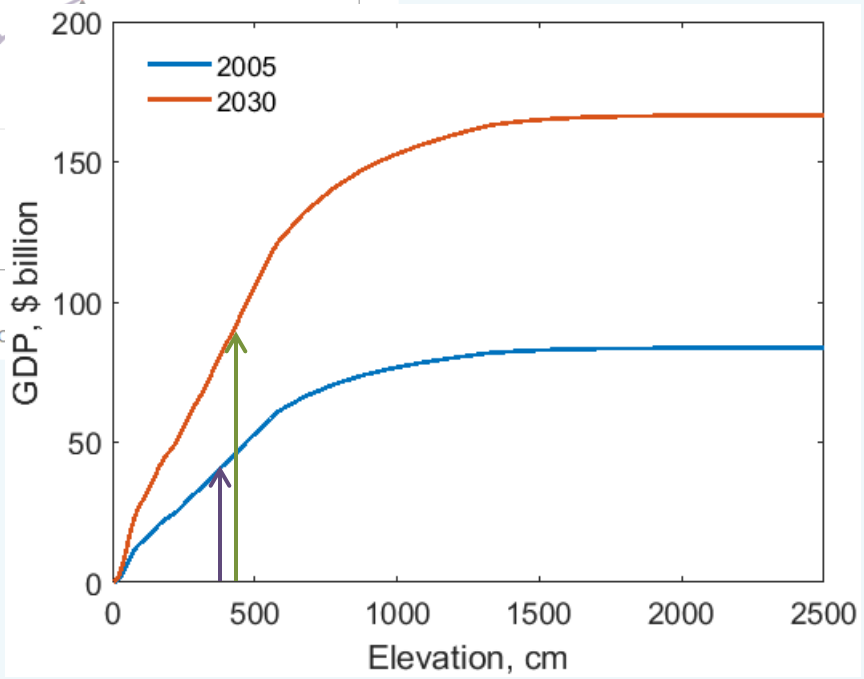
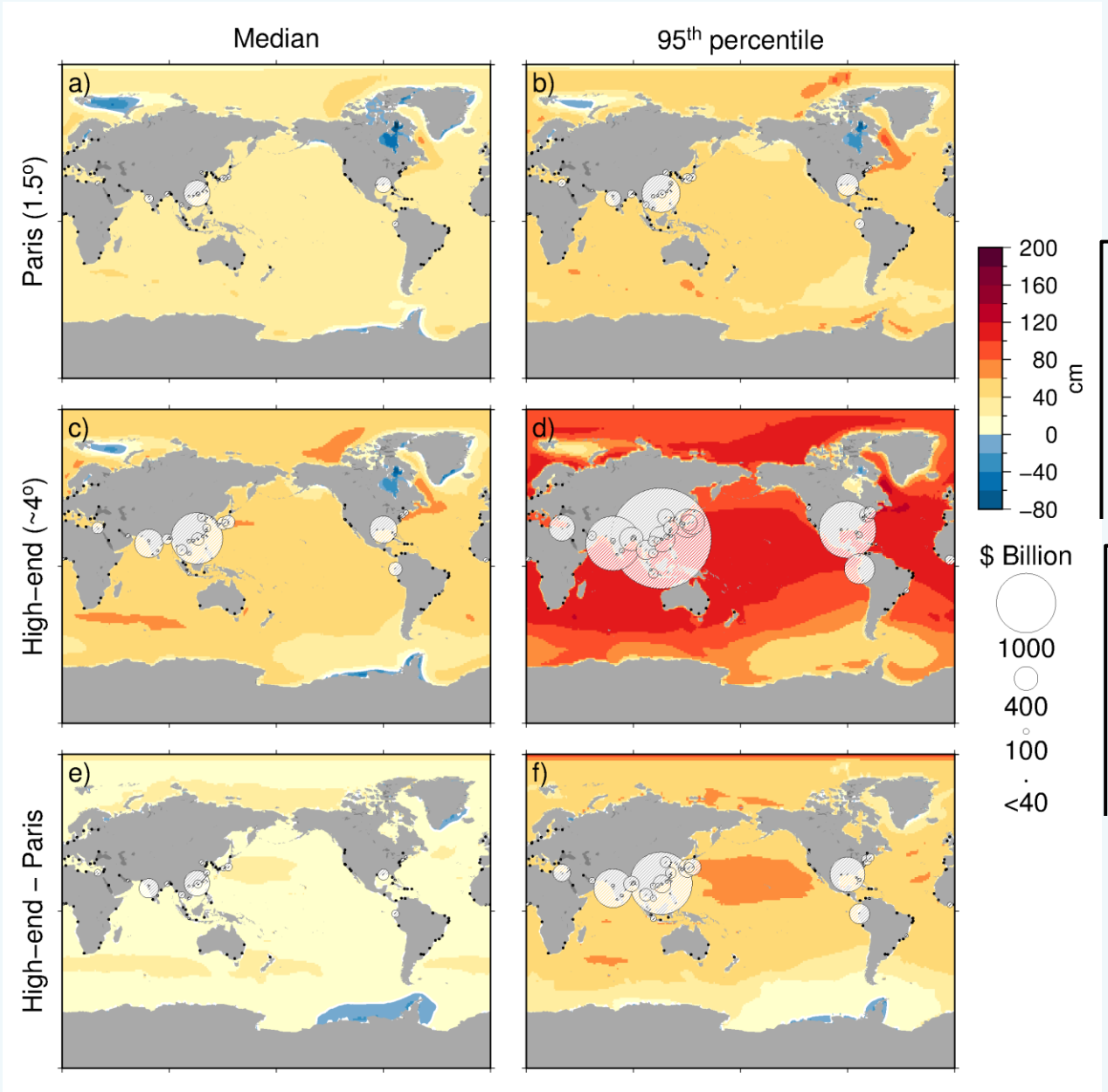
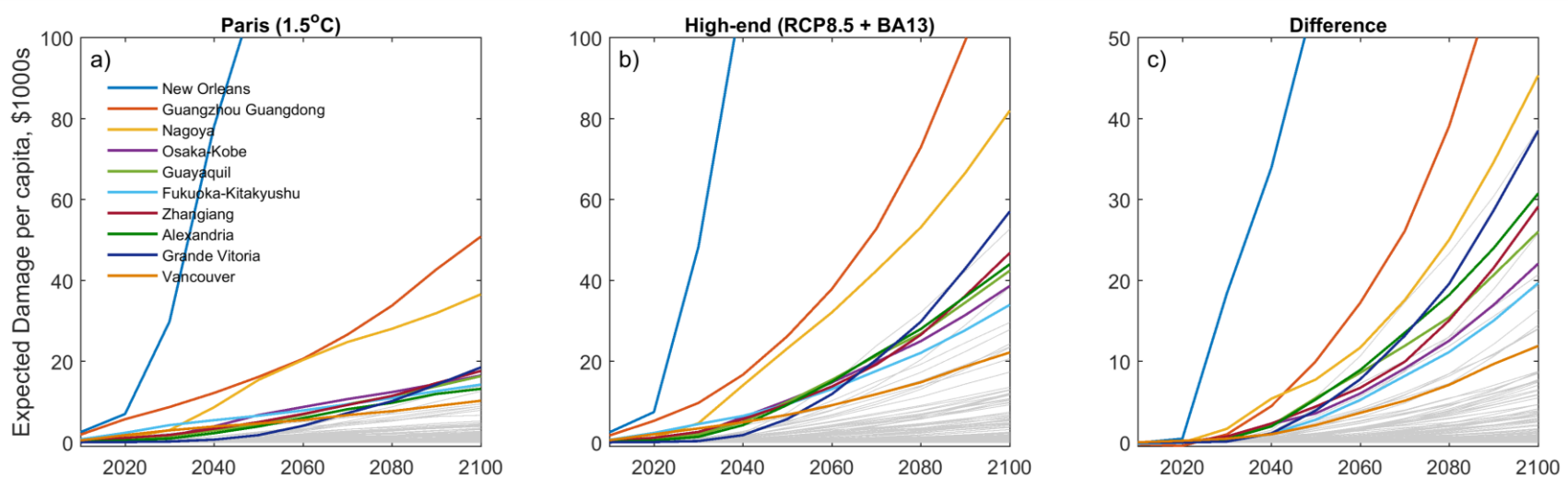


Estimate damages from city-based elevation (above present-day sea level)-future asset curves

Results


Median
95th percentile
a)
b)
c)
d)
e)
f)
Paris (1.5°)
High–end (~4°)
High–end – Paris
200
160
120
80
40
0
–40
–80
cm
$ Billion
1000
400
100
<40
Sea-level change
City-based losses

Is mitigation worth it?

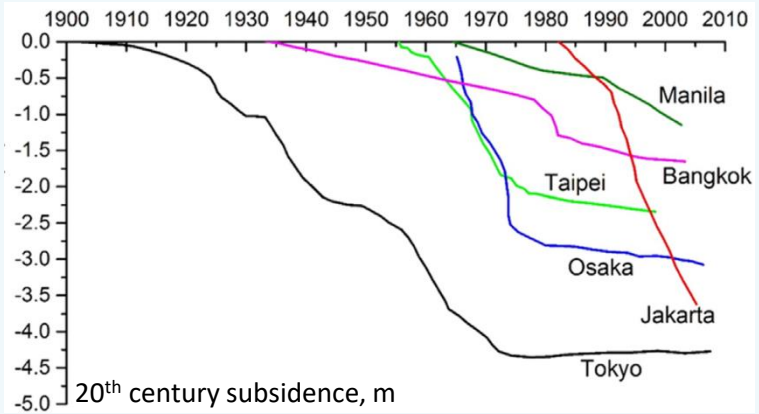


1. City-based damage estimates (no further adaptation) reveal multiple cities will experience additional per-capita losses of tens-of-thousands of dollars under a business-as-usual climate scenario if we miss either of the Paris Accord targets ("below 2 °C and pursue best efforts to 1.5 °C").

2. Subsidence (from ground water pumping and infra-structural loading) is likely to play a major role in future challenges faced by coastal cities.

3. The best available local sea-level projections are needed to make informed adaptation decisions.

4. Policy- and Decision- making in this area is not always clear because of multiple (Sustainable) Development goals being sought simultaneously.



Thank you

Thank you

Group Photo

Drinks at Vincent's Club

1A, King Edward Street, OX1 4HS