Taboos in Finance

Wim SCHOUTENS

BAYES, London

21 February 2024

Taboos in Finance

Wim Schoutens (KU Leuven)

Managing risk is at the core of quantitative finance. In recent times, risk managers have however been confronted with emerging taboos that hinder the identification, quantification, and reporting of risks, often due to narratives conflicting with prevailing notions of political correctness.

In this context, we overview some dynamics in sustainable finance and ESG (Environmental, Social, and Governance) investing. We illustrate how promises made, are subject to uncertainties, are based on subjective and biased data and are sometimes mathematically just impossible. We elaborate on how ESG scoring facilitates green-washing and increases systemic risk.

Moreover, we further elaborate on model risk and its repercussions, not confined solely to derivative pricing, but also to climate risk. The omnipresence of model risk implies there is substantial uncertainty over impact assessment in the field of climate risk modelling.

ESG

WI What is ESG ?

ESG stands for Environmental, Social, and Governance. It represents a framework used by investors and organizations to assess and measure the sustainability and ethical impact of a company's operations and business practices. ESG factors encompass a range of criteria that can include a company's environmental policies, social responsibility, and governance structures.

- **Environmental (E)** factors pertain to a company's impact on the environment, such as its carbon emissions, resource usage, and environmental management practices.
- **Social (S)** factors relate to how a company manages its relationships with employees, communities, customers, and other stakeholders. This includes considerations like diversity, labor practices, and community engagement.
- **Governance (G)** focuses on the systems and structures that guide a company's management and control, covering aspects like board composition, executive compensation, and transparency.

ESG considerations are important because they can affect a company's long-term financial performance, reputation, and attractiveness to socially responsible investors. Many organizations and investors use ESG criteria to make informed decisions that align with sustainability and ethical goals.

Warning !

A series of rating agencies are trying to quantify all ESG aspects.

There is a huge rating divergences.

Review of Finance

Volume 26, Issue 6
November 2022

Article Contents

JOURNAL ARTICLE EDITOR'S CHOICE

Aggregate Confusion: The Divergence of ESG Ratings*

Florian Berg, Julian F Kölbel, Roberto Rigobon

Review of Finance, Volume 26, Issue 6, November 2022, Pages 1315–1344,
https://doi.org/10.1093/rof/rfac033
Published: 23 May 2022 **Article history** ▾

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Abstract

This paper investigates the divergence of environmental, social, and governance (ESG) ratings based on data from six prominent ESG rating agencies: Kinder, Lydenberg, and Domini (KLD), Sustainalytics, Moody's ESG (Vigeo-Eiris), S&P Global (RobecoSAM), Refinitiv (Asset4), and MSCI. We document the rating divergence and map the different methodologies onto a common taxonomy of categories. Using this taxonomy, we decompose the divergence into contributions of scope, measurement, and weight. Measurement contributes 56% of the divergence, scope 38%, and weight 6%. Further analyzing the reasons for measurement divergence, we detect a rater effect where a rater's overall view of a firm influences the measurement of specific categories. The results call for greater attention to how the data underlying ESG ratings are generated.

When tobacco is more ethical than Tesla, it's time to dump ESG ratings

An ESG cottage industry is now profiting off the trend's popularity among pension funds

By Oliver Gill, CHIEF BUSINESS CORRESPONDENT
16 June 2023 • 12:00pm

What is the ESG score of Tesla vs tobacco?

Nonetheless, the electric car pioneer scored 37 points out of a possible 100 in an ESG assessment by the data company S&P. Oil behemoth Chevron scored 43. Philip Morris International, run by chief executive Jacek Olczak and the company behind Marlboro, the world's favourite cigarette brand, scored 84. 16 Jun 2023

Sustainability linked bonds

- One links “sustainability goals” with potential ***step-ups*** if target is missed.
- As investor you hope for a bad scenario ! 
- Call dates are sometimes BEFORE trigger dates.

- **STEP-UP MARGIN: 12.5BP**
- Science-Based Target No. 1” means Lumen’s target to reduce the sum of its annualized absolute market-based Scope 1 Direct Emissions and Scope 2 Indirect Emissions by 18% by 2025 compared to Lumen’s 2018 base year emissions
- **CALL DATE : 15/01/2024**

ESG under Q

Order Article Reprints

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Implied Tail Risk and ESG Ratings

by Jingyan Zhang, Jan De Spiegeleer and Wim Schoutens *

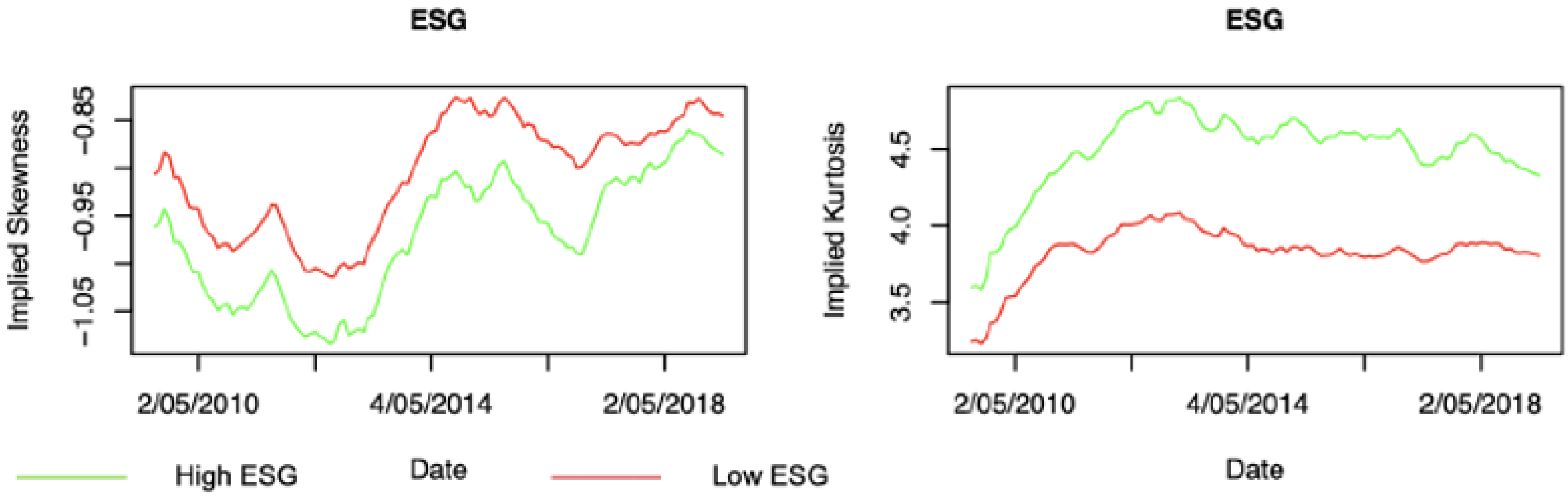
Department of Mathematics, KU Leuven, Celestijnenlaan 200B, 3001 Leuven, Belgium

* Author to whom correspondence should be addressed.

Mathematics **2021**, *9*(14), 1611; https://doi.org/10.3390/math9141611

Received: 28 May 2021 / Revised: 24 June 2021 / Accepted: 5 July 2021 / Published: 8 July 2021

(This article belongs to the Special Issue Stochastic Modelling with Applications in Finance and Insurance)



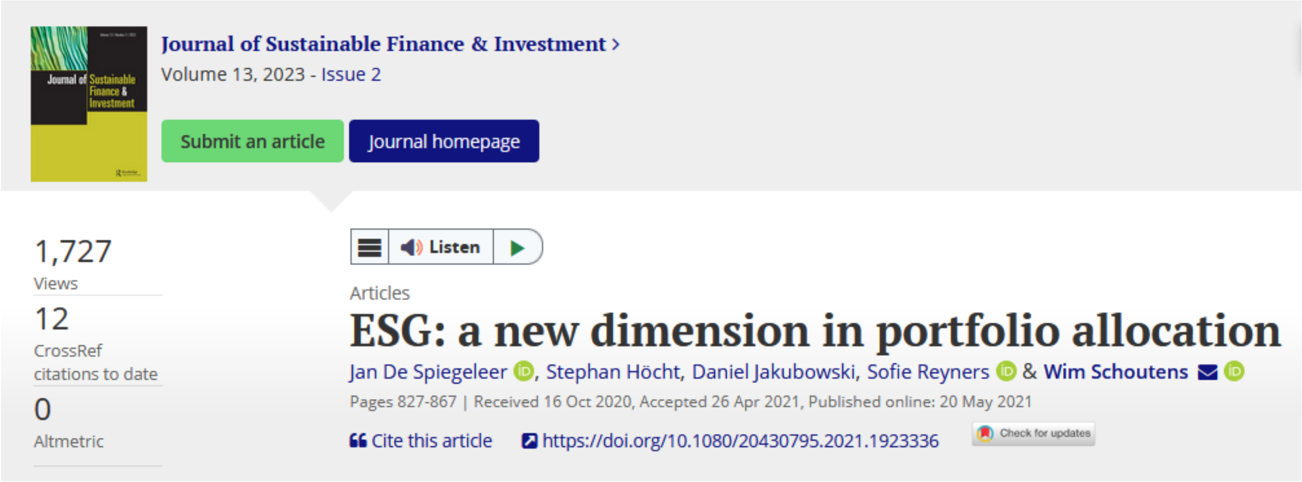
High ESG rating group has higher implied tail risk than low ESG rating group;

Conclusion

- Environmental, social and governance (ESG) factors: extra dimension in portfolio allocation
- ESG investment strategies - based on minimum variance portfolio
- STOXX 600 study:

no clear-cut evidence for enhanced performance

ESG Portfolio Investing


Journal of Sustainable Finance & Investment ›
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Articles

ESG: a new dimension in portfolio allocation

Jan De Spiegeleer, Stephan Höcht, Daniel Jakubowski, Sofie Reyners & Wim Schoutens

Pages 827-867 | Received 16 Oct 2020, Accepted 26 Apr 2021, Published online: 20 May 2021
Cite this article
https://doi.org/10.1080/20430795.2021.1923336
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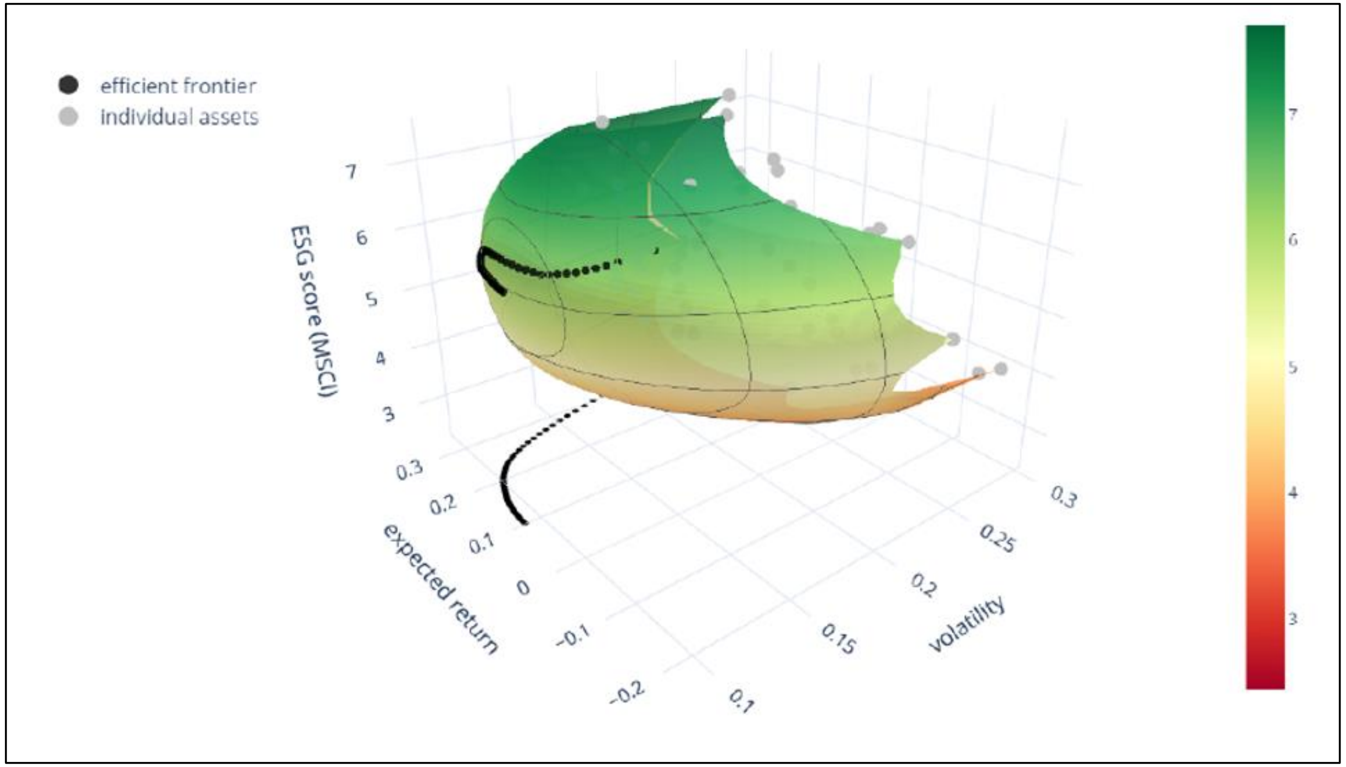
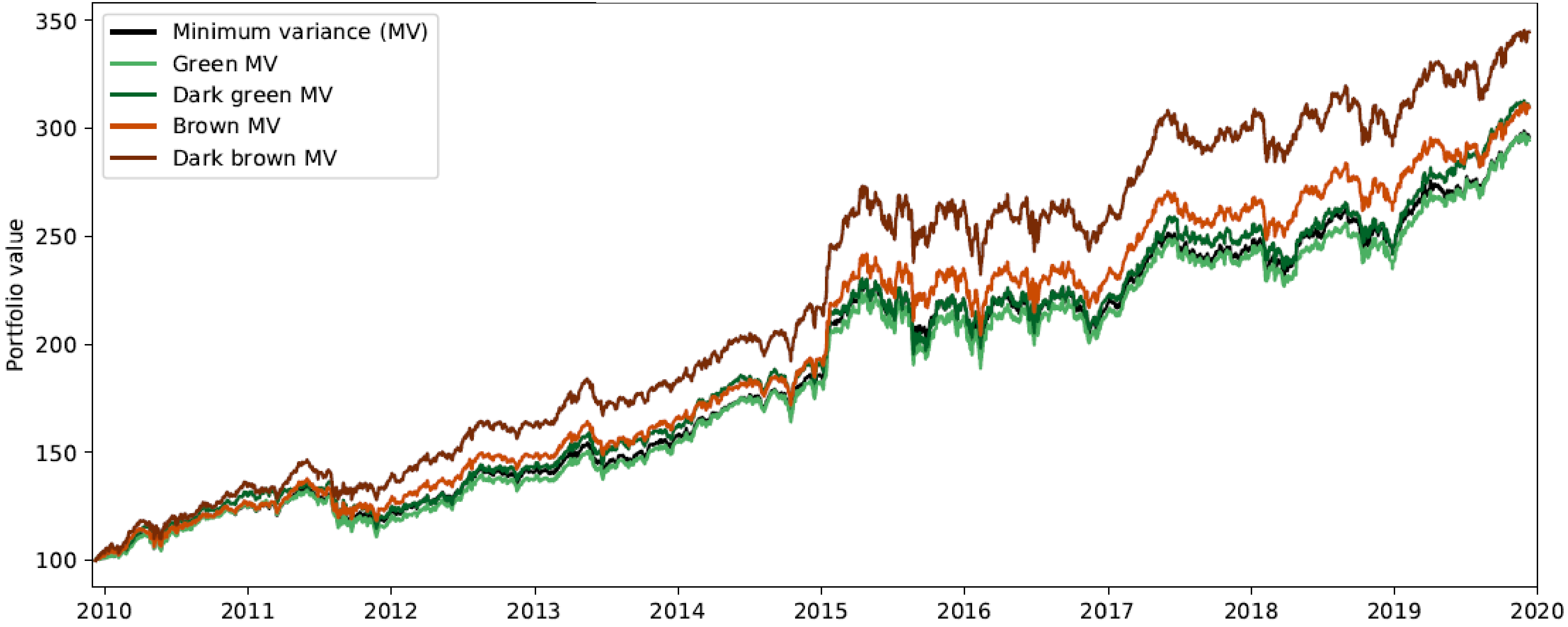


Strategy performance

- quarterly portfolio rebalancing
- Invest in the minimum variance portfolio satisfying ESG targets.
  $\rightarrow$ minimize risk, subject to ESG constraints



Dissecting the Explanatory Power of ESG Features on Equity Returns by Sector, Capitalization, and Year with Interpretable Machine Learning

by Jérémi Assael [1,2,*], Laurent Carlier [2] and Damien Challet [1]

[1] MICS Laboratory, CentraleSupélec, Université Paris-Saclay, 91190 Gif-Sur-Yvette, France

[2] BNP Paribas Corporate & Institutional Banking, Global Markets Data & Artificial Intelligence Lab, 75009 Paris, France

[*] Author to whom correspondence should be addressed.

J. Risk Financial Manag. **2023**, *16*(3), 159; **https://doi.org/10.3390/jrfm16030159**

Received: 10 January 2023 / Revised: 20 February 2023 / Accepted: 27 February 2023 / Published: 1 March 2023

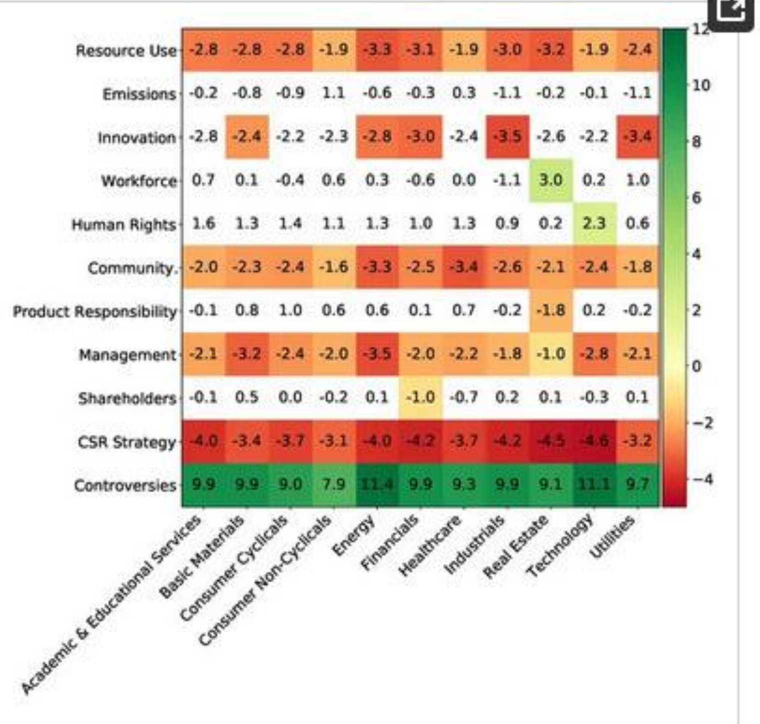


Figure 13. Materiality matrix: marginal effects of the combination ESG feature/Sector feature on the predicted probability of having a positive return. Blank cells are those that were not found to be statistically significant by the Benjamini–Hochberg procedure.

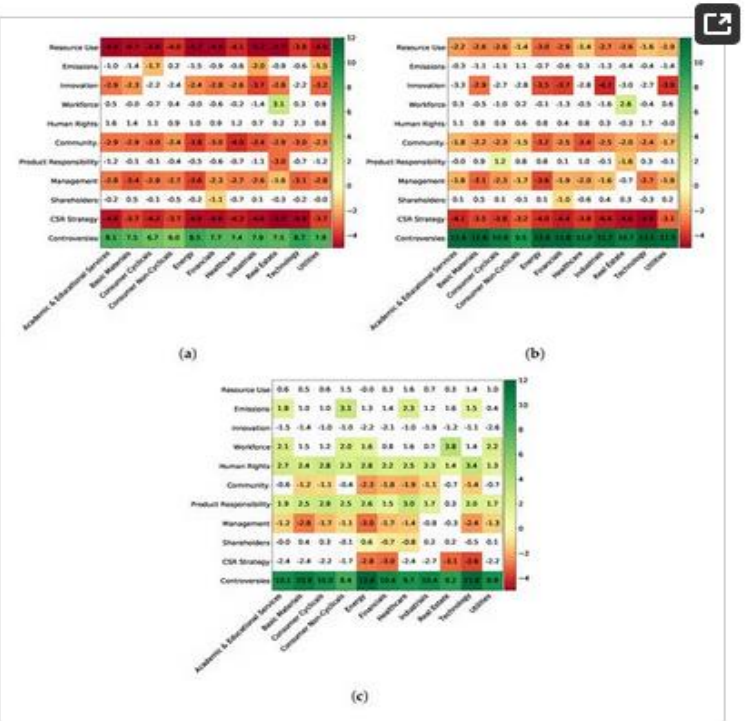
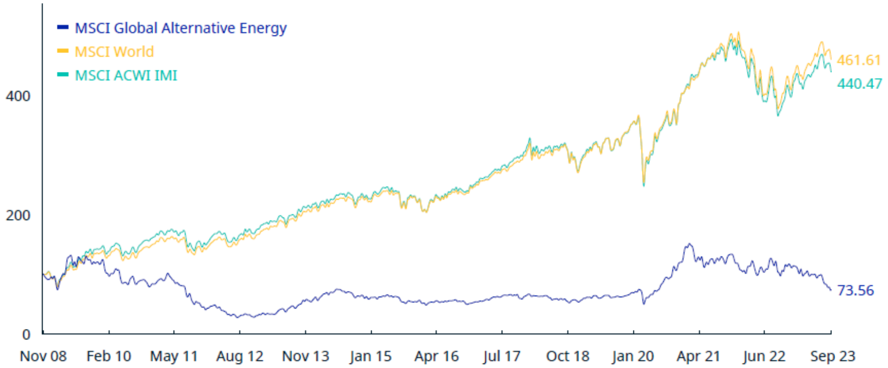


Figure 14. Materiality matrices: marginal effects of the combination ESG feature/Sector feature on the predicted probability of having a positive return, bucketed by market capitalization. Blank cells are those that were not found statistically significant by the Benjamini–Hochberg procedure. (**a**) Small market capitalization (<2 B€); (**b**) Mid market capitalization (>2 B€, <10 B€); (**c**) Large market capitalization (>10 B€).

The MSCI Global Alternative Energy Index includes developed and emerging market large, mid and small cap companies that derive 50% or more of their revenues from products and services in Alternative energy.

CUMULATIVE INDEX PERFORMANCE — GROSS RETURNS (USD) (NOV 2008 – SEP 2023)



ANNUAL PERFORMANCE (%)

Year	MSCI Global Alternative Energy	MSCI World	MSCI ACWI IMI
2022	-6.33	-17.73	-18.00
2021	-17.39	22.35	18.71
2020	108.54	16.50	16.81
2019	28.77	28.40	27.04
2018	-16.69	-8.20	-9.61
2017	22.12	23.07	24.58
2016	-6.54	8.15	8.96
2015	-8.34	-0.32	-1.68
2014	6.64	5.50	4.36
2013	80.73	27.37	24.17
2012	-26.19	16.54	17.04
2011	-49.08	-5.02	-7.43
2010	-29.31	12.34	14.87

INDEX PERFORMANCE — GROSS RETURNS (%) (SEP 29, 2023)

					ANNUALIZED			
	1 Mo	3 Mo	1 Yr	YTD	3 Yr	5 Yr	10 Yr	Since Nov 28, 2008
MSCI Global Alternative Energy	-10.18	-23.92	-28.80	-33.45	-9.71	5.05	4.02	-2.05
MSCI World	-4.28	-3.36	22.58	11.55	8.60	7.80	8.84	10.85
MSCI ACWI IMI	-4.17	-3.30	20.77	9.82	7.38	6.61	7.93	10.50

FUNDAMENTALS (SEP 29, 2023)

	Div Yld (%)	P/E	P/E Fwd	P/BV
MSCI Global Alternative Energy	1.59	35.54	17.53	2.28
MSCI World	2.06	19.45	16.13	2.89
MSCI ACWI IMI	2.19	18.82	15.37	2.47

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					ANNUALIZED			
	1 Mo	3 Mo	1 Yr	YTD	3 Yr	5 Yr	10 Yr	Since Nov 28, 2008
MSCI Global Alternative Energy	-10.18	-23.92	-28.80	-33.45	-9.71	5.05	4.02	-2.05
MSCI World	-4.28	-3.36	22.58	11.55	8.60	7.80	8.84	10.85
MSCI ACWI IMI	-4.17	-3.30	20.77	9.82	7.38	6.61	7.93	10.50

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INDEX RISK AND RETURN CHARACTERISTICS (SEP 29, 2023)

		ANNUALIZED STD DEV (%) [2]			SHARPE RATIO [2,3]				MAXIMUM DRAWDOWN	
	Turnover (%) [1]	3 Yr	5 Yr	10 Yr	3 Yr	5 Yr	10 Yr	Since Nov 28, 2008	(%)	Period YYYY-MM-DD
MSCI Global Alternative Energy	10.34	29.19	28.82	23.29	-0.27	0.25	0.23	na	80.05	2009-06-11—2012-07-25
MSCI World	2.20	17.65	18.48	14.67	0.46	0.41	0.57	0.68	33.99	2020-02-12—2020-03-23
MSCI ACWI IMI	2.39	17.22	18.46	14.69	0.40	0.35	0.51	0.65	34.47	2020-02-12—2020-03-23

[1] Last 12 months [2] Based on monthly gross returns data [3] Based on NY FED Overnight SOFR from Sep 1 2021 & on ICE LIBOR 1M prior that date

Index Factsheet

TOP 10 CONSTITUENTS

	Country	Float Adj Mkt Cap (USD Billions)	Index Wt. (%)	Sector
VESTAS WIND SYSTEMS	DK	21.73	13.18	Industrials
ENPHASE ENERGY	US	16.47	9.99	Info Tech
FIRST SOLAR	US	16.40	9.95	Info Tech
ORSTED	DK	10.34	6.27	Utilities
SOLAREDGE TECHNOLOGIES	US	7.30	4.43	Info Tech
VERBUND A	AT	5.55	3.37	Utilities
EDP RENOVAVEIS	PT	5.05	3.06	Utilities
NORTHLAND POWER	CA	4.13	2.51	Utilities
ADANI GREEN ENERGY	IN	3.77	2.28	Utilities
ORMAT TECHNOLOGIES	US	3.76	2.28	Utilities
Total		94.49	57.32	

The Journal of FINANCE
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Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows

SAMUEL M. HARTZMARK, ABIGAIL B. SUSSMAN

First published: 09 August 2019 | https://doi.org/10.1111/jofi.12841 | Citations: 488

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ABSTRACT

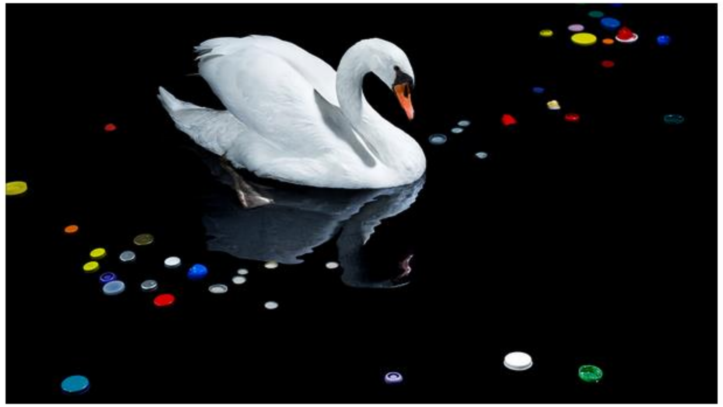
Examining a shock to the salience of the sustainability of the U.S. mutual fund market, we present causal evidence that investors marketwide value sustainability: being categorized as low sustainability resulted in net outflows of more than $12 billion while being categorized as high sustainability led to net inflows of more than $24 billion. Experimental evidence suggests that sustainability is viewed as positively predicting future performance, but we do not find evidence that high-sustainability funds outperform low-sustainability funds. The evidence is consistent with positive affect influencing expectations of sustainable fund performance and nonpecuniary motives influencing investment decisions.

Investment Management

An Inconvenient Truth About ESG Investing

by Sanjai Bhagat

March 31, 2022



John Scott/Getty Images

Summary. Investing in sustainable funds that prioritize ESG goals is supposed to help improve the environmental and social sustainability of business practices. Unfortunately, close analysis suggests that it's not only not making much difference to companies' actual ESG performance, it may actually be directing capital into poor business performers. close

NO evidence high sustainability funds outperformed the low rated funds.

Maybe some investors would be happy to sacrifice financial returns in exchange for better ESG performance. Unfortunately ESG funds don't seem to deliver better ESG performance either.

Conclusion: funds investing in companies that publicly embrace ESG sacrifice financial returns without gaining much.

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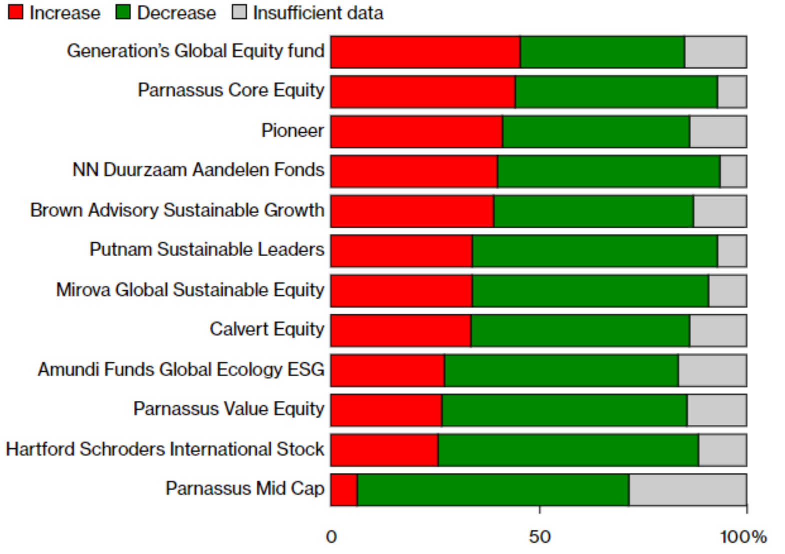
Businessweek + Green

Al Gore's Struggles With ESG Show the Messiness of Green Investing

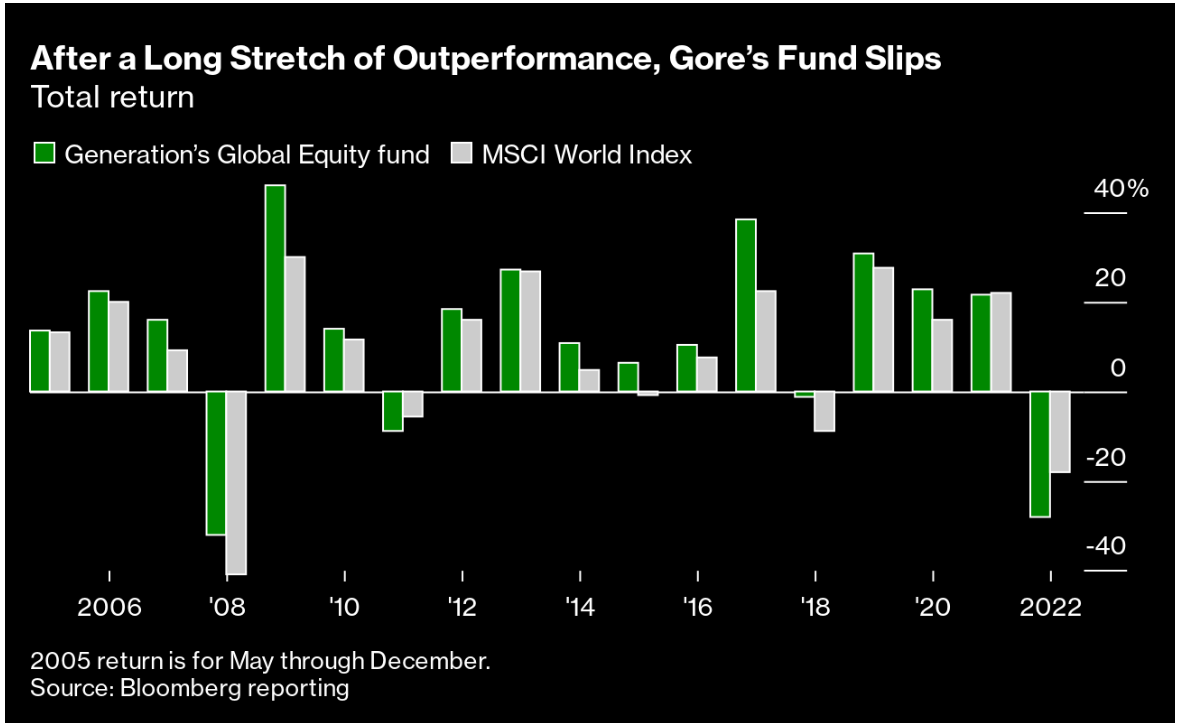
If the former veep's Generation investment firm has trouble meeting lofty environmental and financial goals, who can?

Green Funds' Rising Emissions

Share of investment portfolio assets by net change in emissions between 2015 and 2021



Companies whose absolute Scope 1 and Scope 2 emissions rose from the first year of reported data in the period to the last are categorized as increasing. Market-based Scope 2 data are used where available. Insufficient data category includes bonds, cash and other non-publicly traded securities, as well as companies with no data or only one year of data.
Sources: Generation (Global Equity holdings), Bloomberg (company emissions data and holdings of other funds)



LARRY FINK'S 2022 LETTER TO CEOS:

"We need to be honest about the fact that green products often come at a higher cost."

Source: https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter

A recent study of U.S. fund fees referred to investors in so-called sustainable funds paying "greeniums" compared to conventional funds.

Investors in Sustainable Funds Are Paying a "Greenium"

Investors in sustainable funds are paying a "greenium" relative to investors in conventional funds. This is evidenced by these funds' higher asset-weighted average expense ratio, which stood at 0.61% at the end of 2020 versus 0.41% for their traditional peers. That said, sustainable funds' fees have been falling on both an equal- and asset-weighted basis. Over the past decade, the average fee charged by

Source: https://www.morningstar.com/content/dam/marketing/shared/pdfs/Research/annual-us-fund-fee-study-updated.pdf

In addition, according to my legal counsel, Environmental, Social and Governance (ESG) investing is contrary to Louisiana law on fiduciary duties, which requires a sole focus on financial returns for the beneficiaries of state funds. Focusing on ESG's political and social goals

or placing those goals above the duty to enhance investors' returns is unacceptable under Louisiana law. A letter signed by 19 state attorneys general sent to you recently emphasized this same point.

Under Louisiana law, investors' returns take precedence.

I'm convinced that ESG investing is more than bad business; it's a threat to our founding principles: democracy, economic freedom, and individual liberty. It threatens our democracy, bypasses the ballot box and allows large investment firms to push political agendas. It threatens our economic freedom because these firms use their massive shareholdings to compel CEOs to put political motivations above a company's profits and investors' returns. Finally, it threatens our personal liberty because these firms are using our money to push their agendas contrary to the best interests of the people whose money they are using! There is a difference between offering an ESG investment option for those investors so inclined, and using other peoples' non-ESG investments to promote ESG shareholder initiatives.

JOHN M. SCHRODER
LOUISIANA STATE TREASURER

(225) 342-0010
www.latreasury.com

P.O. Box 44154
Baton Rouge, LA 70804

October 5, 2022

Mr. Laurence D. Fink
CEO
BlackRock, Inc.
55 East 52nd Street
New York, NY 10055

Dear Mr. Fink:

I write today on behalf of the hardworking citizens of the great state of Louisiana. Thank


State Decisions on ESG
Republican-led states push back on ESG while Democratic-led states seek to incorporate it.
Actions targeting entities boycotting certain industries
Actions restricting use of ESG factors
Actions promoting divestment from certain industries
Actions neutral on use of ESG factors
Actions promoting integration of ESG
No significant action
WA
OR
CA
NV
ID
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
ME
MA
RI
CT
NJ
DE
MD
AK
Source: Ropes & Gray LLP
Note: As of Dec. 12
Bloomberg

Carol Roth @caroljsroth · 3h

Remember when @ElonMusk wanted to bring free speech to Twitter and then S&P removed Tesla from their ESG 500 index, but kept in Exxon?

ESG is business social credit. It's a means to control capital, keep business people in line with the narrative, and, ultimately, control you.

117 878 4,797

Elon Musk
@elonmusk

Replying to @caroljsroth

ESG is the devil

9:24 PM · Nov 27, 2022 · Twitter for iPhone

1,537 Retweets **183** Quote Tweets **9,334** Likes

- **ESG investing is from a quantitative finance point of view a SCAM.**
- It can be seen as the implementation of a political agenda.
- Constrained optimizations lead to suboptimal investment decisions.
- Green washing is omnipresent.
- ESG investing is violating mandates (returns/risks).
- Informed consent is needed if you want to do politics with somebody else’s money.
- Litigation risk is enormous.
- **Enforcing ESG via regulation increases systemic risk.**

Omnipresent Model Risk

Mathematical Models

THEORETICAL MODEL

Mathematical dynamics

- systems of (coupled) PDEs and or SDEs
- Examples :
  - Heat-equation
  - Stochastic volatility models

Model parameters

- Observable parameters
  - Earth's gravity constant
- Calibration of unobservable parameters
  - speed of mean reversion of volatility
  - Solar activity intensity
  - …

Boundary conditions

- Initial conditions
  - current stock price
  - initial position & speed of particle
- Final conditions (e.g. payoff at maturity)
- Constraints (e.g. stock price is nonnegative)

Fundamental laws

- Mass/energy conservation
- Non-arbitrage conditions
- Risk-neutral dynamics
- …

Mathematical Models

NUMERICAL IMPLEMENTATION

Mathematical dynamics PDEs/SDEs
- Numerical schemes for discritization
  - Euler, Runge-Kutta, …
  - Euler, Milstein, … Monte Carlo
- Discretization/approximation
  - size and shape
- Random number generator

Model parameters
- Observable parameters
  - Accuracy of measurement
- Calibration of unobservable parameters
  - Calibration instruments
  - Objective function
  - Optimization algorithm

Imposing Boundary conditions
- Initial/final conditions
  - accuracy
- Constraints
  - Absorbing, reflecting, ...
  - Overwrite/delete

Imposing Fundamental laws

- Rescaling
- De-drifting
- Quick fixes
- …

Escaping Model Land

MODEL LAND

THEORETICAL MODEL

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REAL WORLD and POLICY DECISIONS

- Scenario(s)
- Distribution(s)
- Point estimates (meaning)
- Error bounds

- Uncertainty quantification
- Limitations
- Alternatives
- Sensitivity analysis

- Conflict-of-interests
- Accountability (skin-in-the-game)
- Falsification (if implemented how can one detect that the model is not performing as promised).

Model Risk

MODEL 1

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. . .

MODEL N

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Fundamental laws
- Mass/energy conservation
- Non-arbitrage conditions
- Risk-neutral dynamics
- …

A variety of sophisticated and justifiable models could be available, all with their own specificities and incorporation of particular stylized features. None of them is superior/inferior – all just have a particular point of view.

WHAT IS THE IMPACT AND VARIABILITY ON THE PREDICTIONS/ESTIMATIONS WE WANT TO OBTAIN FROM THE MODELS ?

Calibration Risk

NUMERICAL IMPLEMENTATION

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- Constraints
  - Absorbing, reflecting, …
  - Overwrite/delete

Imposing Fundamental laws
- Rescaling
- De-drifting
- Quick fixes
- …

Calibration is itself based on models with a variety of choices and numerical issues. Moreover it also involves a particular strong judgement of the modeler on what is important and what not, via the formulation of the objective function (e.g. minimization of SE, absolute error, tail risk, …).

Implementation Risk

NUMERICAL IMPLEMENTATION

Mathematical dynamics PDEs/SDEs
- Numerical schemes for discritization
  - Euler, Runge-Kutta, …
  - Euler, Milstein, … Monte Carlo
- Discretization/approximation
  - size and shape
- Random number generator

Model parameters
- Observable parameters
  - Accuracy of measurement
- Calibration of unobservable parameters
  - Calibration instruments
  - Objective function
  - Optimization algorithm

Imposing Boundary conditions
- Initial/final conditions
  - accuracy
- Constraints
  - Absorbing, reflecting, …
  - Overwrite/delete

Imposing Fundamental laws
- Rescaling
- De-drifting
- Quick fixes
- …

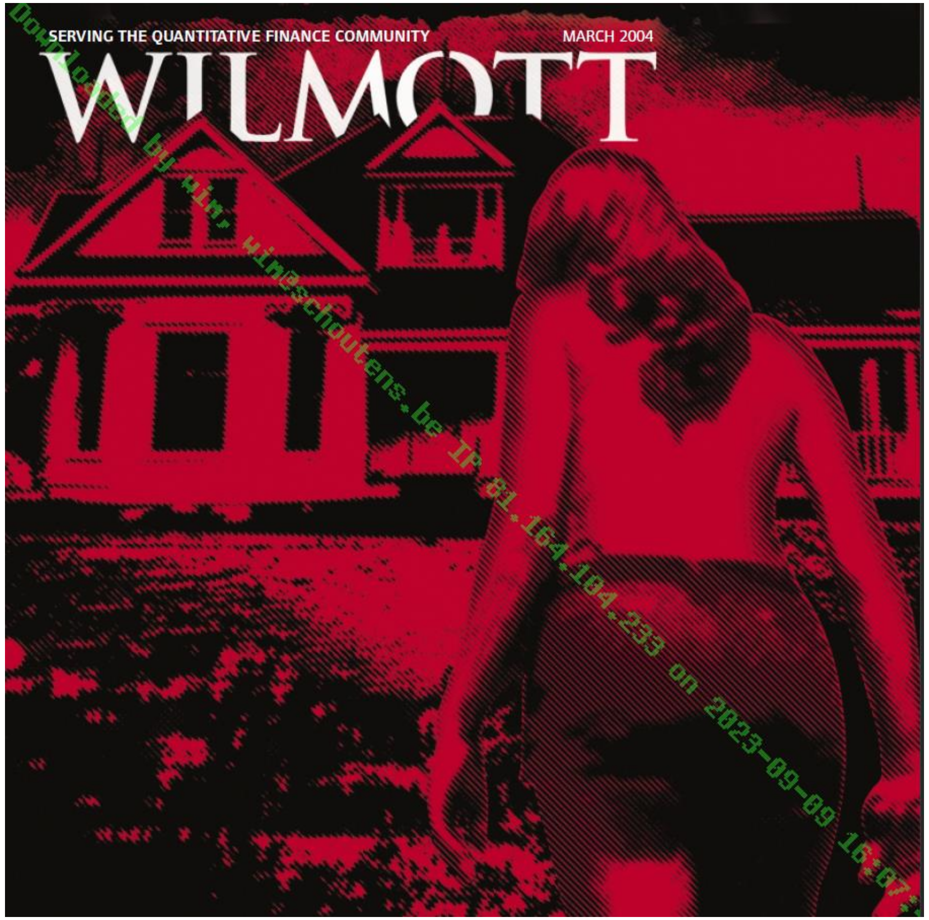
In the implementation plenty of choices need to be made looking for a balance between tractability and accuracy.
It also involves judgements of the modelers that can significantly impact final results and policy recommendations.

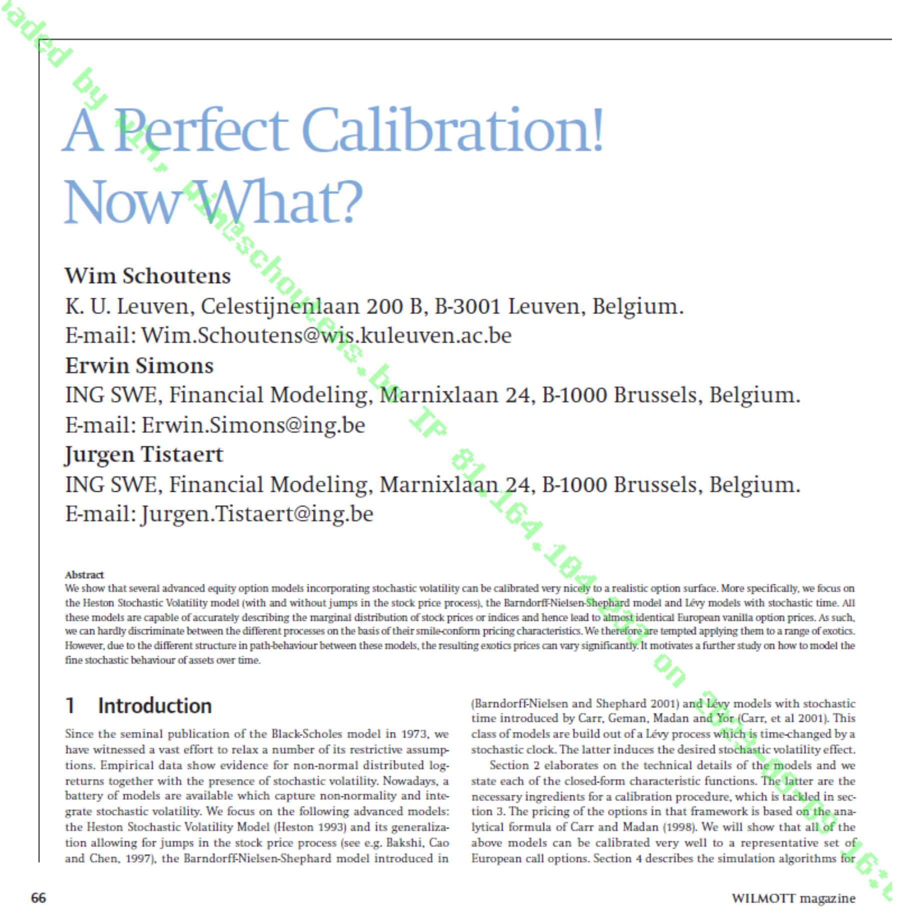
CASE STUDIES

- FINANCE: the pricing and risk-management of financial derivatives and structured products.
- BUTTERFLY EFFECT
- CLIMATE: long term climate models

CASE STUDY : FINANCE

Model risk in finance





A Perfect Calibration! Now What?

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Abstract
We show that several advanced equity option models incorporating stochastic volatility can be calibrated very nicely to a realistic option surface. More specifically, we focus on the Heston Stochastic Volatility model (with and without jumps in the stock price process), the Barndorff-Nielsen-Shephard model and Lévy models with stochastic time. All these models are capable of accurately describing the marginal distribution of stock prices or indices and hence lead to almost identical European vanilla option prices. As such, we can hardly discriminate between the different processes on the basis of their smile-conform pricing characteristics. We therefore are tempted applying them to a range of exotics. However, due to the different structure in path-behaviour between these models, the resulting exotics prices can vary significantly. It motivates a further study on how to model the fine stochastic behaviour of assets over time.

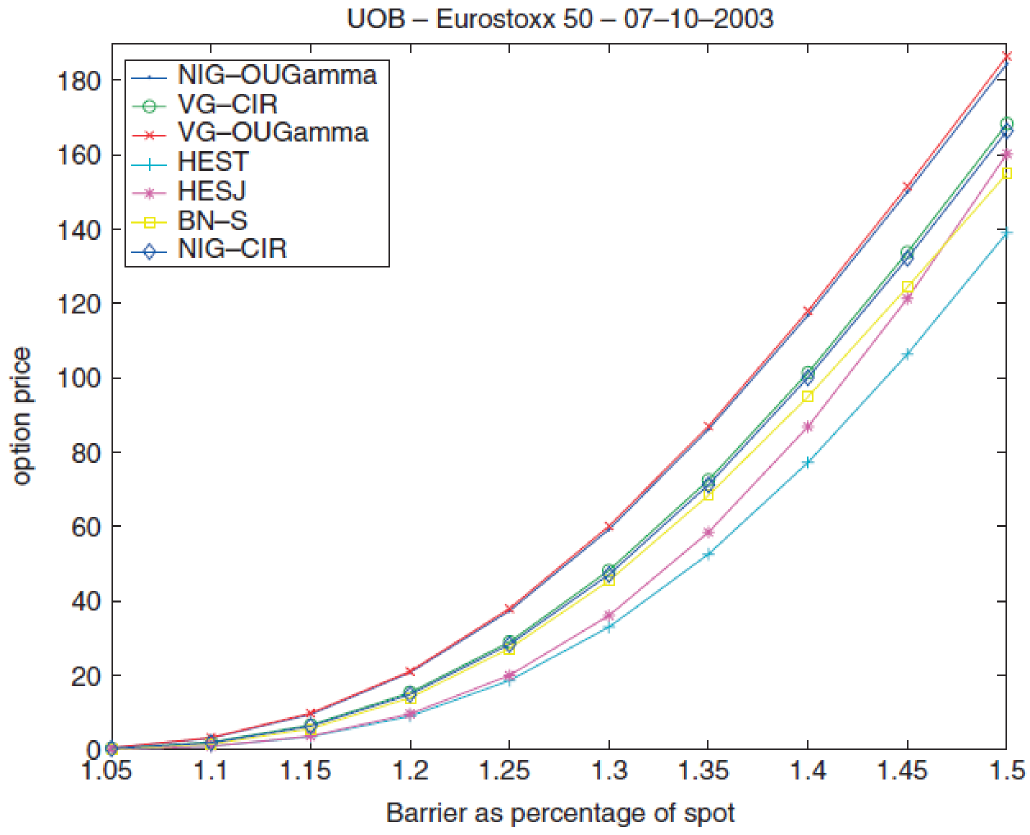
1 Introduction

Since the seminal publication of the Black-Scholes model in 1973, we have witnessed a vast effort to relax a number of its restrictive assumptions. Empirical data show evidence for non-normal distributed log-returns together with the presence of stochastic volatility. Nowadays, a battery of models are available which capture non-normality and integrate stochastic volatility. We focus on the following advanced models: the Heston Stochastic Volatility Model (Heston 1993) and its generalization allowing for jumps in the stock price process (see e.g. Bakshi, Cao and Chen, 1997), the Barndorff-Nielsen-Shephard model introduced in (Barndorff-Nielsen and Shephard 2001) and Lévy models with stochastic time introduced by Carr, Geman, Madan and Yor (Carr, et al 2001). This class of models are build out of a Lévy process which is time-changed by a stochastic clock. The latter induces the desired stochastic volatility effect.

Section 2 elaborates on the technical details of the models and we state each of the closed-form characteristic functions. The latter are the necessary ingredients for a calibration procedure, which is tackled in section 3. The pricing of the options in that framework is based on the analytical formula of Carr and Madan (1998). We will show that all of the above models can be calibrated very well to a representative set of European call options. Section 4 describes the simulation algorithms for

Model risk in finance

- A variety of sophisticated models can be calibrated almost perfectly on a given market.
- The models priced all observable almost perfect.
- Model prices are calculated for unobservable products.
- Model prices vary significantly.
- Impact on book values are very significant.



MAIN CONCLUSION:
DO NOT TRUST JUST ONE MODEL TO MAKE FUTURE PREDICTIONS.
A VARIETY OF PLAUSIBLE MODELS CAN GIVE VERY DIFFERENT PREDICTIONS.

Calibration risk in finance

SFB 649 Discussion Paper 2006-001

Calibration Risk for Exotic Options

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Humboldt-Universität zu Berlin, Germany

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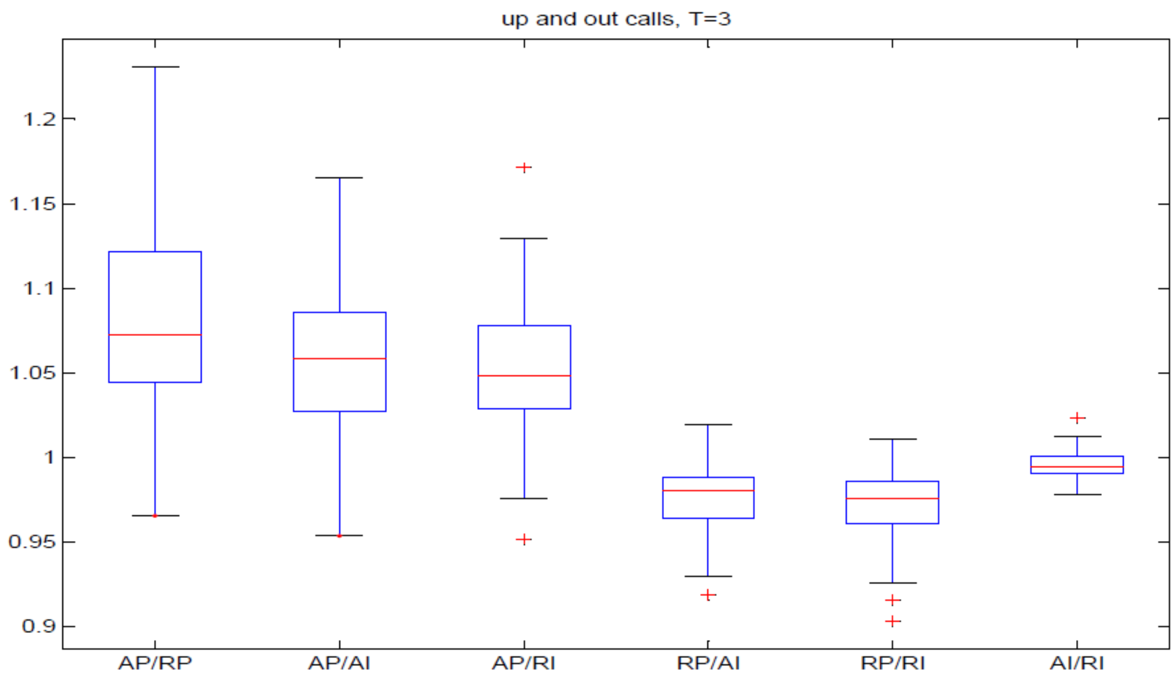
Spandauer Straße 1, D-10178 Berlin

SFB 649 ECONOMIC RISK BERLIN

Calibration risk in finance (1)

- Fixing one sophisticated model, calibration can be performed minimizing different error functions.
- Calibrated model parameters are obtained for each error function.
- Model prices are calculated for unobservable products and again prices can vary significantly.
- Again impact on book values are very significant.



Calibration risk in finance

Rev Deriv Res (2012) 15:57–79
DOI 10.1007/s11147-011-9069-2

Calibration risk: Illustrating the impact of calibration risk under the Heston model

Florence Guillaume · Wim Schoutens

Published online: 8 July 2011

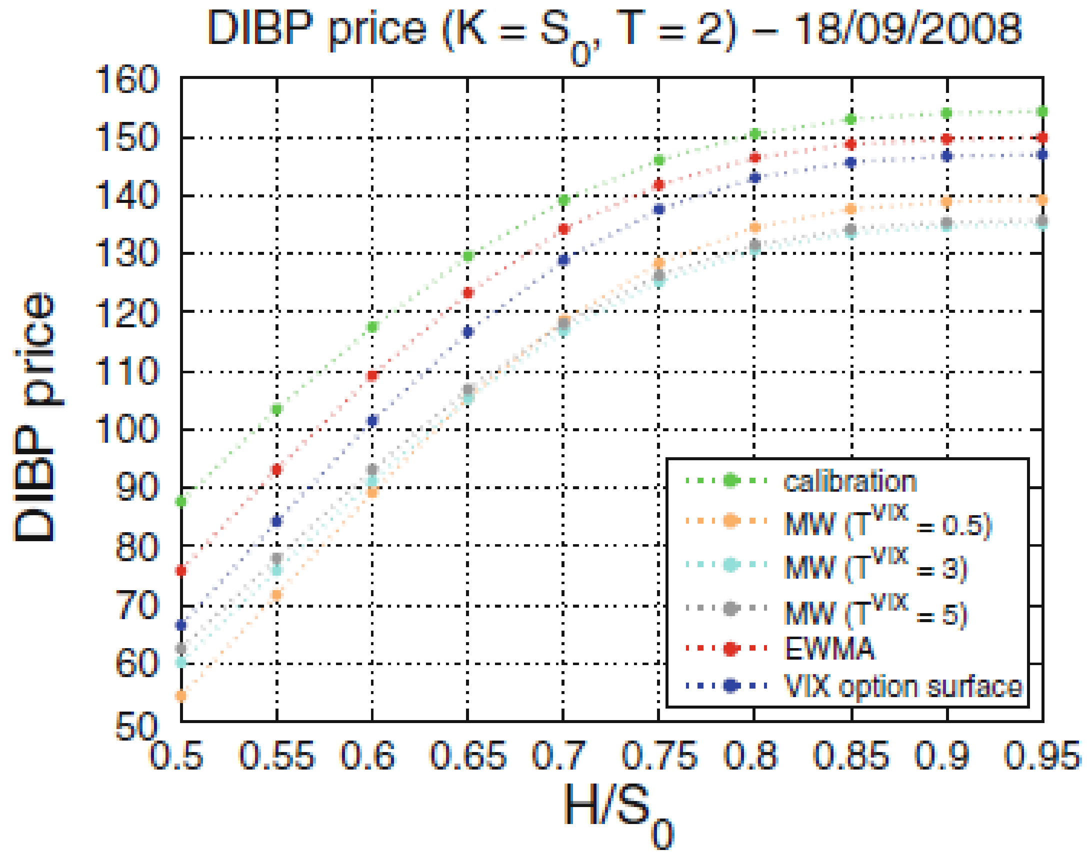
Abstract It is already well documented that model risk is an important issue regarding the pricing of exotics (see Schoutens et al., in A perfect calibration! Now what?, Wilmott Magazine, March 2004: pp 66–78, 2004). Arguments have been made to put this into the perspective of bid-ask pricing using the theory of conic finance and pricing to acceptability (Cherny and Madan Review of Financial Studies, 22: 2571–2606, 2009). In this paper we show also the presence and importance of calibration risk. More particularly, we point out that a variety of plausible calibration methods lead again to serious price differences for exotics and different distributions of the P&L of the delta-hedging strategy. This is illustrated under the popular Heston stochastic volatility model, which is used among practitioners to price all kinds of exotic and structured products. This paper shows that it is prudent to take some additional safety margin into account for the pricing of these structured notes.

Keywords Heston model · Calibration · Model risk · Calibration risk · Exotic options

JEL classification C63 · G17

Calibration risk in finance (2)

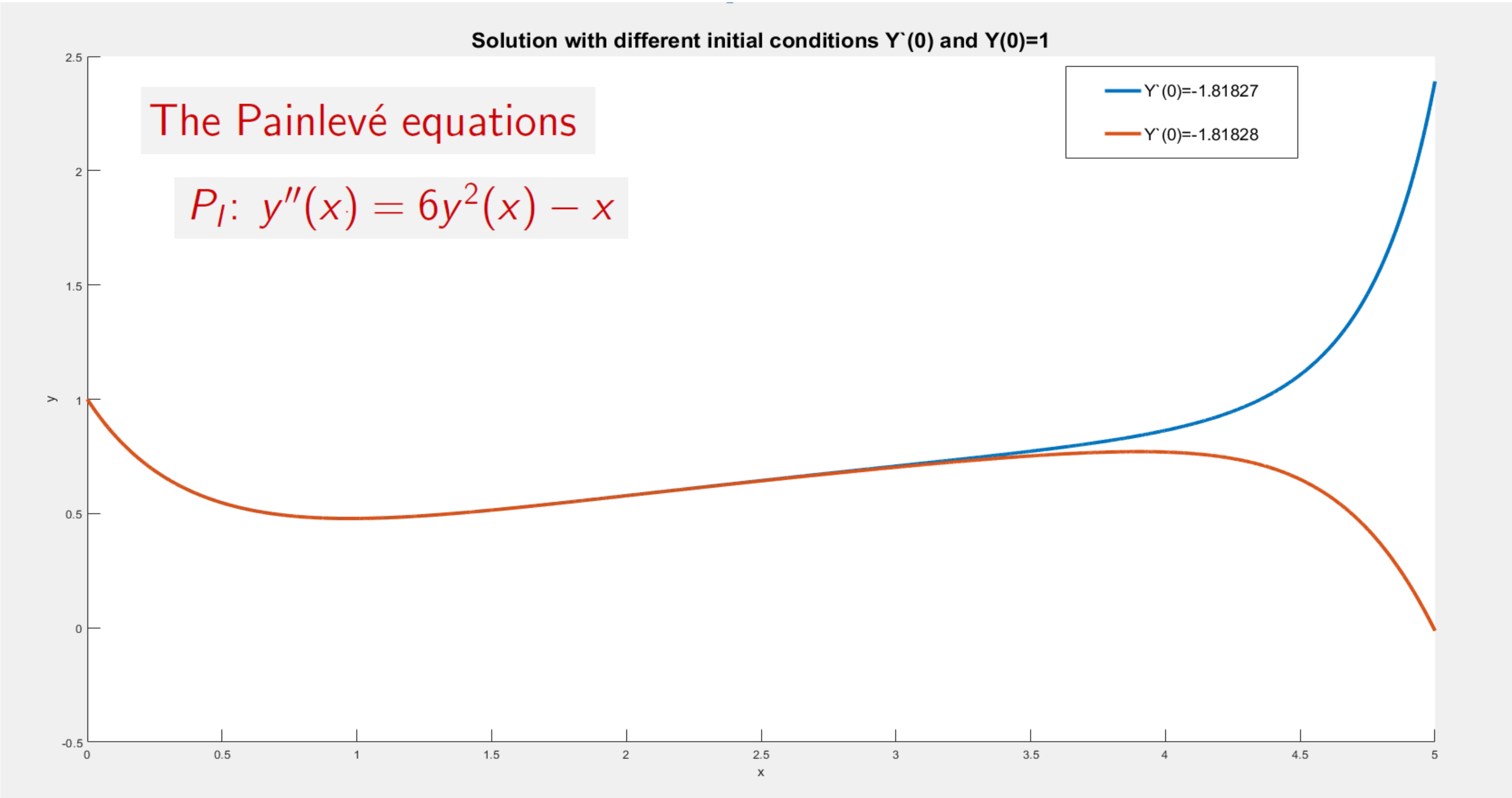
- Fixing one sophisticated model, calibration can be performed using different methodologies employing different data.
- Calibrated model parameters are obtained for each method.
- Model prices are calculated for unobservable products and again prices can vary significantly.



CASE STUDY : BUTTERFLY EFFECT

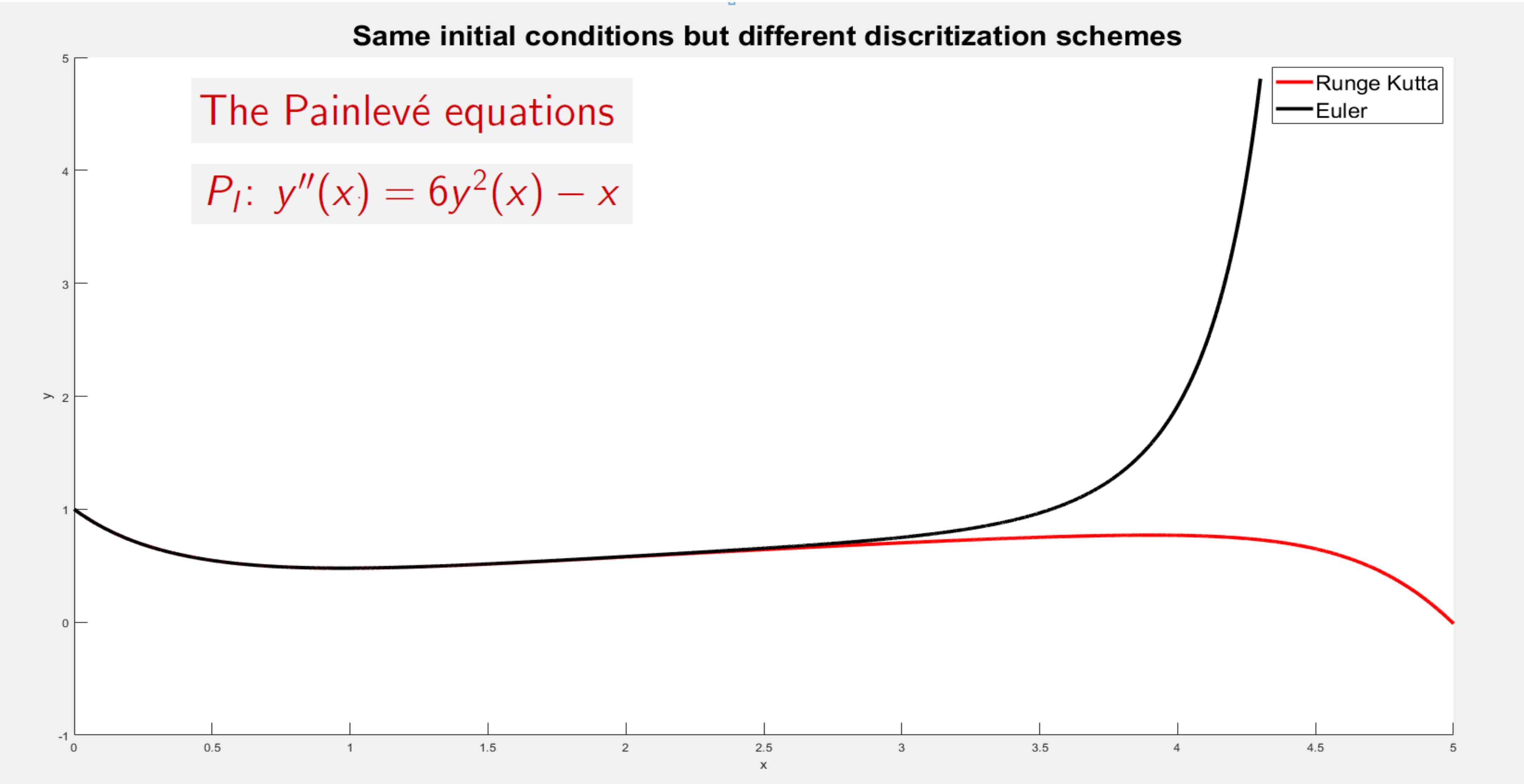
The Butterfly Effect

The strong sensitivity of systems to small differences in the initial conditions.



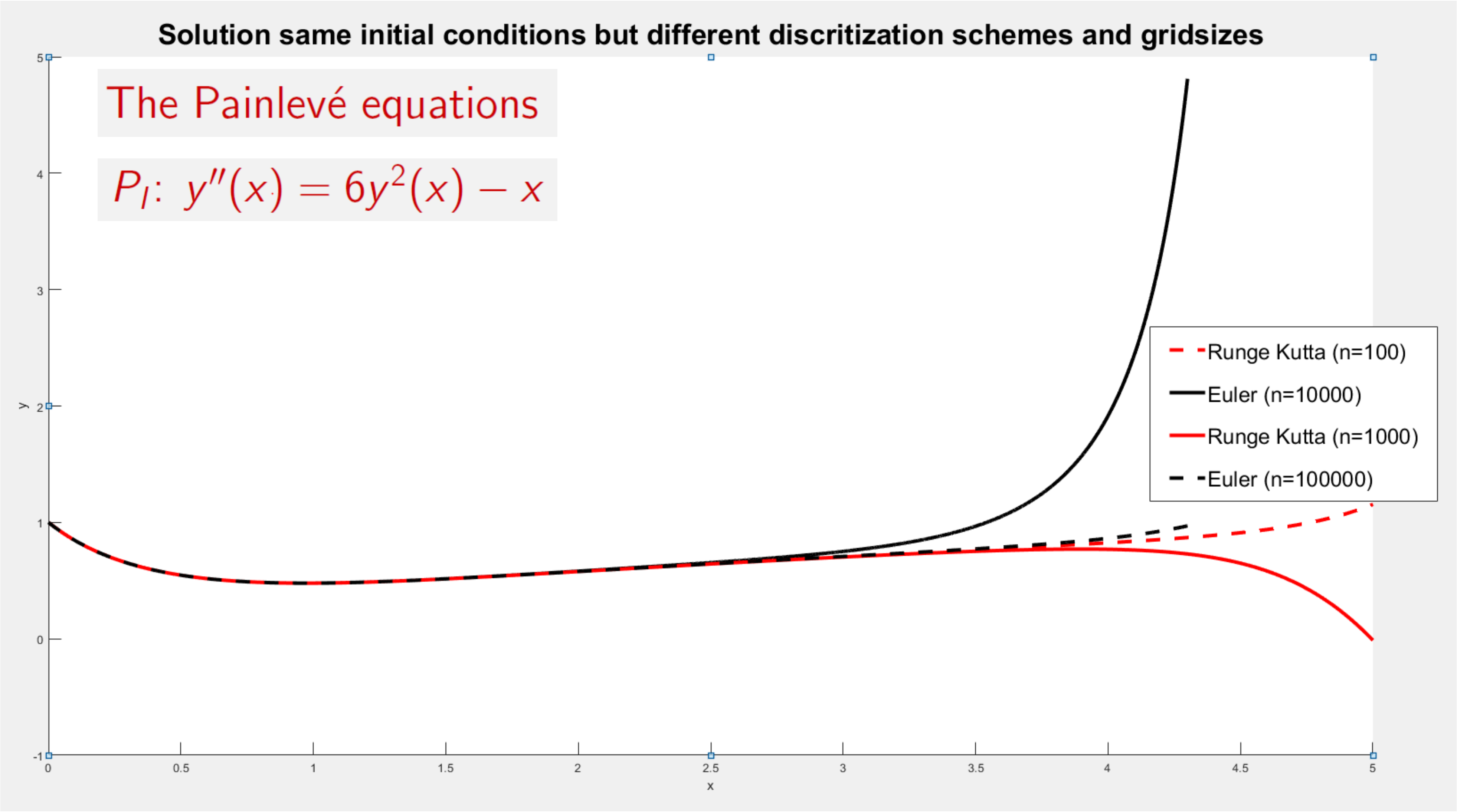
The Butterfly Effect and Numerical Schemes

The strong sensitivity of systems to numerical schemes.



The Butterfly Effect and Numerical Schemes

The strong sensitivity of systems to grid size.



CASE STUDY : CLIMATE MODELLING

Climate Models – Mass-Energy Conservation

One of the most fundamental requirements of any physics-based model of climate change is that it must conserve mass and energy.

Editorial Type: Article

Article Type: Research Article

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A Mass and Energy Conservation Analysis of Drift in the CMIP6 Ensemble

Damien Irving, Will Hobbs, John Church, and Jan Zika

Online Publication: 18 Mar 2021

Print Publication: 01 Apr 2021

Collections: Earth's Energy Imbalance and Energy Flows through the Climate System

DOI: https://doi.org/10.1175/JCLI-D-20-0281.1

Page(s): 3157–3170

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Abstract/Excerpt | Full Text | PDF | Supplementary Materials

Abstract

Coupled climate models are prone to "drift" (long-term unforced trends in state variables) due to incomplete spinup and nonclosure of the global mass and energy budgets. Here we assess model drift and the associated conservation of energy, mass, and salt in CMIP6 and CMIP5 models. For most models, drift in globally integrated ocean mass and heat content represents a small but nonnegligible fraction of recent historical trends, while drift in atmospheric water vapor is negligible. Model drift tends to be much larger in time-integrated ocean heat and freshwater flux, net top-of-the-atmosphere radiation (netTOA) and moisture flux into the atmosphere (evaporation minus precipitation), indicating a substantial leakage of mass and energy in the simulated climate system. Most models are able to achieve approximate energy budget closure after drift is removed, but ocean mass budget closure eludes a number of models even after dedrifting and none achieve closure of the atmospheric moisture budget. The magnitude of the drift in the CMIP6 ensemble represents an improvement over CMIP5 in some cases (salinity and time-integrated netTOA) but is worse (time-integrated ocean freshwater and atmospheric moisture fluxes) or little changed (ocean heat content, ocean mass, and time-integrated ocean heat flux) for others, while closure of the ocean mass and energy budgets after drift removal has improved.

Denotes content that is immediately available upon publication as open access.

Supplemental information related to this paper is available at the Journals Online website: https://doi.org/10.1175/JCLI-D-20-0281.s1.

Corresponding author: Damien Irving, damien.irving@unsw.edu.au

Climate Models – Mass-Energy Conservation

- Coupled climate models are prone to "drift" (long-term unforced trends in state variables) due to non-closure of the global mass and energy budgets.

- Causes:
  - *"The first relates to deficiencies in model coupling, numerical schemes and/or physical processes."*
  - *"… potential issues with the data that are archived and made available to the research community."*

The causes of the energy and mass leaks we identify are many and varied but must essentially belong to one of two categories. The first relates to deficiencies in model coupling, numerical schemes and/or physical processes. For example, the heat flux associated with water transport across the ocean boundary generally represents a global net heat loss for the ocean, because evaporation transfers water away at a temperature typically higher than precipitation adds water. The documented size of this global heat loss ranges from 0.15 (Delworth and Dixon 2006) to 0.30 W m^{-2} (Griffies et al. 2014). In a steady state, this heat loss due to advective mass transfer is compensated by ocean mass and heat transport, which is in turn balanced by atmospheric transport. However, most atmospheric models do not account for the heat content of their moisture field, meaning they represent the moisture mass transport but not the heat content transport (Griffies et al. 2016). Leakage in the simulated global heat budget therefore arises due to a basic limitation of the modeled atmospheric thermodynamics.

The second category has nothing to do with deficiencies of the model itself and instead relates to potential issues with the data that are archived and made available to the research community. For example, in discussions about ocean heat

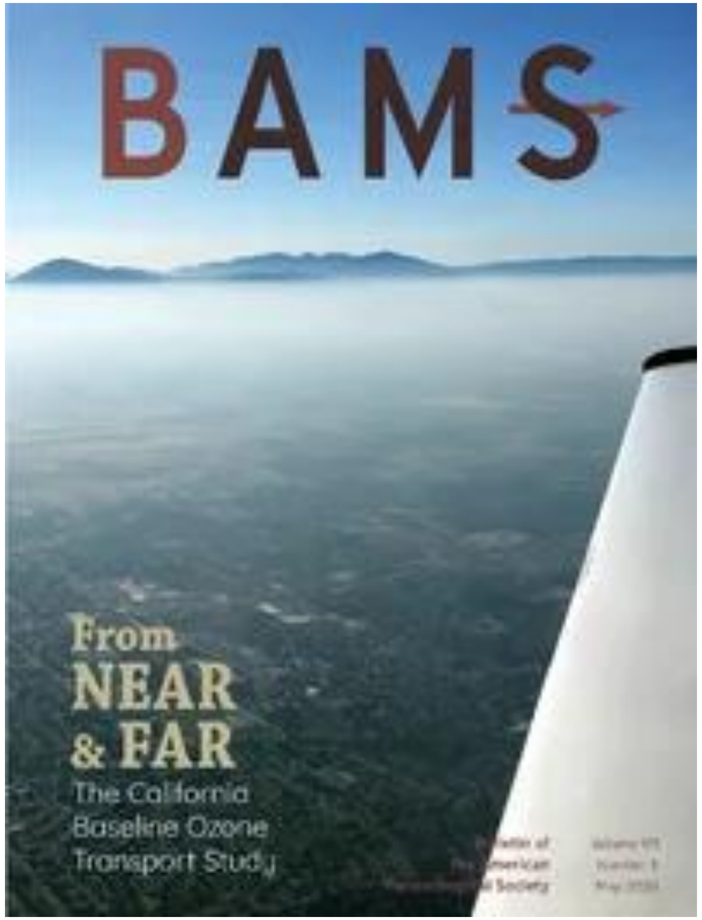
CONCLUSION:
Coupled models are prone to "drift". There are hence serious problems when it comes to our reliance on climate models.

Cfr. Finance:

Imagine valuating derivatives not respecting risk-neutrality.

Climate Models – Grid Size

Today’s grid spacing of global climate models is in the range 50-100 km, leading to staggering large uncertainties in climate projections.



Editorial Type: Article

Article Type: Research Article

Free access

Kilometer-Scale Climate Models: Prospects and Challenges

Christoph Schär, Oliver Fuhrer, Andrea Arteaga, Nikolina Ban, Christophe Charpilloz, Salvatore Di Girolamo, Laureline Hentgen, Torsten Hoefler, Xavier Lapillonne, David Leutwyler, Katherine Osterried, Davide Panosetti, Stefan Rüdisühli, Linda Schlemmer, Thomas C. Schulthess, Michael Sprenger, Stefano Ubbiali, and Heini Wernli

Online Publication: 01 May 2020

Print Publication: 01 May 2020

DOI: https://doi.org/10.1175/BAMS-D-18-0167.1

Page(s): E567–E587

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Abstract/Excerpt | Full Text | PDF

Abstract

Currently major efforts are underway toward refining the horizontal resolution (or grid spacing) of climate models to about 1 km, using both global and regional climate models (GCMs and RCMs). Several groups have succeeded in conducting kilometer-scale multiweek GCM simulations and decadelong continental-scale RCM simulations. There is the well-founded hope that this increase in resolution represents a quantum jump in climate modeling, as it enables replacing the parameterization of moist convection by an explicit treatment. It is expected that this will improve the simulation of the water cycle and extreme events and reduce uncertainties in climate change projections. While kilometer-scale resolution is commonly employed in limited-area numerical weather prediction, enabling it on global scales for extended climate simulations requires a concerted effort. In this paper, we exploit an RCM that runs entirely on graphics processing units (GPUs) and show examples that highlight the prospects of this approach. A particular challenge addressed in this paper relates to the growth in output volumes. It is argued that the data avalanche of high-resolution simulations will make it impractical or impossible to store the data. Rather, repeating the simulation and conducting online analysis will become more efficient. A prototype of this methodology is presented. It makes use of a bit-reproducible model version that ensures reproducible simulations across hardware architectures, in conjunction with a data virtualization layer as a common interface for output analyses. An assessment of the potential of these novel approaches will be provided.

Supplemental material: https://doi.org/10.1175/BAMS-D-18-0167.2

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Climate Models – Grid size

Kilometer-Scale Climate Models: Prospects and Challenges

Christoph Schär, Oliver Fuhrer, Andrea Arteaga, Nikolina Ban, Christophe Charpilloz, Salvatore Di Girolamo, Laureline Hentgen, Torsten Hoefler, Xavier Lapillonne, David Leutwyler, Katherine Osterried, Davide Panosetti, Stefan Rüdisühli, Linda Schlemmer, Thomas C. Schulthess, Michael Sprenger, Stefano Ubbiali, and Heini Wernli

Online Publication: 01 May 2020
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DOI: https://doi.org/10.1175/BAMS-D-18-0167.1
Page(s): E567–E587

- Uncertainties remain staggering high.
- Even extreme values cannot be excluded.
- Key driver is computational resolution (grid size) together with the importance of small-scale processes.
- These small scale processes can significantly amplify or reduce global warming.

While the basic scientific concepts of anthropogenic climate change are now well established, uncertainties in climate projections have remained staggeringly large. For instance, current estimates of the equilibrium climate sensitivity (ECS)—the equilibrium global surface warming in response to a doubling of atmospheric CO_2 concentration—are between 1.5° and 4.5°C. Over the last 40 years, this uncertainty range, covering a probability of 66%, has not narrowed (National Research Council 1979), and according to the most recent IPCC assessment report, even extreme values of the ECS (below 1°C and above 6°C) cannot be excluded (IPCC 2013). This evident uncertainty makes it difficult to plan for adequate response strategies essential to mitigate the anticipated warming. Reducing this uncertainty is also of paramount importance in order to provide more reliable projections of sea level rise, regional climate change, and extreme events, which are essential to climate change adaptation.

The key reason behind the slow progress in reducing the uncertainties of climate projections is likely the lack of adequate computational resolution, together with the importance of small-scale processes in the climate system. In particular, there is evidence that the response of tropical and subtropical clouds may significantly amplify or reduce global warming, depending upon changes in cloud reflectivity with global warming (Bony and Dufresne 2005; Sherwood et al. 2014; Schneider et al. 2017, 2019). Likewise, eddy-resolving ocean models are expected to contribute toward reducing uncertainties in ECS by better representing ocean heat uptake (e.g., Gregory et al. 2002; Ringler et al. 2013; Hewitt et al. 2017), but in the current article we will focus on atmospheric models.

CONCLUSION:
Computational resolution is still a problematic key issue.

Cfr. Finance:
Imagine running a Monte Carlo for valuating a path dependent exotic with time steps in the order of one month.

Climate Models – Cloud formation

Published: 19 November 2014

Climate forecasting: Build high-resolution global climate models

Tim Palmer

Nature **515**, 338–339 (2014) | Cite this article

- Cloud approximations are the main source of errors and uncertainties in climate simulations.
- Simulations of climate change are very sensitive to some of the parameters associated with these approximate representations of convective cloud systems[4].

Grand challenges

The greatest uncertainty in climate projections is the role of the water cycle – cloud formation in particular – in amplifying or damping the warming effect of CO_2 in the atmosphere[2]. Clouds are influenced strongly by two types of circulation in the atmosphere: mid-latitude, low-pressure weather systems that transport heat from the tropics to the poles; and convection, which conveys heat and moisture vertically.

Global climate simulators calculate the evolution of variables such as temperature, humidity, wind and ocean currents over a grid of cells. The horizontal size of cells in current global climate models is roughly 100 kilometres. This resolution is fine enough to simulate mid-latitude weather systems, which stretch for thousands of kilometres. But it is insufficiently fine to describe convective cloud systems that rarely extend beyond a few tens of kilometres.

Simplified formulae known as 'parameterizations' are used to approximate the average effects of convective clouds or other small-scale processes within a cell. These approximations are the main source of errors and uncertainties in climate simulations[3]. As such, many of the parameters used in these formulae are impossible to determine precisely from observations of the real world. This matters, because simulations of climate change are very sensitive to some of the parameters associated with these approximate representations of convective cloud systems[4].

CONCLUSION:
There are huge uncertainties in current global climate models. Small scale processes (thunderstorms, rain showers, cloud processes, ocean eddies, …) are very important but not yet modelled accurately enough.

Cfr. Finance:

Imagine valuating vol-swaps with models without particular important stylized features like stochastic volatility.

Back-testing

"We show that both the magnitude of the trend in the AMOC over different time periods and often **<u>even the sign</u>** of the trend differs between observations and climate model ensemble mean, with the magnitude of the trend difference becoming even greater when looking at the CMIP6 ensemble compared to CMIP5."

PHILOSOPHICAL TRANSACTIONS A

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Discussion

Cite this article: McCarthy GD, Caesar L. 2023 Can we trust projections of AMOC weakening based on climate models that cannot reproduce the past? *Phil. Trans. R. Soc. A* **381**: 20220193.
https://doi.org/10.1098/rsta.2022.0193

Received: 10 March 2023
Accepted: 20 June 2023

One contribution of 13 to a discussion meeting issue 'Atlantic overturning: new observations and challenges'.

Subject Areas:
oceanography

Keywords:
Atlantic meridional overturning circulation, climate models, observational reconstructions

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Can we trust projections of AMOC weakening based on climate models that cannot reproduce the past?

Gerard D. McCarthy[1] and Levke Caesar[2,3]

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The Atlantic Meridional Overturning Circulation (AMOC), a crucial element of the Earth's climate system, is projected to weaken over the course of the twenty-first century which could have far reaching consequences for the occurrence of extreme weather events, regional sea level rise, monsoon regions and the marine ecosystem. The latest IPCC report puts the likelihood of such a weakening as 'very likely'. As our confidence in future climate projections depends largely on the ability to model the past climate, we take an in-depth look at the difference in the twentieth century evolution of the AMOC based on observational data (including direct observations and various proxy data) and model data from climate model ensembles. We show that both the magnitude of the trend in the AMOC over different time periods and often even the sign of the trend differs between observations and climate model ensemble mean, with the magnitude of the trend difference becoming even greater when looking at the CMIP6 ensemble compared to CMIP5. We discuss possible reasons for this observation-model discrepancy and question what it means to have higher confidence in future projections than historical reproductions.

This article is part of a discussion meeting issue 'Atlantic overturning: new observations and challenges'.

THE ROYAL SOCIETY PUBLISHING

CONCLUSION:

Back testing is not satisfactorily. Trend and even the sign are often different with observed reality.

Cfr. Finance:

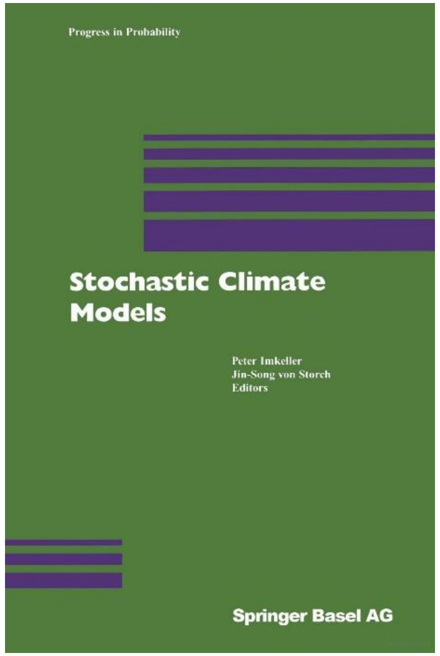
Imagine model prices of derivatives would be systematically off with the actual traded prices…

PETER IMKELLER (Berlin, GER) und ILYA PAVLYUKEVICH (Jena, GER)

Vom Nutzen und Nachteil komplexer Klimamodelle

Im Februar und März 2013 arbeitete am ZiF die Kooperationsgruppe ›Erforschung der Variabilität des Klimas: physikalische Modelle, statistische Inferenz und stochastische Dynamik‹ unter der Leitung von Peter Imkeller (Mathematik, Berlin), Holger Kantz (Physik, Dresden) und Ilya Pavlyukevich (Mathematik, Jena). Ein Interview über die Schwierigkeiten, das komplexe System Klima zu modellieren, wissenschaftliche Bescheidenheit und die Erwartungen der Politik.

Das Gespräch führte Manuela Lenzen.



PETER IMKELLER: Wir möchten Prozesse natürlich so gut verstehen, dass wir auch ihre zukünftige Entwicklung prognostizieren können. Das Phänomen El Niño kann man bis sechs Monate vor Eintreten zuverlässig vorhersagen. Das, was sich jetzt als Temperaturerwärmung zeigt, in die fernere Zukunft zu prognostizieren, das kann niemand.

PETER IMKELLER: Man sieht schon, dass die Temperaturen jetzt um ein oder zwei Grad höher sind, aber wenn man das mit den Zyklen vergleicht, die hinter dem Klima stehen, und etwa die Zwischeneiszeit oder die Eiszeitzyklen betrachtet, da veränderte sich die Temperatur in sehr kurzer Zeit um sechs bis zehn Grad. Jetzt spricht man von zwei bis fünf Grad bis 2060.

PETER IMKELLER: Modellieren kann man immer. Das reale Geschehen hinter den Modellen verstehen, das sollte man versuchen. Aber das Prognostizieren ist enorm schwierig. Wir neigen dazu, ein wenig zu übertreiben, wenn wir davon sprechen, was wir durch Wissenschaft und Technologie beherrschen können. Für mich sind die Erkenntnisse in der Klimatologie und in der Mathematik, die mit der Klimatologie zu tun hat, immer mit dem Eingeständnis einer gewissen Bescheidenheit verbunden. In der Gesellschaft hat die Klimaforschung eine hohe Akzeptanz. Aber was Projektionen unserer Einflüsse angesichts der schwer überschaubaren und komplexen z. B. astronomischen Zyklen im Hintergrund langfristig bedeuten, das ist schwer zu sagen.

PETER IMKELLER: Wie gesagt, ich glaube, dass die Temperaturen sich verändert haben. Wenn man unseren Klimatologen folgt, sind die besten Prognosen für lokale Veränderungen aufgrund von Modellsimulationen heute nicht besser als die, die auf linearen Prognosemodellen beruhen und mit Hilfe von sogenannten Regressionen gewonnen werden. Aber für die nicht-linearen Systeme, die hinter der Klimamathematik stehen, sind Übergänge zwischen so genannten metastabilen Zuständen typisch. Das heißt, für einige Zeit bewegen sich die Werte in der Umgebung eines bestimmten Wertes und dann plötzlich kommt ein ganz abrupter Übergang in die Umgebung eines

There are huge uncertainties in long-term climate models

- Forecasting is enormously challenging.
- Climate involves many non-linear chaotic dynamics with butterfly effects.
- It's difficult to say what projections of our influences mean in the long term, given the difficult-to-forecast and complex background.

CONCLUSION:

Do not to put too much trust in models that intrinsically can not with high certainty model the aspects of a very complex reality one wants to model.

Main Conclusions

In sustainable finance there are plenty of significant risks which are not fully recognized with potential huge impacts.

ESG investing is from a quantitative finance point of view a SCAM: “Higher returns and lower risks” is a fairy tail.

Enforcing ESG via regulation increases systemic risk.

There are huge uncertainties in long-term climate models and hence in all derived societal and financial decisions around it.