

TOULOUSE ECONOMISTS ON **Asset Management**

ANNUAL REPORT 2017 - 2018

R E S E A R C H H I G H L I G H T S

ARNAUD REYNAUD

Mapping the risk
of water conflict

RENÉ GARCIA

How well do hedge
funds perform?

CHRISTIAN GOLLIER

Investing in a
better world



Amundi
ASSET MANAGEMENT

 Toulouse
School
of Economics

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R E S E A R C H H I G H L I G H T S

“ One of our main objectives was to draw a spatially explicit data-driven index to help policymakers monitor the dynamics that influence water-related issues.

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“ We aim at finding a family of admissible positive measures that are particularly suited to evaluate the performance of complex dynamic strategies.

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“ Two prices drive most financial decisions: the price of time, which is the interest rate, and the price of risk.

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EXPERTS IN PARTNERSHIP

How can finance become a tool for improving our society, and how should we take into consideration the well-being of future generations? How can understanding the behavior of individual investors help asset managers to better serve their clients? What is the impact of the risks associated with natural resources on long-term investment? These are some questions at the heart of the research partnership between Amundi and TSE on asset management and responsible investments.

2018 was an eventful and a productive year for our research collaboration and it is a great pleasure to highlight some of the most recent projects and activities that have stemmed from the partnership. Arnaud Reynaud presents his work on water-conflict risks, explaining how his team's explicit data-driven index can help policymakers to monitor the dynamics that influence water-conflict issues. René Garcia provides his analysis on how investors best evaluate the performance of hedge funds. His work reveals considerable variation in funds' rankings depending on the evaluation approach and investors attitudes towards asymmetry or tail risks. Meanwhile, Christian Gollier in his book "Ethical Asset Valuation" shows how the valuation of long-term risk and time, based on transparent moral principles, can help to guide our choices for the future.

2019 promises to be full of exciting events on long term investing at TSE, among which the launch of the TSE Sustainable Finance Center. The Center is dedicated to profound and relevant academic research centered around Sustainable Finance and Responsible Investments, Financial Technologies and Digital Markets, Financial Intermediaries and Regulation, and Financial Markets (in)Efficiency.

I hope you enjoy reading, and I extend you my best wishes for the New Year.



Milo Bianchi (TSE researcher)
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MEET THE RESEARCHERS

World-class economics



MARIANNE ANDRIES

An assistant professor in finance, Marianne joined TSE in 2012. Her areas of interest are asset pricing and behavioral finance theory. After working as an investment banker, she did her PhD in finance at Chicago University. She was a visiting researcher at Banque de France in 2016-2017.



MILO BIANCHI

Formerly an associate professor at Paris-Dauphine University, Milo has been a TSE researcher since 2013. A junior member of the Institut Universitaire de France, he also won the 2014 AFSE Malinvaud Prize for best published paper among economists under age 40. With a PhD from Stockholm School of Economics, his interests include financial and behavioral economics and corporate finance.



RENÉ GARCIA

After several years at EDHEC Business School as a Chair professor in Finance, René has recently rejoined Montreal University where he taught econometrics and finance from 1991 until 2007. A graduate of ESSEC with a PhD from Princeton, he is the co-founder and former editor-in-chief of the Journal of Financial Econometrics. His research interests include the valuation of financial assets, portfolio and risk management, nonlinear and regime-switching models.



CHRISTIAN GOLLIER

Alongside Jean Tirole, Christian created TSE and subsequently served as director. His interests include decision theory under uncertainty, environmental economics, finance, investment, consumption theory, insurance and cost-benefit analysis. Christian has published over 100 articles in top-tier journals and seven books including The Economics of Risk and Time, winner of the 2001 Paul A Samuelson Award. He is also a knight of the Legion of Honor.



ALEXANDER GUEMBEL

Alexander is a professor of finance at the Toulouse School of Management, where he is affiliated with CRM and TSE. Alexander's research in finance focuses on incentive problems and information aggregation. He was visiting Professor at London Business School. His work has been published in the Journal of Finance, Review of Economic Studies, European Economic Review and the Journal of the European Economic Association.



NOUR MEDDAHI

After 10 years' teaching at Montreal University, Nour became a TSE professor in 2013, returning to the city where he earned his PhD. He is also an associate editor of the Journal of Business and Economics Statistics. His research interests include financial econometrics, econometrics, time-series, asset pricing and risk management.

In the fast-changing landscape of today's financial markets, Amundi representatives can draw directly on the knowledge networks, nuanced opinion and latest discoveries of TSE's research hub.

Here, we present some of the leading economists involved in the partnership.



SÉBASTIEN POUGET

Professor of finance at University of Toulouse Capitole and Director of Research Partnerships at TSE, Sébastien has also taught asset management and behavioral finance at Princeton. He studies financial markets using a multidisciplinary approach that combines insights from economics, psychology and history.

His research has been published in international academic journals. He is co-director of the research center on Sustainable Finance and Responsible Investment (FDIR chair).



NICOLAS TREICH

A research director at INRA (French Institute for Research in Agriculture), Nicolas combines his work at TSE with his position as co-editor-in-chief of the Geneva Risk and Insurance Review. His research concerns risk and decision theory, environmental economics and benefit-cost analysis. He has published several scientific papers including some on the precautionary principle, the value of statistical life and climate policy. He has organized several international conferences, and has written various broad audience papers and reports on risk policy issues.



ARNAUD REYNAUD

Deputy director of the TSE-R research program, Arnaud is also research director at INRA (French Institute for Research in Agriculture). He is a natural resource economist with a strong specialization in water economics. He has worked on dynamic models for water allocation across heterogeneous agents and has conducted research for the Joint Research Centre of the European Commission. He won the Quality of Research Discovery Award by the American Association of Agricultural Economics in 2006.



STÉPHANE VILLENEUVE

Professor of applied mathematics and dean of the mathematics department at University of Toulouse Capitole, Stéphane is also affiliated with the Centre for Research in Management (CNRS) and TSE.

He coordinates the Market Risk and Value Creation Chair, sponsored by SCOR under the aegis of the Fondation du Risque. His research focuses on stochastic methods in finance and more recently on their applications in dynamic contracting.

PARTNERS IN ACTION

Research for a better world

Amundi representatives can access cutting-edge economic research and interact with TSE members at regular events organized by the partnership. Structured around key research themes, here we feature some of the partnership's recent activities and relevant publications.

TO FIND OUT MORE ABOUT THE PARTNERSHIP: www.tse-fr.eu/amundi

SOME RECENT RESEARCH

- ▶ Milo Bianchi, *"Financial Literacy and Portfolio Dynamics"*, Journal of Finance, vol. 73, n. 2, pp. 831–859, 2018.
- ▶ Milo Bianchi (with Jean-Marc Tallon), *"Ambiguity Preferences and Portfolio Choices: Evidence from the Field"*, Management Science, 2018.
- ▶ René Garcia (with Caio Almeida, Kym Ardison, and Jose Vicente), *"Non-Parametric Tail Risk, Stock Returns and the Macroeconomy"*, Journal of Financial Econometrics, 15-3, 333–376, 2017.
- ▶ René Garcia (with Caio Almeida), *"Economic Implications of Nonlinear Pricing Kernels"*, Management Science, 63-10, 3361–3380, 2017.
- ▶ Christian Gollier, *"Stochastic volatility implies fourth-degree risk dominance: Applications to asset pricing"*, Journal of Economic Dynamics and Control, 2018.
- ▶ Christian Gollier (with Simon Dietz and Louise Kessler), *"The climate beta"*, Journal of Environmental Economics and Management, vol. 87, pp. 258–274, January 2018.
- ▶ Alexander Guembel (with James Dow and Itay Goldstein), *"Incentives for Information Production in Markets where Prices Affect Real Investment"*, Journal of the European Economic Association, vol. 15, n. 4, pp. 877–909, 2017.
- ▶ Nour Meddahi (with Prosper Dovonon, Silvia Goncalves and Ulrich Hounyo), *"Bootstrapping high-frequency jump tests"*, Journal of the American Statistical Association, 2018.
- ▶ Nour Meddahi (with Silvia Goncalves and Ulrich Hounyo), *"Bootstrapping Pre-Averaged Realized Volatility under Market Microstructure Noise"*, Econometric Theory, 33, 791–838, 2017.
- ▶ Nour Meddahi (with Tim Bollersley), *"High Dimensional Multivariate Realized Volatility Measures"*, Journal of Econometrics, 2018.
- ▶ Sébastien Pouget (with Will Goetzmann and David Le Bris), *"The Present Value Relation Over Six Centuries: The Case of the Bazacle Company"*, Journal of Financial Economics, 2018.
- ▶ Sébastien Pouget (with Julien Sauvagnat and Stéphane Villeneuve), *"A Mind is a Terrible Thing to Change: Confirmation Bias in Financial Markets"*, The Review of Financial Studies, vol. 30, n° 6, p. 2066–2109, 2017.

- Sébastien Pouget (with Paula Margaretic), *"Sovereign bond spreads and extra-financial performance: An empirical analysis of emerging markets"*, International Review of Economics and Finance, 2018.
- Arnaud Reynaud (with Manh-Hung Nguyen and Cécile Aubert), *"Is there a demand for flood insurance in Vietnam? Results from a choice experiment"*, Environmental Economics and Policy Studies, 2018.
- Arnaud Reynaud (with Bruna Grizzetti, Denis Lanzasova and C. Liquele), *"Going Green? Ex-post Valuation of a Multipurpose Water Infrastructure in Northern Italy"*, Ecosystem Services, vol. 27, pp. 70–81, October 2017.
- Arnaud Reynaud (with Denis Lanzasova), *"A global meta-analysis of the value of ecosystem services provided by lakes"*, Ecological Economics, vol. 137, pp. 184–194, July 2017.
- Arnaud Reynaud, *"Science and Management of Intermittent Rivers and Ephemeral Streams (SMIRES)"*, Research Ideas and Outcomes, n. 3, 2017.
- Nicolas Treich (with Carole Bernard and Christoph Rheinberger), *"Catastrophe Aversion and Risk Equity in an Interdependent World"*, Management Science, 2018.
- Nicolas Treich (with Christoph Rheinberger), *"Attitudes Toward Catastrophe"*, Environmental and Resource Economics, vol. 67, n° 3, p. 609–636, July 2017.
- Nicolas Treich (with Matthew Adler), *"Utilitarianism, Prioritarianism, and Intergenerational Equity: A Cake Eating Model"*, Mathematical Social Sciences, vol. 87, p. 94–102, July 2017.
- Nicolas Treich (with Matthew Adler, David Anthoff, Valentina Bosetti, Greg Garner and Klaus Keller), *"Priority for the worse-off and the social cost of carbon"*, Nature Climate Change, p. 443–449, July 2017.
- Stéphane Villeneuve (with Sébastien Pouget and Julien Sauvagnat), *"A Mind is a Terrible Thing to Change: Confirmation Bias in Financial Markets"*, The Review of Financial Studies, vol. 30, n° 6, p. 2066–2109, 2017.
- Stéphane Villeneuve (with Jean-Paul Décamps, S. Gryglewic and E. Morellec), *"Corporate Policies with Temporary and Permanent Shocks"*, The Review of Financial Studies, vol. 30, n° 1, p. 162–210, 2017.

WORKING PAPERS

- René Garcia (with Caio Almeida and Kym Ardison), *"Nonparametric Assessment of Hedge Fund Performance"* Université de Montréal and TSE, 2018.
- René Garcia (with Carlos Campani), *"Approximate Analytical Solutions for Consumption and Portfolio Decisions under Recursive Utility and Finite Horizon"*, 2018.
- René Garcia (with Carlos Campani), *"Optimal Portfolio Strategies in the Presence of Regimes in Asset Returns"* 2017
- René Garcia (with Veronika Czellar and François Le Grand), *"Limited participation in the joint behavior of asset prices and individual consumptions"*, 2017.
- Christian Gollier (with Frédéric Cherbonnier), *"The economic determinants of risk-adjusted social discount rates"*, TSE Working Paper, n. 18-972, 2018.
- Christian Gollier, *"On the efficient growth rate of carbon price under a carbon budget"*, TSE Working Paper, n. 18-952 2018, revised November 2018.
- Christian Gollier, *"Valuation of natural capital under uncertain substitutability"*, TSE Working Paper, n. 17-813, 2017, revised December 2018.
- Sébastien Pouget (with Jieying Hong and Sophie Moinas), *"Learning in Speculative Bubbles: An Experiment"*, TSE Working Paper, n° 18-882, 2018.
- Sébastien Pouget (with Marie Brière and Loredana Ureche), *"BlackRock vs Norway Fund at Shareholder Meetings: Institutional Investors' Votes on Corporate Externalities"*
- Stéphane Villeneuve (with Tiziano De Angelis and Fabien Gensbittel), *"A Dynkin game on assets with incomplete information on the return"*, TSE Working Paper, n° 17-815, 2017.

LINKED EVENTS

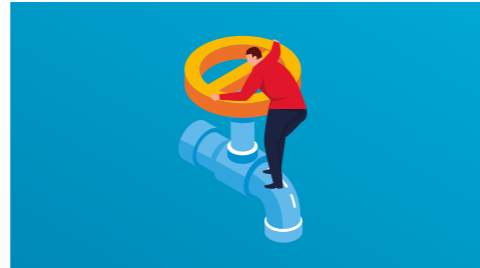
- **WORKSHOP ON FACTOR INVESTING** (Amundi, June 2018)
 - René Garcia (TSE): *Robust Assessment of Hedge Fund Performance through Nonparametric Discounting*
 - Nour Meddahi (TSE): *High-Dimensional Multivariate Realized Volatility Estimation*
- **WATER MANAGEMENT CONFERENCE** (AFG, September 2018)
 - Arnaud Reynaud (TSE): *Cooperation and Conflict in International River Basins: Findings From an Empirical Analysis*
 - Valentin Jouvenot (University of Genève): *Does Water Management Improve Corporate Value?*
- **FINANCIAL ECONOMETRICS CONFERENCE** (TSE, May 2018)
 - Conference Organizers: Jihyun Kim, Nour Meddahi

DISTINCTIONS/PRIZES OF OUR RESEARCHERS

- **Nour Meddahi** was elected member of the Regional Standing Committees of the Econometric Society in January, 2018 and Fellow of the Econometric Society in November, 2018. The Econometric Society is an international society for the advancement of economic theory in its relation to statistics and mathematics.
- **Marianne Andries** and Guillaume Vuillemeys (HEC) won the *4nations cup 2018* last June. This event brings the most promising young scholars in financial economics together in one day of "mini seminars". The four nations that competed for the cup were: France, Germany, Sweden, and the UK.
- **Christian Gollier** has been elected President of the European Association of Environmental and Resource Economists (EAERE). He will serve as President-Elect in 2018 and 2019. The EAERE is an international scientific association which aims to contribute to the development of environmental and resource economics as a science; to improve communication between teachers, researchers and students in environmental and resource economics and to encourage the cooperation between university-level teaching and research institutions.
- **Milo Bianchi** has been appointed as a junior member of the Institut universitaire de France by the French minister of higher education and research.
- **Stéphane Villeneuve** has been appointed as a member of a working group on green finance organized by the Institut Louis Bachelier and by Pierre-Louis Lions from Collège de France. This project aims to develop multidisciplinary interactions between research chairs and laboratories, to increase the visibility of the French research community in the field of sustainable finance.
- **Sébastien Pouget** has been appointed member of Principles for Responsible Investments Academic Network committee as well as a member of the scientific committee of the Principles for Responsible Investments Academic Network conference which will take place on September 9, 2019.

MAPPING THE RISK OF WATER CONFLICT

Arnaud Reynaud



Exacerbated by population growth and climate change, competition over water resources is a rising threat to global stability. In 'An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues', TSE's Arnaud Reynaud and his coauthors offer policymakers a valuable new empirical tool to identify areas where water disputes are likely to develop.

Water crises have been placed among the major risk factors for the coming decades by the Global Risks Perception Surveys conducted by the World Economic Forum between 2015 and 2017. Concerns about water-related conflict led to the inclusion in the UN's 2030 Agenda for Sustainable Development of a specific indicator on "Proportion of transboundary basin area with an operational arrangement for water cooperation" (6.5.2), together with "Degree of integrated water resources management implementation" (6.5.1), for the assessment of Target 6.5 "Water resources management".

Increasing demographic pressure, environmental degradation, and climate change impacts on water spatio-temporal distribution represent the largest determinants of current and future water-related issues. Nevertheless, the analytic evidence of the correlation between violent conflicts and climatic factors is not completely clear, and new methods are needed to pursue a scientifically sound and quantitative assessment of available information.

In our study, we analyzed the pre-conditions favoring the insurgence of water management issues in shared water bodies. We chose not to make a distinction between past episodes of cooperation and dispute over water, using them collectively as 'hydro-political interactions', a measure of the magnitude of the associated water issue. This was motivated by the fact that water disputes have rarely ended in violent conflicts, at least in recent times, and by the consideration that classification of interactions as cooperative or conflictive has often been arbitrary and ambiguous.

MACHINE-LEARNING ANALYSIS

Our empirically based analysis correlated past transboundary water interactions with information about river basin freshwater availability, climate stress, human pressure on water resources, socioeconomic conditions (including institutional development and power imbalances), and topographic characteristics. Using a machine-learning tool, the Random Forests regression algorithm, this analysis allowed us to identify of the main factors that determine water interactions. We found population density to be among the

top drivers, while climate factors were less important in terms of magnitude, but more relevant in terms of impacted area extent.

Our research also highlighted the non-linear nature of the relations between certain variables and their impact on the hydro-political interactions. The increasing inverse U-shaped relation between population density and water interactions could be explained by the role of hydraulic infrastructures in mitigating water stress in densely populated areas, and the extreme consequences when water infrastructure can no longer cope with climatic variability and population growth.

Almost opposite results are found for per capita water availability: in areas where water availability is lowest, increasing values are associated with a marginal decrease in the likelihood of water issues. The slightly negative relation is, however, non-linear: it is positive in areas where relatively more water is available and almost negligible in water-abundant areas.

Relative territorial supremacy was found to have an inverse U-shaped relation: the likelihood of water interactions appears to be very low among actors occupying similar territorial extensions of the shared river basin; similar conclusions could be drawn for countries occupying the majority of the basin territory, while hydro-political interactions are found to be more likely in the middle cases.

Low to medium levels of national power were associated with a higher likelihood of water interactions. Very upstream and very downstream countries are more likely to get involved in water interactions. Rural and agriculturally dependent economies and, in general, lower to middle income countries are more prone to experience water issues.

HYDRO-POLITICAL GEOGRAPHY

One of the main objectives of this study was to draw a spatially explicit data-driven index aimed to help policymakers monitor the dynamics of the factors that influence water-related issues, and in identifying areas at risk of water disputes. To achieve this objective, we calculated the medium-term mean (1997–2012, when available) of the selected indicators at the highest spatial resolution allowed by

data availability, and used our model to map the likelihood of hydro-political interactions.

High likelihood of water-related issues could be determined by potential water scarcity in densely populated areas, as in the Nile Delta, which reaches a high average value on the index (score 0.761). Socioeconomic, political conditions and distribution of water resources determine the differences in the index for the Upper Nile. A combination of low governance, high population density, physical water stress, and almost complete economic dependency on agricultural activities, shaped the distribution of the index in the Ganges-Brahmaputra (highest in our ranking, score 1.000), and Indus basins (score 0.675). More pronounced precipitation stress, lower population density and lower economic dependency on agricultural production characterized the Euphrates-Tigris river basin (score 0.592). Population density, high economic dependence on agriculture, and human pressure on water resources determine the distribution of the index on the lower Niger (score 0.447), in particular within the borders of Burkina Faso and Nigeria.

Population distribution and socioeconomic conditions shape the index in the Congo basin (score 0.432), while relatively good governance characterizes the Zambezi, with hotspots in the most populated areas, and increasing values towards the outlet of the basin (overall score 0.431). Human pressure and relatively heterogeneous socioeconomic conditions determine the need for water cooperation in the Mekong basin (score 0.492). Despite the progress made after EU integration, our results highlight high likelihood of water issues in the Danube basin (score 0.499), especially in the eastern and southern parts where institutional development needs to be consolidated and economic dependency on agriculture remains relevant.

Some of the areas highlighted in the results are well-known hotspots for hydro-political issues. Other areas suffer from political tensions not directly related with water. Although direct comparison with previous studies is not possible, given our different focus on water interactions as a measure of the magnitude of water issues, the results of the different approaches are aligned. Of the 12 basins we found to be more likely to experience water issues, 10 are identified as basins at risk in previous analyses, namely: Ganges/Brahmaputra, Pearl/Bei Jiang, Nile, Feni (or Fenney), Indus, Colorado, Tarim, Shatt al-Arab – Tigris/Euphrates, Hari, and Irrawaddy.

POPULATION AND CLIMATE THREATS

To estimate trends for hydro-political interactions under future conditions (2050 and 2100), we compared our baseline outline to four distinct climate and population density projections, including scenarios of moderate and extreme climate change. We found that the combination of climate and population growth dynamics will considerably elevate overall hydro-political risk, with an average increase in water interactions in the main transboundary river basins ranging from 74.9% by 2050 with moderate climate change, to 95% by 2100 with extreme climate change.

The convergence of the increasing trends in population density and temperature, together with decreasing precipitation, is the combination that most increases hydro-political risk, as in the case

of Southern Europe, Central Asia, and Middle East. Increasing population and temperature were found to be dominant with respect to increasing precipitation, as in the case of some tropical areas in sub-Saharan Africa and South-East Asia, in some cases due to the seasonal distribution of the rainfall. Harsher climate conditions offset the benefits derived by decreasing population density, as in the case of North-Eastern China in the second half of the 21st century. Only a handful of transboundary basins – characterized by low population density and, in northern latitudes, abundant water availability – are expected to benefit from or not be impacted by climate and population changes.

The difficulties and the limitations encountered in this study were multiple. Water-events databases are extremely hard and expensive to collect and to manage. Data collection is mostly conducted through the application of mining algorithms operating in the news databases available only in the most widely spoken western languages. For this reason, the available datasets are necessarily biased and incomplete. The time period covered is very limited (only 11 years in our case) and sub-national geographic characteristics of the specific water-related events is, in the majority of the cases, not considered.

RESEARCH FOR A BETTER FUTURE

We hope to boost interest in the hydro-political field of study by offering a new perspective and a methodology that had never been considered before in this kind of analysis, and by exploring the possibility of creating a spatially explicit interactive tool to assist stakeholders and policymakers in dealing with water-related issues. Future studies could further develop the instrument by integrating updated socioeconomic, biophysical, and demographic projections.

Our index should be considered for systematic application in assessment of Sustainable Development Goal 6, in particular concerning the impacts of future potential biophysical or socio-environmental changes on the likelihood of hydro-political issues at global scale, as well as other SDGs, such as SDG 16 on peace, justice and institutions. We recommend further development of our analysis in regional or sub-regional contexts where more detailed data is available.

The increasing pressure that future climate and population dynamics are expected to pose upon already problematic basins, especially in the Sahelian and Sub-Saharan Africa, Central, South and South-East Asia, should be carefully monitored to avoid hydro-political turmoil. In particular, the institutional and governance capacity of national and supranational institutions should be enhanced to minimize the vulnerability of specific river-basin systems.



The increasing pressure that future climate and population dynamics are expected to pose upon already problematic river basins should be carefully monitored

HOW WELL DO HEDGE FUNDS PERFORM?

René Garcia



How can investors best evaluate the performance of hedge funds? In a new paper, 'Nonparametric Assessment of Hedge Fund Performance', TSE's René Garcia and his coauthors propose a new class of performance measures based on empirically identifiable stochastic discount factors (SDFs). Their analysis reveals considerable variation in funds' rankings depending on the evaluation approach and investor attitudes towards asymmetry or tail risks.

Investment management and portfolio performance evaluation go hand in hand. Professional portfolio managers propose services to investors in the form of funds. Pension committees, endowments or retail investors need to assess whether the proposed funds achieve a superior performance to the portfolios they could form given their available information. Investors will seek funds that deliver a superior performance achieved with dynamic strategies built on a refined information set.

To evaluate performance, investors rely mainly on a series of ratios or on a Jensen's alpha with respect to a set of benchmark assets. In a seminal paper, Chen and Knez (1996) propose a general framework for evaluating the performance of a managed portfolio with respect to a set of benchmarks and specify a set of conditions for a performance measure to be admissible. These conditions exclude the Jensen's alpha measure but accept a large set of positive admissible measures that guarantee no-arbitrage when evaluating managed returns. However, their empirical analysis, focused in analyzing a subset of mutual fund returns, concentrates only on two versions of the Hansen and Jagannathan (1991) SDF, the unconstrained and the non-negatively constrained ones. The performance measures implied by these two SDFs are both admissible but not always positive. Positivity (or not) of these measures directly depends on the particular dataset of observed benchmark returns.

In our paper, we aim at finding a family of admissible positive measures that are particularly suited to evaluate the performance of complex dynamic strategies. Performance evaluation for hedge funds has been mainly conducted with linear factor models that include the index returns of main asset classes and the returns on derivative positions with respect to these benchmarks. This approach recognizes that hedge funds can short assets and use derivatives to manage their portfolios, creating highly nonlinear payoffs. However, the performance measure is not guaranteed to be positive, and positivity is fundamental to rank managed funds consistently. Moreover, the linear exposure to the derivative factor payoffs does not capture the concave relations between the individual hedge fund strategy and

the derivative benchmark returns since the inherent strike positions of the latter usually differ from the fund position.

HIGHER-ORDER MOMENTS

We provide a broad set of strictly positive SDFs, all sensitive to higher moments of the joint distribution of the benchmark assets and each generating a positive admissible performance measure. The performance is shown to depend on all the co-moments of the benchmark returns with each hedge fund returns, generalizing the linear factor models that include co-skewness and co-kurtosis with the market returns.

From an investor perspective, our measures give more weight to positive returns in states of nature where marginal utility is high (bad times), a feature that traditional performance measures fail to capture. Each measure puts different weights on the states of nature and in this sense can be assimilated to an investor with a particular attitude towards risk. In contrast to utility-based evaluation of performance, our approach is nonparametric and based on pricing exactly the benchmark risk factors.

We minimize general convex functions of SDFs called Minimum Discrepancy (MD) measures to obtain a projected nonlinear SDF that prices exactly a set of selected reference assets. A well-known example of such discrepancy measures is the Kullback-Leibler information criteria or entropy. Our family of discrepancy functions offers other information criteria that have different implications for assessing performance.

The solutions for the nonlinear SDFs are obtained through dual portfolio problems that are easier to solve than the primal problems. This extends the duality between the minimum-variance SDF and the quadratic portfolio problem in Hansen and Jagannathan (1991). The first-order conditions for these portfolio optimization problems provide solutions for the optimal weights of the chosen reference assets. We provide a complete estimation and inference theory for these weights and the resulting performance alpha, which measures the expected discounted value of the fund return under the nonlinear SDF. Given the

small number of returns often found in individual hedge fund returns, we complement these asymptotic tests with bootstrap tests.

The implementation of the performance measurement tests involves the selection of the benchmark factors, also called reference or basis assets. We choose four sets of reference assets that have been used in the literature on alpha measurement in hedge funds. The most popular set is the ten-factor model from Fung and Hsieh (2001), where risk factors including equities, bonds, credit, currencies, and commodities are considered together with several trend-following strategies. We also include a nine-factor model which considers the options strategies from Agarwal and Naik (2004). The Carhart (1997) four-factor model and the CRSP value-weighted market portfolio are added for comparison purposes and completeness.

MULTIPLE FILTERS

We apply our methodology to a panel of 4815 individual hedge funds. Commercial hedge fund databases suffer from severe biases: in particular, survivorship and backfill. They can also suffer from serious problems such as hedge funds with excessive zero returns, consecutive equal returns, and repeated "blocks" of returns. We apply the strictest filters that have been put forward to eliminate patterns that could bias our findings.

In our empirical analysis, we contrast our approach with the Jensen's alpha as well as the Hansen and Jagannathan (1991) measure used in Chen and Knez (1996). Our family of measures will be indexed by a parameter ν that will capture the curvature of the functions optimized in our dual portfolio problems. A Taylor expansion of our performance measure shows the intrinsic relationship between the fund's performance and its sensitivity to the higher-order mixed moments with respect to the benchmark assets. In particular, depending on the value of ν more or less weight is given to, say, co-skewness and co-kurtosis. For values close to one (Hansen and Jagannathan case) the weights assigned to higher-order moments are negligible, as in the case of the Jensen's alpha. On the contrary, moving to the negative values ($\nu < 0$), positive weights are assigned to co-skewness and negative weights are assigned to co-kurtosis. Rather than computing co-skewness and co-kurtosis statistics with respect to the market returns, our method is neither restricted to a single asset nor does it rely on imprecise estimates of higher-order co-moments.

EMPIRICAL FINDINGS

First, we consider the statistical significance of the selected reference assets. A reassuring fact is that all investors will want to hold a statistically significant positive share of the market, regardless of the set of factors we consider. With the Carhart (1997) set of factors, both the high-minus-low and the momentum factors are significant and all investors are long in these two factors in the dual portfolio. With the Fung and Hsieh (2001) set of factors, the credit spread appears as an additional significant asset held positively in all portfolios, while the only significant trend-following strategy is to short the stock lookback straddle. The results for the Agarwal and Naik (2004) model are somewhat consistent. The weights assigned to the S&P 500 index returns increase substantially when the options are introduced in

the estimation of the dual portfolios, and remarkably all investors short out-of-the-money puts and buy the at-the-money ones.

Next, we compute the alpha performance measures for the categories of strategies used in the database to group the individual hedge funds based on their own reporting. The first conclusion is that the estimated Jensen's alpha and Hansen-Jagannathan alpha are practically identical for all categories of hedge funds. More notable differences appear for other values of the curvature parameter ν . For several categories such as CTA, fixed-income arbitrage, global macro, managed futures and funds of funds, the estimate for very negative values of ν is much lower than in the linear case and becomes often not statistically different from zero. These differences at the aggregate level of fund categories are indicative of strong heterogeneity in performance at the individual fund level.

A first important statistic is the percentage of individual funds with a positive and statistically different-from-zero performance. While for the linear model the percentage is around 20% for the various sets of factors, it falls considerably for all values of ν to around 13%. In terms of cross-sectional distributions, the estimated alphas differ considerably between the ν 's and across the sets of reference assets. We also show that the ranking of the funds differs considerably between the Jensen's alpha measure and our new proposed measures putting more weight on bad states of the world.

SUMMING UP

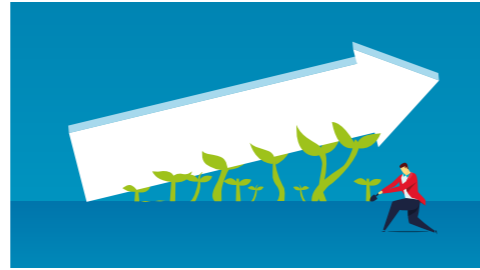
We propose a new class of performance measures for hedge fund returns based on a family of empirically identifiable SDFs. These measures incorporate no-arbitrage pricing restrictions and naturally embed information about higher-order mixed moments between hedge fund and benchmark factors returns. We provide a full asymptotic theory for our SDF estimators to test for the statistical significance of each fund's performance and for the relevance of individual benchmark factors within each proposed measure.

Our empirical analysis reveals that fewer funds have a statistically significant positive alpha compared to the Jensen's alpha obtained by the traditional linear regression approach. Moreover, the funds' rankings vary considerably between the two approaches. Performance also varies between the members of our family because of a different fund exposure to higher-order moments of the benchmark factors, highlighting the potential heterogeneity across investors in evaluating performance.

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A reassuring fact is that all investors will want to hold a statistically significant positive share of the market, regardless of the set of factors we consider

INVESTING IN A BETTER WORLD

Christian Gollier



By controlling the allocation of capital, financial markets hold the key to the great challenges of our time, such as the fight against poverty, climate change, and cancer. In his latest book, 'Ethical Asset Valuation and the Good Society', TSE co-founder Christian Gollier suggests that this power can only be harnessed if we can determine the financial prices that are compatible with the public good. In particular, he shows how the valuation of long-term risk and time, based on transparent moral principles, can help to guide our choices for the future.

Can financial markets decentralize an efficient allocation of scarce resources? There are strong arguments, well studied at TSE, for believing that markets are not good at eliciting our collective values or aligning private interests with the public good. Agency problems such as moral hazard and adverse selection inhibit market efficiency, and the inability to trade with future generations prevents markets from efficiently valuing assets and investments that benefit future generations. More importantly, corporate profits do not fully internalize the impacts from production on social welfare. For example, the emission of greenhouse gases remains mostly free of charge, despite their destructive impact.

If markets are unable to aggregate our collective values, how can we evaluate private and public acts? How should we, for example, compare environmental protection with job protection, lives in Bangladesh versus purchasing power in Europe, workplace safety against corporate profits, reduced inequality versus growth, or more consumption today or in 200 years? Debating social values should be at the root of our democracy. If these values are incompatible with observed market prices, then public authorities should implement corrective actions.

THE PRICE OF TIME

Two prices drive most financial decisions: the price of time, which is the interest rate, and the price of risk. The choice of interest rate determines whether we do too much, or too little, for future generations. Too high an interest rate inhibits investment for the future. Too low an interest rate induces excessive investment, forcing people to sacrifice too much current well-being.

The level of our collective aversion to inequality is a key determinant of the socially desirable interest rate. In a growing economy, investing for the future increases intergenerational inequality. So the interest rate should be the minimal rate of return on a safe investment that

compensates for this increased inequality. If Western consumption per capita continues to grow at 2 percent per year, people living two centuries from now will be more than 50 times wealthier. This context justifies a high discount rate of 4 per cent per year.

However, deep uncertainty engulfs the distant future. Just as households make sacrifices by saving more when their future income becomes more uncertain, we should collectively make more effort to improve a more uncertain future. To encourage investment, we need to lower the discount rate slightly below twice the anticipated growth rate of consumption for risk-free benefits materializing within the next two to three decades. For more distant time horizons, deep uncertainty justifies discount rates close to 0 per cent.

THE PRICE OF RISK

Many investments for the future increase collective risk, as their benefits are larger when consumption is greater. Penalizing risk-increasing actions therefore reduces investment, which inhibits innovation and growth. Has the tradeoff favored the maximization of growth, or the minimization of risk?

It is socially desirable to adjust the discount rate to the risk profile of each investment project by adding an investment-specific risk premium. In keeping with the calibration of the interest rate, a risk premium of around 1 percent should be used at short maturities, for projects whose risk profile is similar to the macroeconomic risk. But because of the deep uncertainty surrounding the distant future, an aggregate risk premium of 2.5 percent should be used for very long maturities.

Financial markets penalize firms that increase the aggregate risk by raising their cost of capital. A 1-to-2.5 percent risk premium is in line with the equity premium imposed by markets on riskier firms. Much more worrying is the absence of any formal penalization of risk in the evaluation of public policies in most countries.

COST-BENEFIT ANALYSIS

Many countries have established implicit prices to evaluate the actions of public institutions. These include prices for human lives, time lost, natural assets, and carbon, in sectors as diverse as energy, transportation, health, science, and education. These prices are subject to much debate among experts; but these debates remain inaccessible to the public, and this is unacceptable.

Ultimately, collective decisions should be made by comparing costs and benefits, using a coherent system of values. This includes a value for delaying consumption (an interest rate), a value for risk acceptance (a risk premium), and values for all the non-monetary impacts of our actions.

As well as improving our decisions, cost-benefit analysis is an important tool in the fight against populism. Lack of evaluation reinforces the impression that policies are driven by ideology rather than the common good. Instead, democracy can be strengthened by forcing politicians to make explicit the values on which their decisions are made.

“As well as improving our decisions, cost-benefit analysis is an important tool in the fight against populism”

How can we encourage investors to be more socially responsible?

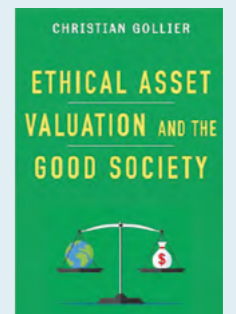
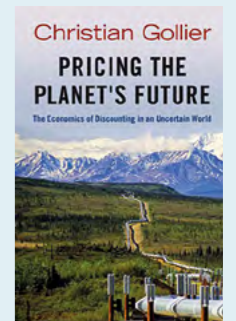
In conversation with Christian Gollier

“In my book, I try to combine the basic principles leading to a transparent methodology for evaluating investment choices with a socially responsible approach. I propose identifying the different sources of non-financial performance, such as safety at work or the reduction of inequalities, as well as the various emissions of pollutants. In addressing socially responsible investment (SRI) funds, my aim is to make them aware of the importance of including carbon prices and negative externalities into their investment valuations and portfolio allocations, as well as simply maximizing returns.”

“For example, companies are currently obliged to publish their carbon emissions in their annual reports. SRI funds should therefore look at corporate emissions and multiply them by the price of carbon, and then re-incorporate this cost in their valuations. They should also adopt the same method for other negative externalities, and even for positive externalities such as well-being within the company and wage increases for the lowest paid employees (possibly because of relocation), which helps reduce global inequality.”

“In general, SRI funds adopt a ‘best-in-class’ view, but without really quantifying emissions. Instead they make relative comparisons between companies according to their degree of social responsibility. My approach goes much further. I propose using quantitative finance techniques, particularly the Markowitz model, on dividend-per-share profitability data, which includes non-financial performance ethically evaluated under an SRI filter. It doesn’t matter that SRI funds post different values for positive and negative externalities. What is important is that investors can choose in accordance with their own ethical preferences. This would also make SRI funds more transparent, and therefore more attractive.”

FURTHER READING: Christian refers quantitatively frustrated readers of *“Ethical Asset Valuation”* (2017) to his other recent book, *“Pricing the Planet’s Future”* (2012), which provides more extensive technical details.



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