Building the analytical foundations for greening the financial system

The first report of the International Network for Sustainable Financial Policy Insights, Research and Exchange – INSPIRE

INSPIRE

About INSPIRE

The International Network for Sustainable Financial Policy Insights, Research and Exchange (INSPIRE) is co-chaired by Ilmi Granoff, Director of ClimateWorks Foundation's sustainable finance programme, and Nick Robins, professor in practice for sustainable finance at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science (LSE). INSPIRE's trajectory is guided by an Advisory Committee who provide domain expertise independently but in close interface with the work priorities of the Network for Greening the Financial System (NGFS). Chaired by Nick Robins, the INSPIRE Advisory Committee consists of Pierre Monnin (Council on Economic Policies), Jakob Thomä (2° Investing Initiative), and Yao Wang (International Institute of Green Finance of Central University of Finance and Economics). Philanthropic support for INSPIRE is provided by ClimateWorks, and commissioning research is seed-funded by the ClimateWorks and Children's Investment Fund Foundation. www.climateworks.org/inspire/ **Contact:** inspire@climateworks.org

About the secretariat institutions

The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science (LSE). The Institute brings together international expertise on economics, finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute – Climate Change and the Environment at Imperial College London. www.lse.ac.uk/grantham/

ClimateWorks Foundation is a global platform for philanthropy to innovate and accelerate climate solutions at scale. It delivers global programmes and services that equip philanthropy with global knowledge, networks and solutions to drive climate progress. Since 2008, ClimateWorks has granted over $1billion to more than 500 grantees in over 40 countries. www.climateworks.org/

About the advisory committee institutions

The Council on Economic Policies (CEP) is an international non-profit nonpartisan economic policy think tank for sustainability based in Zurich, Switzerland. CEP formulates and promotes economic policy solutions that strengthen individual opportunity, social cohesion and environmental stability. It focuses on designing appropriate fiscal, monetary and trade policy frameworks. CEP was founded in 2012. www.cepweb.org/

The 2° Investing Initiative is the leading global think tank on sustainable finance and the main beneficiary of European research funding on the topic. The organisation is not-for-profit and non-commercial. It helps develop the regulatory frameworks, performance metrics, data, and tools to support the integration of financial markets with climate goals. 2° Investing Initiative has introduced climate scenario analysis of investment and lending portfolios into regulatory frameworks (France, EU, California); investors' and banks' practices (for more than 900 users and €60 tn of assets); and supervisory practice (UK, EU, California and Japan). 2° Investing Initiative's research on the suitability assessment test in Europe triggered, via the High-Level Expert Group on Sustainable Finance, the reform of the Markets in Financial Instruments Directive (MiFID) and the insurance distribution directive (IDD), introduced by the European Commission regulatory package on sustainable finance. 2degrees-investing.org/

The International Institute of Green Finance (IIGF) of Central University of Finance and Economics (CUFE) is an independent and non-profit think tank based in Beijing, China. Its goal is to support the development of green finance in China as well as internationally. IIGF grew out of the Research Centre for Climate and Energy Finance (RCCEF), which was founded in September 2011. IIGF is specialised in research, policy advice and consulting in green finance, climate finance, energy finance, green insurance, carbon-trading, information disclosure, and risk assessment. http://iigf.cufe.edu.cn/

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Foreword by the Chair of the Network for Greening the Financial System

Frank Elderson, Chair of the NGFS, Executive Board Member of the Dutch Central Bank

The task of greening the world's financial system needs to be based on a robust evidence base, innovative analytical approaches and policy-relevant conclusions. That is why I am so pleased to see this first report from INSPIRE, one of the research stakeholders of the Network for Greening the Financial System (NGFS).

Central banks and financial supervisors have a strong research tradition and in the NGFS, we recognise the importance of working with the international research community to help inform our efforts to incorporate climate risk and green finance into our operational routines. INSPIRE is one of the NGFS' research stakeholders and this first INSPIRE report provides a useful overview of the breadth of work that is now underway, the initial findings that are emerging, as well as the hurdles that are yet to be overcome.

I welcome this report and the wider efforts of INSPIRE in informing and inspiring central banks and supervisors by advancing the understanding of the appropriate tools, methodologies, and empirical and theoretical evidence necessary to identify, quantify and mitigate climate- and other environment-related risks. I am very impressed that INSPIRE has already commissioned 21 research projects and regards this only as a starting point in a much bigger research agenda that will be expanded in the years to come. Across the NGFS workstreams on micro-prudential risk, macro-financial stability, the scaling up of green finance and the work that we are starting on data, there are a range of research questions in front of us. The support of INSPIRE and the wider research community in tackling those questions is indispensable.

The COVID-19 crisis has only served to deepen our commitment at the NGFS. We face not only a public health crisis, as the climate crisis has not just suddenly disappeared. This is the time to invest once and for all in a truly resilient and sustainable economy. The core agenda of the NGFS and the immediate issue of greening recovery measures both need to be underpinned by in-depth and independent research. The NGFS is looking forward to continue our collaboration and dialogue with the INSPIRE research community so that we can respond to this systemic responsibility and opportunity.

Foreword by the INSPIRE Co-Chairs and Advisory Committee

Ilmi Granoff (Co-chair), ClimateWorks Foundation

At the One Planet Summit in December 2017, a small but global network of central banks and supervisors, the Network for Greening the Financial System (NGFS), bravely stepped forward to consider their role in protecting society from the risks of climate change and environmental degradation and in promoting a more sustainable economy and financial system. INSPIRE was created in response. It represents an effort to mobilise the research community in support of these financial authorities: to equip and encourage – indeed, inspire – financial policy action that meets the urgency of the crisis posed by climate change and environmental degradation, based on the best available evidence and analysis. The body of work summarised here represents INSPIRE's initial efforts to rise to the challenge, and equip the NGFS members for ambitious action. It lands in a changed world. Central banks and supervisors have shown they can react forcefully in an emergency, but the question remains: can we build back a better, more prudent system that is resilient to the climate crisis?

Nick Robins (Co-chair and Advisory Committee Chair), Grantham Research Institute on Climate Change and the Environment

In little over a year, INSPIRE has moved from being an interesting idea to becoming a fully operational international network of researchers. This report contains the first harvest of insights from 21 INSPIRE research teams commissioned in 2019 and demonstrates how fresh analytical approaches can support central banks and financial supervisors in their efforts to align their decision-making with the Paris Agreement and the Sustainable Development Goals. As a research stakeholder of the Network for Greening the Financial System (NGFS), INSPIRE has benefitted from dialogue and feedback from a growing number of central bank officials and regulators, enabling us to identify research that can have greatest impact. The COVID-19 crisis has only deepened the need for this combination of profound thinking and practical approaches. In the year ahead, INSPIRE's work will be framed by the need to build a sustainable recovery out of this severe health and economic emergency, providing the evidence base for the next phase in central bank implementation.

Yao Wang, International Institute of Green Finance of Central University of Finance and Economics

The regulation of finance should be compatible with a sustainable future. Research is crucial in developing this kind of regulation. While 21 dedicated projects funded by INSPIRE have started this development, there still exist many issues that need to be addressed. On the one hand, open questions are concerned with how financial regulators can prevent and resolve long-term and highly uncertain climate change-related and environmental risks. This has implications for the traditional framework and method of prudential regulation, which need to be extended and updated. On the other hand, questions remain on how to actively encourage the financial sector to support greener growth (especially after COVID-19). This means that the traditional mandate and toolkit of financial regulators need to be reconsidered and redesigned. With regard to both aspects, significant research gaps exist on how the financial system can be aligned with sustainable economic development. We look forward to more researchers working together with us on this promising area and creating a sustainable future.

Pierre Monnin, Council on Economic Policies

Central banks' monetary operations are contributing to shaping global finance flows. The conditions under which central banks purchase financial assets, accept these assets as collateral, and provide refinancing operations to banks have an impact on the allocation of equities, bonds and loans in the economy. Research thus far has shown that central banks' monetary policy operations have disproportionally benefitted economic sectors that are not aligned with the climate goals of the Paris Agreement. The massive emergency measures taken by central banks in response to the COVID-19 crisis are likely to reinforce this situation. Several policy options have been proposed to improve this, but these options remain subject to the following questions: Would these policies achieve climate and sustainability goals? Which policies strike the best balance between impact and costs? Are these policies in line with other objectives in central banks' mandate? The 21 projects funded by INSPIRE help to answer these questions and provide welcome inputs for central bankers in policymaking.

Jakob Thomä, 2° Investing Initiative

We may look back on the COVID-19 pandemic as the dawn of the era of existential risk management and supervision. Mega risks like climate change, the growing threat of nuclear conflict, and related issues will represent a new challenge for financial supervisors and central banks. In parallel, the mandate of supervisors and central banks is evolving, both concretely in terms of legislation and in the public perception, to cover a responsibility for ensuring and contributing to the broader sustainability of financial markets and society. These challenges require new tools, models and approaches. It effectively requires supervision beyond the business cycle. In this context, INSPIRE and the 21 projects play a pivotal role in laying out the roadmap to supervising the brave new world of existential risk.

List of abbreviations

ABM	Agent-based model
ASEAN	Association of Southeast Asian Nations
CFTC	Commodity Futures Trading Commission
CMN	Brazilian National Monetary Council
CRA	Credit rating agency
CRFR	Climate-related financial risk
CRI	Global Climate Risk Index
EBA	European Banking Authority
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions
ESG	Environmental, Social and Governance
ESMA	European Securities and Markets Authority
ESMS	Environmental and social management systems
GRI	Global Reporting Initiative
GSF	Green supporting factor
IAM	Integrated assessment model
ICAAP	Internal capital adequacy assessment process
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRI	Initiative for Responsible Investment, Harvard University
LSE	London School of Economics and Political Science
MIFID II	Markets in Financial Instruments Directive
NGFS	Network for Greening the Financial System
OeNB	Oesterreichische Nationalbank
PD	Probability of default
SDGs	Sustainable Development Goals
SEC	United States Securities and Exchange Commission
SSE	Sustainable Stock Exchange Initiative
UN	United Nations
WS	Workstream

1. Introduction

Context and purpose of this report

Achieving the transition to a green and low-carbon economy is pivotal to a sustainable future and how this transition is achieved has far-reaching implications for all financial market participants. While climate change is one of many sources of structural change affecting the financial system, it has distinctive characteristics that require a rethinking of conventional approaches and new and innovative research across many dimensions of the system. INSPIRE – the International Network for Sustainable Financial Policy Insights, Research and Exchange – has been created to contribute towards closing the existing knowledge gaps and enhance research efforts that can inform the work of the Central Banks and Supervisors Network for Greening the Financial System (NGFS), its workstreams and its members.

The aim of this report is to provide an overview of these research efforts and of the 21 projects that INSPIRE has commissioned to date. All but one of these project abstracts were written prior to the COVID-19 crisis. However, in exploring the dimensions of financial risk created by climate- and environment-related disruption, the INSPIRE-commissioned research teams provide vital insights into the opportunities and challenges that can guide central bank and supervisory policymakers to contribute to delivering a green, sustainable and resilient recovery. This overview informs NGFS members, researchers and other stakeholders of the topics and methodological details of the ongoing INSPIRE research projects, as well as future research priorities. INSPIRE seeks to encourage exchange, coordination and cooperation between researchers, NGFS members and other policymakers. The preliminary results of INSPIRE projects presented in this report point towards important policy implications, as well as to the need for further research and exchange between researchers and central banks and supervisors.

This first research overview report outlines the 21 INSPIRE projects that were commissioned in 2019, most of which are ongoing at the time of writing (April 2020). Commissioned from two calls for research proposals, these projects respond to the broad range of research topics and research questions identified by the NGFS workstreams. The research portfolio of INSPIRE is organised along six broad themes:

1. Microprudential regulation, disclosure, climate change and environment
2. Macroprudential regulation, financial instability, climate change and environment
3. Evaluating risk differentials based on environmental factors
4. Monetary policy, direct and indirect monetary instruments, climate change and the environment
5. Sovereign bonds and climate- and environment-related risk
6. Cross-cutting: Assessing the effectiveness and impact of central bank and supervisory policies in greening the financial system

Moving forward, INSPIRE seeks to further evolve its research portfolio to commission research based on more targeted, single-issue calls that aim to direct research efforts towards cutting-edge topics as identified by INSPIRE, the NGFS and the wider research community. INSPIRE's third call for research, announced in March 2020 and currently under review, aims to enhance the assessment of the effectiveness and impact of central bank and supervisory policies in greening the financial system.

The following sections of this Introduction describe in greater detail INSPIRE's mission, the independent commissioning process and research commissioned directly by the NGFS.

Structure of the report

Section 2 outlines the 21 research projects commissioned from the two calls for proposals issued by INSPIRE in 2019. This section is organised into six subsections. The first five each represent an overarching theme within INSPIRE's current research portfolio and the sixth subsection focuses on the cross-cutting and targeted scope of the third INSPIRE call, released in 2020.

Section 3 outlines future research themes, highlighting specific topics that are a priority for the NGFS and setting out INSPIRE's future plans and ambitions.

INSPIRE's mission and team

INSPIRE was launched in February 2019 with a three point mission:

1. To **commission** independent, gold standard research and policy analysis on central bank and supervisory practice to manage climate risks and promote green finance
2. To **convene** researchers, policymakers and practitioners
3. To **communicate** the results widely

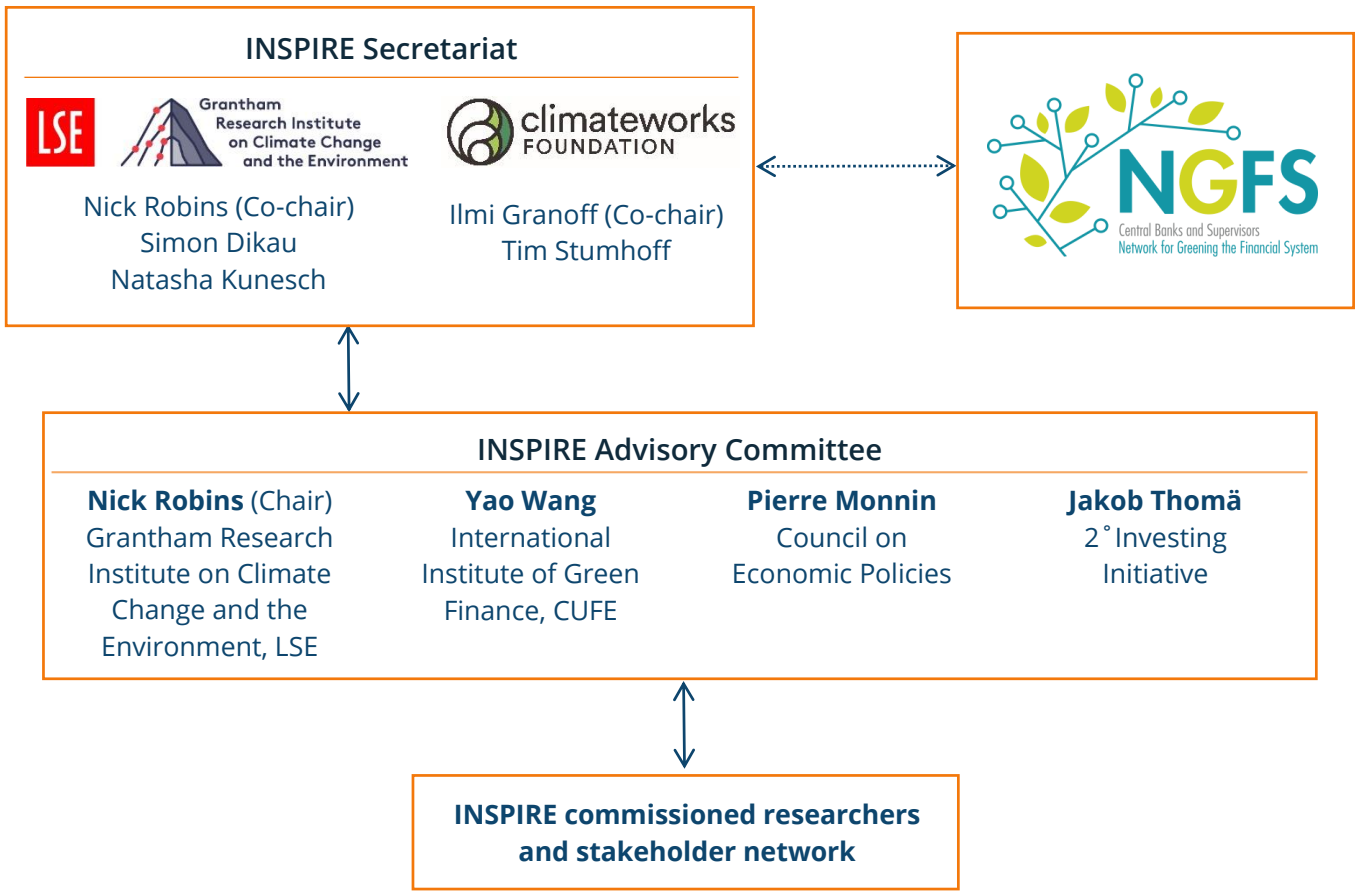
In September 2019, INSPIRE became a global research stakeholder of the Central Banks and Supervisors Network for Greening the Financial System. It specifically supports NGFS members though evidence-based action within the NGFS's three workstreams, thereby enhancing the NGFS's work programme and deliberation. Co-chaired by ClimateWorks Foundation and the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science (LSE), INSPIRE commissions research guided by an Advisory Committee, chaired by Nick Robins (Grantham Research Institute) and with the domain expertise of Pierre Monnin (Council on Economic Policies), Jakob Thomä (2° Investing Initiative) and Yao Wang (Central University of Finance and Economics) and in cooperation with the NGFS's workstreams (Figure 1).

Since its launch at the One Planet Summit in Paris in 2017, the NGFS has continued to expand steadily from the eight founding members to a network of 66 central banks and supervisors, in addition to 12 international organisations from around the globe. Promoting research is key to the NGFS's ability to deliver on its commitments. Within its First Comprehensive Report (NGFS, 2019a), the Network highlighted a number of key research priorities, including:

- Further research on climate-related financial risks in the financial system
- Development of 'green'/'brown' taxonomies and analytical understanding of risk differentials
- More in-depth analysis of environment-related financial risks
- Models that better capture the physical impact on the economy and financial stability
- Scenario analysis, the interaction with mandates and monetary policy frameworks
- Development of tools and methods to assess these risks
- Identification and alleviation of data problems

INSPIRE is aligned with the NGFS's global endeavour and evolving work programme, facilitating new research frontiers to mainstream green finance and advance understanding of climate- and environment-related financial risk. By doing so, INSPIRE contributes to strengthening the financial system's ability to manage these risks and mobilise finance to support the smooth transition to a low-carbon and climate-resilient economy, backed by political mandates such as Article 2.1(c) of the Paris Agreement and international climate- and environment-related targets such as the Sustainable Development Goals (SDGs).

Figure 1. INSPIRE organisational structure



Research commissioning process and outcomes

The primary goal of INSPIRE is to commission cutting edge research on key aspects relating climate change and environmental sustainability to inform the operations of central banks and supervisors. INSPIRE commissioned two calls for research in March and July 2019. These calls responded to the broad range of research topics and research questions in alignment with enhancing the NGFS's three workstreams: microprudential and supervision topics (WS1); analysing the macrofinancial impact of climate change (WS2); and scaling up green finance (WS3), as well as a number of themes that cross-cut these workstreams:

- Under the **microprudential** supervision theme, topics include: the investigation of how environmental factors translate into microprudential risks for financial institutions; the potential (and limitations) of disclosure to address market failures; the methodologies or methods for financial institutions to conduct scenario analysis and/or stress testing.
- Under the **macrofinancial** supervision topic, the main challenges for research include: the improvement of understanding and modelling systemic climate-related risks; the integration of 'long-term risks' into supervisory mandates; practices focused on managing financial stability over the business cycle; and the development of a common set of scenarios for quantitative assessments of climate risks.
- With regard to **scaling up green finance**, priority areas are investigating how far central banks can work to support market growth and incorporating sustainability factors into monetary policy.

- **Cross-cutting** themes include opportunities and limitations of 'green' and 'brown' taxonomies; the identification of green finance response measures to future crises; and questions over new principles and approaches that could be needed.

This broad research agenda continues to evolve as our understanding of green finance topics advances and the NGFS's research priorities develop further. Research into crises is particularly timely owing to the human tragedy and economic disruption caused by the global COVID-19 pandemic. However, as highlighted within the NGFS Annual Report 2019 (NGFS, 2020), climate change remains an urgent and pressing issue requiring collective action from central banks and supervisors, to account for the physical and transitional risks posed by climate change and to support the transition to a resilient and low-carbon economic recovery.

So far, in direct response to the needs of the NGFS and with the goal of advancing the broader research agenda on climate change, central banking and supervision, INSPIRE has commissioned 21 projects on topics relating to the NGFS workstreams, but also on broader, far-reaching themes. The 21 projects commissioned to date are listed in Table 1 and are outlined in greater detail in Section 2 of this report.

Table 1. Commissioned research projects from calls 1 and 2 (2019)

	Principal researcher	Corresponding NGFS workstream
Theme 1: Microprudential regulation, disclosure, climate change and environment		
Mandatory Environmental Social Governance disclosure and financial stability	Dragon Yongjun Tang	1
Supervision beyond the business cycle: A framework for long-term financial supervision	Ben Caldecott	2
Management of climate risks in the financial industry of a resource based economy: A Canadian scenario analysis	Olaf Weber	2
Environmental and social risk management in Brazilian banking: from an environmental and social management structure to climate scenario analysis development	Guilherme Teixeira	1
How could the US Federal Reserve and other financial market supervisors incorporate climate considerations into their responsibilities?	Adele Morris	Cross-cutting
Working Group on Banking Supervision and Sustainable Development in The Americas	Kevin Gallagher	Cross-cutting
Theme 2: Macro-financial risk, macroprudential regulation, financial instability and climate change		
Climate-related financial policy in a world of radical uncertainty – towards a precautionary approach	Josh Ryan-Collins	1
Low-carbon transitions and systemic risk	Jason Eis	3
The stochastic impact of extreme weather events	Amit Kara	2
Assessing forward-looking climate risks in investors' portfolios: from theory to practice	Stefano Battiston	2

	Principal researcher	Corresponding NGFS workstream
Prudential instruments to scale up green finance: simulating the impact of green prudential regulations in an agent-based macrofinancial model	Paola D'Orazio	1
What are the options for sustainable crisis response measures?	Kate Levick	Cross-cutting
Theme 3: Evaluating risk differentials based on environmental factors		
Is credit risk lower for banks' green assets?	Zhong Rui	1
Using credit risk as an empirical basis for the development of 'brown' investment taxonomies	Charles Donovan	Cross-cutting
Estimating the impact of climate physical risks on default probability of mortgage loans	Tianyin Sun	1
Theme 4: Monetary policy, direct and indirect monetary instruments, climate change and the environment		
The role of monetary policy under a low-carbon transition	Jason Eis	2
Greening the Eurosystem collateral framework	Yannis Dafermos	1
Central banks' mandate in green credit guidance: beyond prudential regulation	Muriuki Muriungi	1
Theme 5: Sovereign bonds and climate- and environment-related risk		
Climate change and sovereign credit ratings	Matthew Agarwala	2
The impact of country Sustainable Development Goals performance on sovereign bond spreads	Eline ten Bosch	2
Sovereign risk and climate change	Ulrich Volz	3

The response to INSPIRE's research calls has been global. The first call for INSPIRE research commissions in March 2019 received 28 proposals from research groups representing 14 countries. In July 2019, the second call received double the number of proposals, contributed to by researchers representing institutions in 18 countries spanning all inhabited continents. Geographically, European-led research teams submitted the greatest overall number of proposals and were awarded the largest number of INSPIRE commissions. With future calls, INSPIRE aims to continue broadening the geographical allocation of future research projects and support further research on emerging market and less economically developed contexts.

Third call for proposals

INSPIRE's third call for research proposals focuses on the effectiveness and impact of central bank and supervisory policies in greening the financial system. Issued in March 2020, this call is currently under review. The call is the first in a series of targeted calls focusing on specific research priorities that have been identified through dialogue with NGFS members and insight gained from the first and second

INSPIRE research calls. The emerging research priorities, set out in Section 3 of this report, can be seen as indicative of the future research priorities of INSPIRE.

Exchanging insights

INSPIRE convened a first workshop with 42 participants in September 2019 on 'New Research Frontiers for Greening the Financial System' in association with fellow NGFS research stakeholder, the Global Research Alliance for Sustainable Finance and Investment at Oxford University. With the aim of delivering tangible policy insights, the workshop facilitated an exchange between researchers funded by INSPIRE and central bank policymakers.

To provide the necessary theoretical and empirical evidence for the next phase in central bank implementation and building a sustainable recovery out of the severe health and economic emergency created by COVID-19, INSPIRE will continue to strengthen two-way dialogue between INSPIRE researchers and central banks and supervisors. Future webinars and workshops are planned for 2020 and 2021.

Research commissioned by the NGFS through INSPIRE

INSPIRE works closely with the NGFS and the greater research community through two complementary modalities. Firstly, independently identified research informed by dialogue with the NGFS, which is laid out in Section 2. Secondly, research commissioned directly by the NGFS to inform work products developed by the NGFS. To date, such work includes occasional papers and development of reference scenarios.

Occasional papers

In 2019, INSPIRE supported the efforts of the NGFS Workstream 1 on microprudential and supervision to publish the comprehensive NGFS Occasional Paper *Case studies of environmental risk analysis for financial institutions* alongside its *Handbook of environmental risk analysis for financial institutions*. The NGFS Occasional Paper outlines in detail 30 case studies covering a variety of environmental risk analysis methodologies that have been developed by financial institutions, research organisations and non-governmental organisations. The case studies cover methodologies for banks, insurance companies and asset managers, cross-cutting approaches to analyse and address physical, transition and Environmental, Social and Governance (ESG) risk, as well as scenarios and other factors.

Occasional papers are to be published by the NGFS in July.

Development of reference scenarios

Following the outline scenario framework for central banks and supervisors provided by the NGFS in its first comprehensive report (NGFS, 2019a), which combines climate change transition risks and physical risks in one common framework, it is now necessary to develop well documented and consistent reference scenarios as a vital next step to further mainstream forward-looking climate risk analysis by market participants and by supervisory authorities.

With support from Bloomberg Philanthropies, INSPIRE is supporting efforts to develop a common set of reference scenarios that include (i) a first set of climate change scenarios based on existing scenarios that aims to enable rapid uptake and use, and (ii) the setting up of a longer-term process that will enable more consistent and tailor-made scenario frameworks to facilitate full implementation of the envisioned stress-testing and risk assessments. The parties involved are the Potsdam Institute for Climate Impact Research, the International Institute for Applied Systems Analysis, the Joint Global Change Research Institute – University of Maryland, Climate Analytics, and ETH Zurich. Their objective is to establish the public good of an open platform for climate change scenario information to be used in climate-related financial risk analysis.

2. The INSPIRE research portfolio

The research projects commissioned by INSPIRE broadly cover topics that are aligned to one of NGFS's three workstreams or cross-cut these workstreams, as described in Section 1. The 21 INSPIRE projects commissioned to date have been further organised into five broad thematic groups. Incorporating the research priorities from the first and second INSPIRE research calls and enabling a more granular grouping of future research efforts, these groups are:

1. Microprudential regulation, disclosure, climate change and environment
2. Macroprudential regulation, financial instability, climate change and environment
3. Evaluating risk differentials based on environmental factors
4. Monetary policy, direct and indirect monetary instruments, climate change and environment
5. Sovereign bonds and climate- and environment-related risk

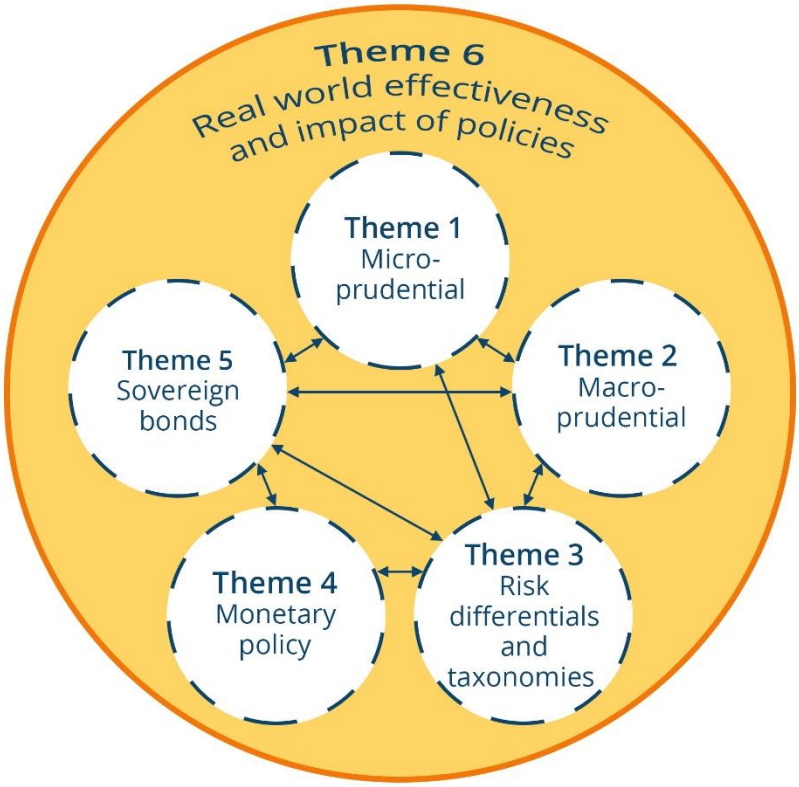
The third INSPIRE call for research proposals released in March 2020, currently under review, will add a sixth cross-cutting theme to the INSPIRE research portfolio:

6. Assessing the real world effectiveness and impact of central bank and supervisory policies in greening the financial system

Figure 2 depicts the interaction between these six INSPIRE themes. While the first, second and fourth themes correspond more closely to the NGFS workstreams – microprudential (WS1), macro-financial risk aspects (WS2) and the scaling up of green finance (WS3) – the analysis of risk differentials and the value of taxonomical classifications (theme 3) and of sovereign bonds (theme 5) have direct or indirect implications on the former. The sixth theme on the effectiveness and impact of central bank and supervisory policies, to which INSPIRE's third call is devoted, serves as a broad cross-cutting theme under which the capabilities of existing and proposed measures under the five initial INSPIRE themes (but not limited to them) are to be investigated.

It is important to emphasise that the selection of these six themes merely represents INSPIRE's current portfolio of commissioned and to-be-commissioned work and does not claim to comprehensively map the entire landscape. There are other important themes not yet covered by the INSPIRE research portfolio that also warrant future research, some of which are discussed in greater detail in Section 3. Equally, further research is needed within each of these INSPIRE research themes and we indicate some areas where this is the case within this report.

Figure 2. Interaction between INSPIRE research themes



Theme 1: Microprudential regulation, disclosure, climate change and environment

Climate-related risks have strong implications for the objectives of microprudential regulation, which focus on ensuring the safety and soundness of individual financial institutions, cutting across the classic pillars of the Basel III framework of risk-weighted capital, supervisory review and market discipline through disclosure. With its First Progress Report, the NGFS (2019a) reinforced member institutions' acknowledgement that climate change, environmental degradation and the transition towards a low-carbon economy are relevant sources of financial risks at the microprudential level.

The INSPIRE research portfolio on microprudential supervision and climate-related risks includes six projects, which investigate a variety of related issues, including research on disclosure and long-term supervision, as well as four regional projects providing studies on Canada, Brazil, the United States and the wider Americas region.

Further research in this field is needed to, first, investigate and assess how climate- and environment-related factors affect financial risks for individual financial institutions and, second, to further strengthen the design of prudential regulation and supervision in the wake of climate change. In terms of assessment, the identification of physical and transition risk transmission channels within the financial system and the development of scenarios to enable the quantitative climate- and environment-related risk analysis are key areas that warrant further research. With regard to the integration of climate risks into prudential supervision, the development of supervisory expectations, as well as the implications for risk-weighted capital requirements, supervisory reviews and disclosure requirements, have to be further explored.

How climate risks are priced in and taken into account in fundamental financial concepts in financial institutions' traditional risk management (e.g. value-at-risk and discount rates), and the instruments' limitations in climate risk modelling and capturing radical uncertainties and longer time horizons, are also questions for further research.

PROJECT

Mandatory Environmental, Social and Governance disclosure and financial stability

Dragon Yongjun Tang*[a], Rui Zhong[b]

**Principal researcher*

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

In recent years, due to the strongly increasing demand for Environmental, Social and Governance (ESG) information to further enhance sustainable growth, many countries and jurisdictions have issued regulations that require firms and financial institutions to disclose their ESG-relevant information and activities. Assessing the real impacts of these mandatory ESG disclosure regulations on financial market is an important question that will also inform future practices. Ioannou and Serafeim (2017) find that mandatory ESG disclosure improves the quantity and quality of disclosure as well as firms' valuation. In this INSPIRE study, we address this issue by examining the real effect of ESG disclosure on the financial stability of firms around the world.

Our theoretical analysis is based on two competing theories. First, the concept of 'information revelation' describes how mandatory ESG disclosures force firms to release non-financial information in a more timely manner, which increases information transparency and reduces financial risk. Second, 'regulation arbitrage' describes how in the face of mandatory disclosure, firms have the tendency to hide profitable but environmentally detrimental projects, which motivates managers to distort ESG information revelation, thereby exacerbating financial risk. Based on these theories, we construct two testable hypotheses to conduct an empirical analysis on the real effect of mandatory ESG disclosure on financial risk.

Empirically, we compile a comprehensive mandatory ESG disclosure dataset by manually merging multiple sources, including the data provided by the Sustainable Stock Exchange Initiative (SSE), the Global Reporting Initiative (GRI) and the Initiative for Responsible Investment (IRI) at Harvard University. We extract global equity and firms' fundamental information from WorldScope and DataStream at Thomson Reuters and country-level characteristics from the World Bank. After merging all the datasets, our sample includes about 28,000 firms in 46 countries over a sample period of 2000 to 2017.

We measure the financial stability of a firm along two dimensions: (1) the volatility of equity return; (2) the likelihood of stock price crashes. The equity return volatility reflects the oscillation of equity return within a year. Higher equity return volatility indicates lower financial stability, while stock price crash risk measure refers to the likelihood of experiencing extremely negative stock returns, which reflects the stability of equity market from another dimension. Specifically, we construct three standard measures of stock price crash risk, including negative skewness, down-to-up volatility, and the probability of actual stock price crashes (see e.g. Jin and Myers, 2006; Hutton et al., 2009; Kim et al., 2011a; Kim et al., 2011b).

Our preliminary findings are first, using multivariate regressions, that equity return volatility is lower after mandatory ESG disclosure. We then break down equity return volatilities into systematic and idiosyncratic volatilities using a capital asset pricing model. We find that both systematic and idiosyncratic volatility are significantly lower after mandatory disclosure. Second, we find that stock crash risks are mitigated after the implementation of mandatory ESG disclosure. This finding is robust to alternative crash risk measures and econometric methodologies. The result is both statistically significant and economically meaningful. Since the enforcement of mandatory ESG disclosure might not be a random event, there could be potential endogeneity concerns, such as reverse causality or simultaneity. We adopt a propensity score matching and placebo tests to address these concerns, respectively. We document consistent and robust results.

Our findings support calls for more government interventions in the ESG area and the mandatory introduction of ESG information disclosure requirements. In particular, stock exchanges should increase their ESG disclosure policies as we show that mandatory disclosure improves the information environment. Moreover, our findings on financial stability are of interest to central banks, as financial stability is the first concern of central banks. Although we have witnessed progress in the area of green finance, such as the fast growth of the green bond market, much remains to be done for scaling up green finance. The entire financial system needs to be involved. Showing benefits of mandatory ESG disclosure can be seen as an encouraging step towards more participation by other market participants.

Further reading authored by INSPIRE researchers:

Tang, D.Y., Zhang, Y. 2020. Do shareholders benefit from green bonds? *Journal of Corporate Finance*. 61. https://doi.org/10.1016/j.jcorpfin.2018.12.001

PROJECT

Supervision beyond the business cycle: A framework for long-term financial supervision

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Financial supervisory mandates are interpreted to ensure financial stability 'over the business cycle' (3–5 years). New risks (climate change, pandemics, artificial intelligence) are challenging this paradigm, as they manifest themselves both over longer time horizons and as secular, one-directional shocks. This exploratory conceptual project seeks to identify potential mechanisms and levers financial supervisors can mobilise in order to 'supervise the long-term' and reframe their mandate to cover more long-term risks.

Current financial policy and supervisory analysis falls into two categories. In the first category, financial policy analysis seeks to identify potential levers within the mandate to supervise risks over the business cycle (e.g. capital requirements) or support societal goals. The second category involves the development of tools to analyse the financial materiality of long-term risks (e.g. climate scenario analysis). Missing within this paradigm is the 'adapter' that allows for the integration of the second category of analysis into mainstream supervisory frameworks. As a result, 2030 stress-tests are intellectually satisfying, but remain largely theoretical exercises.

This INSPIRE project seeks to begin to fill this gap by suggesting a framework for what long-term financial supervision could look like that would allow for the integration of these long-term risk assessments, as well as the steering of policy levers beyond business cycle risk management. This requires a review of both existing and potential 'new' policy instruments, as well as more general questions over how such policy could work (including related to the arbitrage between short-term and long-term risks).

The primary output of this INSPIRE research will be a discussion paper focused on two central questions:

- What are the instruments to enhance the supervision of long-term risks?
- How might governance and mandates need to change to support the supervision of long term risks?

PROJECT

Management of climate risks in the financial industry of a resource based economy: A Canadian scenario analysis

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Although some studies exist on how the financial industry is affected by climate risks and how it might manage them, no such studies exist for a country with an economy that is mainly based on carbon-intensive resources, such as oil, gas and mining. Therefore, we will conduct a scenario analysis based on an impact matrix that uses both physical and transition risks to model impacts on the financial portfolio of Canadian chartered banks. Consequently, we support the Bank of Canada and its commitments as an NGFS member and will analyse how the Canadian financial industry is affected by physical climate risks and transition risks and how these risks can be managed.

This INSPIRE research will complement findings about climate-related risks and opportunities in Europe, Asia and Africa that are exposed to different climate change-related risks to North America and that have implemented different regulatory frameworks. The research will be based on a formative scenario analysis (Godet, 1986). An impact matrix will be created based on the Intergovernmental Panel on Climate Change (IPCC) climate scenarios and climate scenarios for Canada, such as scenarios taken from www.climatedata.ca, a climate data portal produced collaboratively by the country's leading climate organisations and supported, in part, by the Government of Canada. Based on different data sources, we will conduct a MICMAC Analysis (a system of multiplication of matrices applied to the impact matrix), to calculate both direct and indirect impacts on Canadian banks' financial risks.

The expected results will help policymakers in countries with carbon-intensive economies to create financial policies, regulations and supervision regimes that could be applied by central banks and other financial regulators to mitigate climate risk for the financial industry without creating otherwise significant negative impacts for these countries' economies. These measures are not only intended to reduce the risks for the financial industry, but also to mitigate climate change-related economic risks in general because

banks might channel their loans and investments to industries and borrowers with lower carbon intensities.

The results of this INSPIRE research will help banks to implement strategies to reduce their exposure to climate-related financial risks. Consequently, negative impacts on the Canadian financial industry could be avoided. This is important given that the Canadian banking sector is dominated by five chartered banks that are similar with regard to their businesses.

Further reading authored by INSPIRE researchers:

Oyegunle, A., Weber, O., 2015. *Development of Sustainability and Green Banking Regulations Existing Codes and Practices*. CIGI Papers Series no. 65. Centre for International Governance Innovation, Waterloo, Ontario, Canada. https://www.cigionline.org/publications/development-sustainability-and-green-banking-regulations-existing-codes-and-practices

Weber, O., Feltmate, B., 2018. *Sustainable Banking, Managing the Social and Environmental Impact of Financial Institutions.* University of Toronto Press, Toronto. https://doi.org/10.3138/9781442629325

Weber, O., Oyegunle, A., 2019. *Climate Scenarios for the Canadian Lending and Investment Industry*. CIGI Papers Series no. 216 Centre for International Governance Innovation, Waterloo, Ontario, Canada. https://www.cigionline.org/publications/climate-scenarios-canadian-lending-and-investment-industry

PROJECT

Environmental and social risk management in Brazilian banking: from an environment and social management structure to climate scenario analysis development

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

In 2014, the Brazilian National Monetary Council (CMN) issued Resolution 4327, which set out the guidelines and principles with which financial institutions have to comply in the development and implementation of their Environmental and Social Responsibility Policy and in associated governance and reporting practices.

For this INSPIRE project, SITAWI, a think tank, has carried out a literature review of the resolution's impacts and has gained insights from market participants. Its preliminary findings are described below.

Since 2014, the Brazilian banking sector has accelerated progress in sustainable finance and large banks have revised their Environmental and Social Management Systems (ESMS), while medium-sized and small banks have introduced first-ever practices and governance to address Environmental and Social (E&S) issues in their operations. The Brazilian central bank has increased its awareness and oversight capacity by developing questionnaires to assess banks' progress and has also improved internal guidance for staff involved in supervision. Moreover, some features that are related to the Brazilian central bank's oversight approach, such as the emerging requirements to integrate E&S issues into the overall risk management framework and the need to address emerging climate change-related risks, will require banks to go beyond the current level of efforts and sophistication of practices. Having joined the NGFS in April 2020, the Central Bank of Brazil is taking encouraging steps for greening the country's financial system.

Resolution 4327 has been the first E&S cross-cutting norm for Brazilian banks. At the time of its introduction there were only specific norms to prevent illegal deforestation and forced labour in certain types of credit operations. The Resolution has a principles-based approach that encourages the development of ESMS. However, these ESMS, which have to be compatible with Brazil's diverse financial system, also create challenges for commercial banks and the central bank, which has to calibrate its supervisory practices accordingly.

These unprecedented norms call for regulatory improvements. To this end, the CMN issued a new resolution in 2017 that explicitly mentions that E&S risks should be addressed by institutions' integrated risk management framework along with other risks (e.g. credit, market and liquidity risk). The subsequent revision of other norms incorporates E&S risks into prudential regulation and into the Internal Capital Adequacy Assessment Process (ICAAP). However, banks' progress in this area appears to be limited thus far. The review of these norms has led to the understanding that national regulation comprises the requirement of risk management exercises for E&S risks, when deemed relevant. It means that banks should conduct E&S sensitivity analyses and stress tests. At the same time, the potential impacts of climate-related risks are becoming clearer, and banks have been pushed to respond to them. Some initiatives indicate that banks are aware of the necessity to incorporate climate-related risks into their risk management models, but other priorities, knowledge gaps, lack of databases and macroeconomic factors are barriers for the integration of these risks into the integrated risk management structure.

The development of national self-regulation norms to translate the CMN resolutions into more tangible requirements, the voluntary adoption of guides and tools provided by industry associations, and the increasing number of lessons coming from international experiences on how to assess climate-related risks may be understood as enablers for the improvement of E&S risk management in Brazilian banks. This INSPIRE research also finds that the following initiatives can support banks and the central bank towards such progress:

- Harmonisation of taxonomy/concepts behind the principles-based approach of the current E&S regulatory framework for banks
- Development of pilot E&S scenario analyses and stress tests focused on climate risks
- 'Tropicalisation' of international benchmarking from oversight bodies and market players, as a strategy to improve E&S risk management process

At the final stage of this research, we will present results to Brazilian commercial and development banks, as well as to the central bank. Besides the research report, a Self-Assessment Tool is currently under development. It will provide a checklist to support banks in grasping the concepts behind the principles-based approach of the national E&S regulatory framework and contribute to harmonising understanding of how to implement each requirement.

Further reading authored by INSPIRE researchers:

Pimentel, G., Teixeira, G., Maciel, B., Fernandes de Vasconcelos, M.S., Secaf, B.S., Tannús, T.N., 2019. Climate Risk Sensitivity Assessment Tool: Implementation Guide for Banks. SITAWI Finance for Good, and Brazilian Federation of Banks (FEBRABAN). São Paulo, Brazil. https://www.tcfdhub.org/resource/climate-risk-sensitity-assessment-tool/

Schuchmann, C., Besso, R., Pimentel, G., Mungol, G., 2018. *The Coolest Bonds: Eligible assets and projects for issuing Brazilian Green Bonds aligned to the Paris Climate Agreement*. SITAWI Finance for Good, São Paulo, Brazil. http://info.sitawi.net/thecoolestbonds

SITAWI Finance for Good., 2019. *Implementing the TCFD recommendations: a roadmap for the Brazilian banking sector*. Prepared for Brazilian Federation of Banks (FEBRABAN). São Paulo, Brazil. https://www.sitawi.net/publicacoes/implementing-the-tcfd-recommendations-roadmap-for-the-brazilian-banking-sector/

Teixeira, G., Pimentel, G., Alves, C., 2018. *The Sustainability Journey of BNDES: Capital market operations through an E&S lens.* SITAWI Finance for Good, São Paulo, Brazil. https://www.sitawi.net/publicacoes/the-sustainability-journey-of-bndes-2/

PROJECT

How could the US Federal Reserve and other financial market supervisors incorporate climate considerations into their responsibilities?

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

The United States Federal Reserve (Fed) and US financial market regulators (e.g. the Securities and Exchange Commission [SEC] and the Commodity Futures Trading Commission [CFTC]) do not currently participate in the NGFS. In this INSPIRE project we ask what positions might they take on NGFS agenda items, were they to participate? What constraints and flexibilities do they have to factor climate change into their financial stability monitoring and supervision and other key responsibilities?

To date the US Federal Reserve has said relatively little about its potential to incorporate climate change considerations into its work. In 2010, the SEC released guidance urging companies to disclose the risks from climate change but has lately been cautious about new sustainability disclosures and climate-related shareholder resolutions. Federal banking supervisors have announced no plans to require banks to impose climate-related stress tests. Such institutions may be wary of wading into politically fraught waters, and their statutory authorities may limit how proactive they can be on climate-related risks.

In Congressional testimony, Fed Chairman Jerome Powell said the Fed is preparing the financial system for more severe weather, but he noted that climate-related risks do not fit squarely in the Fed's current financial stability framework.

We explore the question of what these institutions could or would do on climate if unfettered by political or institutional constraints. The Brookings Institution will convene a workshop of former and current financial market regulators and other experts to explore the goals and recommendations of the NGFS. We will discuss the statutory, regulatory, and institutional barriers and opportunities that pertain to these US institutions should they consider taking on a climate-related agenda. Based on this expert insider input, Brookings scholars will author a research paper outlining the mandates of the Fed and US supervisors and how they could shape the US institutions' capacity to engage on climate.

The policy research paper emerging from this expert-insider discussion will inform current and future policymakers, investors, banks and other stakeholders about how the international dialogue on climate as a financial risk translates to the United States. For example, US institutions may have unique statutory or other constraints that may limit the extent to which they can adopt NGFS recommendations. Likewise, they may have as-yet-unexploited opportunities to contribute to the reduction of the risks of global climate disruption. Our research will lay out the options and describe their advantages and disadvantages.

Further reading authored by INSPIRE researchers:

Liu, W., McKibbin, W.J., Morris, A.C., Wilcoxen, P.J., 2019. *Global economic and environmental outcomes of the Paris Agreement*. Climate and Energy Economics Discussion Paper. Brookings Institution, Washington, DC. https://www.brookings.edu/wp-content/uploads/2019/01/ES_20190107_Paris-Agreement.pdf

McKibbin, W.J., 2012. *A new climate strategy beyond 2012: lessons from monetary history*. The Singapore Economic Review. 57(3), 1250016. https://doi.org/10.1142/S0217590812500166

McKibbin, W.J., Morris, A.C., Wilcoxen, P.J., 2014. Pricing carbon in the U.S.: A model-based analysis of power-sector-only approaches. *Resource and Energy Economics* 36, pp. 130–150. https://doi.org/10.1016/j.reseneeco.2013.11.007

McKibbin, W.J., Morris, A.C., Wilcoxen, P.J., 2008. *Expecting the Unexpected: Macroeconomic Volatility and Climate Policy*. Global Working Papers No. 28. Brookings Institution, Washington, DC.

https://www.brookings.edu/research/expecting-the-unexpected-macroeconomic-volatility-and-climate-policy/

McKibbin, W.J., Morris, A.C., Wilcoxen, P.J., Panton, A.J., 2017. *Climate change and monetary policy: Dealing with disruption.* Climate and Energy Economics Discussion Paper. Brookings Institution, Washington D.C. https://www.brookings.edu/research/climate-change-and-monetary-policy-dealing-with-disruption/

McKibbin, W.J., Pearce, D., Stegman, A., 2009. Climate change scenarios and long term projections. *Climatic Change* 97 (23). https://doi.org/10.1007/s10584-009-9621-3

McKibbin, W.J., Pearce, D., Stegman, A., 2007. Long term projections of carbon emissions. *International Journal of Forecasting* 23, 637–653. https://doi.org/10.1016/j.ijforecast.2007.10.004

McKibbin, W.J., Wilcoxen, P.J., 2009. Uncertainty and climate change policy design. *Journal of Policy Modelling, Climate Change and Energy Policy* 31, 463–477. https://doi.org/10.1016/j.jpolmod.2008.12.001

McKibbin, W.J., Wilcoxen, P.J., 2002. The Role of Economics in Climate Change Policy. *The Journal of Economic Perspectives* 16, 107–129 https://doi.org/10.1257/0895330027283

PROJECT

Working Group on Banking Supervision and Sustainable Development in the Americas

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Banking regulations are known to have substantial leverage on the real economy for the simple reason that finance permeates everywhere. By the same token, they are a suitable instrument for improving the preparedness of the real economy for climate change. We will convene a working group of prominent practitioners from among the collectivity of bank supervisors and regulators in the Americas along with recognised experts in the field in order to review the state of practice regarding the incorporation of climate change into microprudential regulatory frameworks.

For purposes of ordering the discussion, existing and potential practices will be grouped into four categories:

- *Provide* – Those where the authorities provide finance by instruction; an example might be finance from a government-owned development bank.
- *Promote* – Those where the authorities provide incentives for desired types of finance; examples might be differential capital requirements or differential provisioning for climate-friendly finance.
- *Protect* – Those where the authorities reduce financial risk by socialising potential losses by means of insurance, direct payments or exceptional access to citizens' own assets.
- *Prevent* – Those where systems are set up to prevent, contain and abate negative externalities; an example might be requiring extended due diligence for socio-environmental risk.

To assist the Working Group's deliberations, we will provide reference documents on existing practices (such as Frisari et al., 2019 and Superintendencia De Banca Seguros Y AFP, Republica del Peru., 2015), as well as on plausible modifications in existing regulations that can have important positive impacts for climate change and adaptation. The Working Group will also be asked to discuss the feasibility of specific innovations for making regulations more climate-friendly, and to review potential obstacles, barriers and resistance to the implementation of such potential change. The document emerging from the Working Group's deliberations will provide policy recommendations and, where appropriate, a further research agenda.

Further reading authored by INSPIRE researchers:

Schydlowsky, D.M., 2019. *Prudential Regulations for Greening the Financial System: Coping with Climate Disasters* (No. 036), GEGI Working Paper. Global Development Policy Center., Boston, U.S. https://www.bu.edu/gdp/files/2020/02/WP36-Schydlowsky-Dec-2019-1.pdf

Schydlowsky, D.M., Thompson, R.C., 2014. Reducing the Financial Risk of Social Conflict. *Americas Quarterly*. 8 (2) 82-86. https://www.americasquarterly.org/content/reducing-financial-risk-social-conflict

Theme 2: Macro-financial risk, macroprudential regulation, financial instability and climate change

Analysing and understanding the macrofinancial impact of climate change, particularly with regard to the implications for financial stability and, in response, macroprudential regulation, is of central importance to enabling central banks and supervisors to achieve their financial stability objectives. The 'greening' of macroprudential policy would thereby aim to mitigate climate- and environment-related risk across the system as a whole by taking the systemic aspects of climate- and environment-related risks into account.

The INSPIRE research portfolio on financial (in)stability, macroprudential regulation, climate change and environment includes six projects that investigate the macroeconomic impact and systemic nature of climate change- and environment-related risks. Starting from the highest level, the projects question whether climate-related financial risks that are considered to have unique characteristics and whether radical uncertainty can be accurately assessed under current approaches. In response to this, a precautionary financial policy approach to address the financial stability risks created by climate change is debated. With regard to climate risks in general, but more specifically concerning portfolios of corporate and sovereign bonds characterised by different degrees of exposure to 'climate-policy-relevant sectors', projects are also concerned with the inadequacy of standard financial risk approaches to deal with the endogeneity and deep uncertainty of climate-related financial risks.

Focusing more closely on the potentially systemic risks associated with a low-carbon transition and hence on transition risk, other projects investigate the channels through which an adverse shock can lead to a realisation of systemic risk, the gaps in existing methodologies and policy implications. With regard to physical risk, the direct and indirect impacts of abnormal weather shocks on the global macroeconomy are assessed and quantified, based on a large macroeconometric model.

Moving to prudential policy, one INSPIRE project investigates the implications for macroprudential policy and proposes a framework to analyse the impact of green prudential regulations, thereby investigating how prudential regulations could deal with risks to financial stability arising from climate change.

Finally, in the context of the manifestation of macro-financial risks, financial imbalances and the aftermath, one project is concerned with the response measures that could be deployed rapidly by central banks and other financial institutions in the context of a new financial crisis in a way that contributes to sustainability.

The identification of relevant transmission channels of cross-border systemic climate- and environment-related risks and, more specifically, the financial stability impact of physical and transition risks, is a **topic for further research**. The modelling of systemic climate-related financial risk is still subject to several challenges relating to, among other issues, the development of reference scenarios, the fundamental uncertainty involved, absence of data granularity and the nonlinearity and complexity within the transmission mechanisms of climate-related risks. As a consequence of greater challenges to model environment-related financial risk, fewer NGFS members have included it within their risk analysis (NGFS, 2019b). **Further research is needed** to address these challenges. As a zoonotic disease, COVID-19 demonstrates how environmental degradation and biodiversity loss can create financial instability. Likewise, in the context of methodological questions with regard to the shortcomings of backward-looking analysis and the benefits of forward-looking scenario-based analysis, climate stress testing frameworks are highly relevant and need to be discussed further.

PROJECT

Climate-related financial policy in a world of radical uncertainty – towards a precautionary approach

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Research commissioned following March 2019 call for proposals

Research status: Completed and available at www.ucl.ac.uk/bartlett/public-purpose/publications/2019/dec/climate-related-financial-policy-world-radical-uncertainty

Climate-related financial risks (CRFR) are now recognised by central banks and supervisors as material to their financial stability mandates. But while CRFR are considered to have some unique characteristics, the emerging policy agenda for dealing with them has largely focused on conventional market-based solutions. Current policy emphasises information gaps that prevent the accurate assessment of market risk. The assumption is that these gaps can be remedied via disclosure, transparency, scenario analysis and stress testing, which will enable markets to self-correct. We argue this approach is misguided as CRFR are characterised by radical uncertainty and hence 'efficient' price discovery is not possible.

Since climate change poses a severe and potentially irreversible threat, lack of scientific certainty as to its exact nature or timing should not prevent regulatory action to mitigate its impact. In this INSPIRE project, we have proposed the adoption of a Precautionary Financial Policy (PFP) approach to deal with the financial stability risks created by climate change. This approach is justified because CRFR, both transition and physical, are characterised by radical uncertainty, meaning conventional backwards-looking probabilistic financial risk modelling is not fit for purpose in dealing with them. While scenario analysis and stress testing to some extent recognise the uncertainty problem, they remain based on assumptions that are subject to significant uncertainty and do not sufficiently justify action in the short term, despite widespread recognition of the risks posed by inaction.

In contrast, a PFP approach justifies fully integrating CRFR into financial policy, including both prudential and monetary policy frameworks, helping justify preventative actions now to mitigate the potentially catastrophic financial and economic damages created by climate change, and shape financial markets in a clear direction towards a preferred net-zero carbon future. In particular, because of the global, deep, long-term, systemic and endogenous characteristics of CRFR, the proper way to envisage financial regulation must be through macroprudential-type rules and discretion. These consider not only an aggregation of individual financial institutions and markets but also the financial system as a whole in the way it shapes the macroeconomy. In terms of implementation, we propose the comprehensive integration of climate risk into capital adequacy requirements, monetary policy operations (including asset purchases and collateral criteria), quantitative credit controls and credit guidance, and the enhancement of financial system resilience.

Policymakers adopting a precautionary approach should be aware of the likely short-term trade-off between efficiency and resilience, and likely resistance from market actors with shorter-term time horizons. There is a need to 'learn by doing' in this new environment, just as policymakers are learning from the success and failures of macroprudential policy interventions over the past few decades (Lim et al., 2011). Not all precautionary-type interventions will be successful. But, on balance, we would argue that more valuable information can be learnt from intervening and studying the (endogenous) reactions that follow a particular intervention than can be gleaned from non-interventionist analysis, modelling and forecasting.

This INSPIRE project is an exploration and attempt to lay out a new policy framework for dealing with CRFR rather than a turn-key solution for financial regulation in the face of such risks. Future streams of research would involve deeper analyses of the possible tools and policies that can be activated, which we discuss only at a high level in our paper. In parallel, objective evaluations of which CRFR challenges are priorities in

terms of (further) data and modelling effort, aiming to establish appropriate policy actions for each time horizon considered, i.e. distinguishing the level of knowledge that can be expected in six months, one year, three years, ten years, etc. and those policy actions that, since they address challenges that will remain subject to radical uncertainty, can be taken much sooner.

Beyond climate change, the approach developed in this paper could be extended to other complex environmental challenges characterised by radical uncertainty, including biodiversity loss, water and air pollution, and natural resources depletion. Indeed, most of these areas have important interactions with climate change itself and so should as far as possible be incorporated into a PFP framework.

PROJECT

Low-carbon transitions and systemic risk

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The principal researchers wish to thank Alex Bowen and Christian Brownlees

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Research status: Completed

The low-carbon transition has been cited by policymakers as a potential driver of systemic risk that could lead to financial instability and negative macroeconomic outcomes. Transition risk refers to the economic and financial risks associated with a disorderly transition to a low-carbon economy. Policymakers have highlighted that the systemic nature of transition risk could lead to an adverse impact on financial stability. In particular, several have warned of the potential for a transition-driven 'Minsky moment' whereby a disorderly transition leads to a sudden collapse in asset prices (Carney et al., 2019).

This INSPIRE project draws on the frameworks of central banks and academic studies to identify the channels through which an adverse shock can lead to a realisation of systemic risk. Systemic risk can be defined as the risk of a shock that has negative externalities on economies and financial systems via networks. This risk can be realised when a large number of financial market participants are impacted simultaneously or when a sector-specific shock leads to contagion and feedback loops that amplify the impact. The realisation of systemic risks can also be more likely when the source of risk is not well understood. This makes it inherently challenging to identify them ex-ante, but therefore important to consider the multiple possible channels and work through their potential implications.

Our report then considers the channels through which systemic risk could materialise under a low-carbon transition. The main sources of risk identified are a sudden downward repricing of carbon-intensive (or low-carbon) assets and energy price shocks. The repricing of assets would lead to losses for those directly and indirectly exposed. Feedback loops can also amplify the initial losses and have a negative impact on the wider economy. Further, a disorderly transition could lead to an energy price shock which has a large negative impact on economic growth. Within these main sources, we outline the detailed transmission channels for systemic risk stemming from overlapping portfolios, lending between financial market participants, and the interaction between the financial system and the real economy.

While there is an extensive literature on systemic risk, the literature on systemic risk in relation to a low-carbon transition is still in the early stages of development. Since the financial crisis, there has been a growing emphasis in the literature on assessing the systemic financial risk triggered by unexpected shocks, such as the bursting of the subprime mortgage bubble in the United States. Approaches include the development of market-based indicators that capture the build-up and materialisation of systemic risk, general equilibrium models and stress testing frameworks. While the literature focusing on transition risk in particular is more limited, there are studies which have employed network approaches to estimating systemic risk in the context of a low-carbon transition.

We identify the main gaps in existing methodologies for estimating the systemic risk posed by a low-carbon transition and recommend areas for future research. First, further data collection is required to better assess the exposure of assets to transition risk. In addition, policymakers should work to develop more comprehensive climate-related stress testing exercises, with more of a focus on second-round impacts. Where possible, these exercises could draw on historical events with similar characteristics, such as a large swing in energy prices. Further, the development of more comprehensive approaches such as multi-layered models of financial and production networks, and frameworks that include both the impact of rising and declining industries, have the potential to improve the assessment of systemic risk.

Further reading authored by INSPIRE researchers:

Vivid Economics, 2019. *Low-carbon transition scenarios: Exploring scenario analysis for equity valuations, Investing in the low-carbon transition*. HSBC Global Asset Management Limited, London, UK. https://no.assetmanagement.hsbc.com/en/institutional-and-professional-investor/news-and-insights/low-carbon-transition-scenarios

Vivid Economics, Energy Transition Advisors, UN PRI, 2019. *The Inevitable Policy Response: Preparing financial markets for climate-related policy/regulatory risks.* United Nations Principles for Responsible Investment, London, UK. https://www.unpri.org/inevitable-policy-response/what-is-the-inevitable-policy-response/4787.article

PROJECT

The stochastic impact of extreme weather events

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

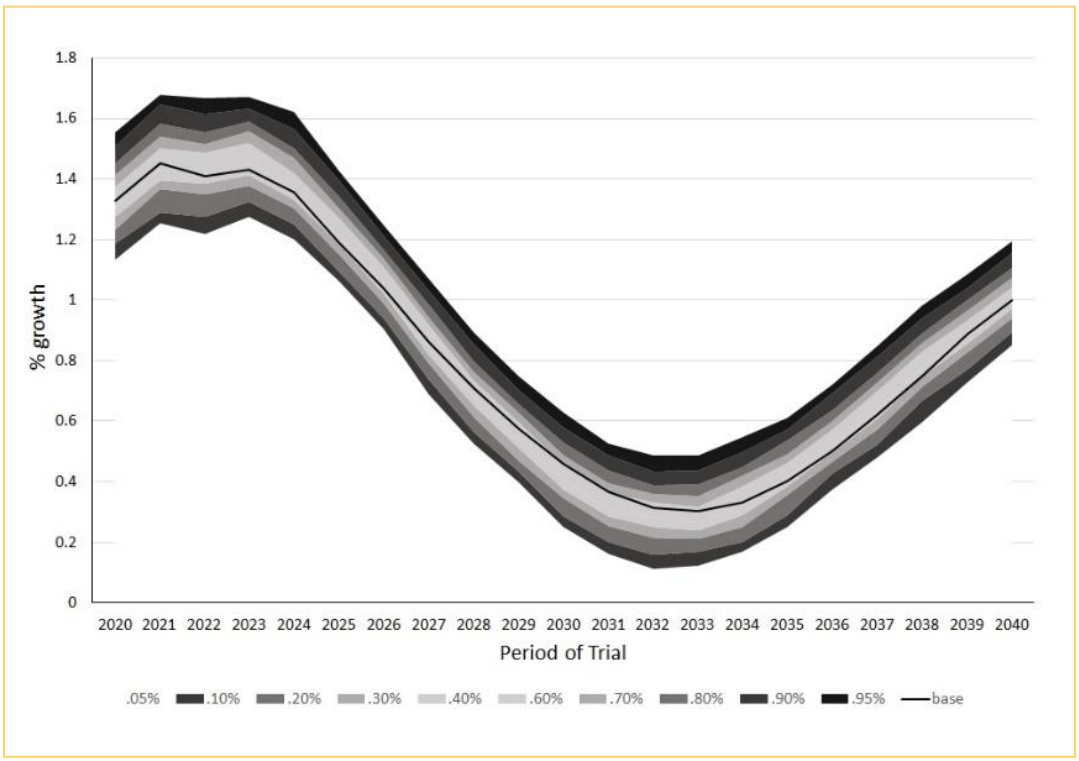
In this INSPIRE project we assess the impact of abnormal weather shocks on the global macroeconomy. Extreme weather events are random in size and location. We use stochastic trials to generate a distribution of weather shocks across the world to capture that randomness and use NiGEM, a large macroeconometric model, to quantify the impact of these shocks on the macroeconomy. NiGEM links countries through trade and non-trade channels and as such, a shock that impacts on a single country or region will reverberate to other parts of the world. Our project captures the direct and the indirect impact of extreme climate events.

For each weather event we shock population and the capital stock. We use publicly available data to define the size of an impact on the population and capital stock and we rely on previous studies to determine the frequency of an extreme event occurring in any given region/country. The shocks are applied as a single period change to capital stock and population and the economy is then allowed to heal and recover from the climate event over time. The speed of healing and the associated dynamics are driven by the model.

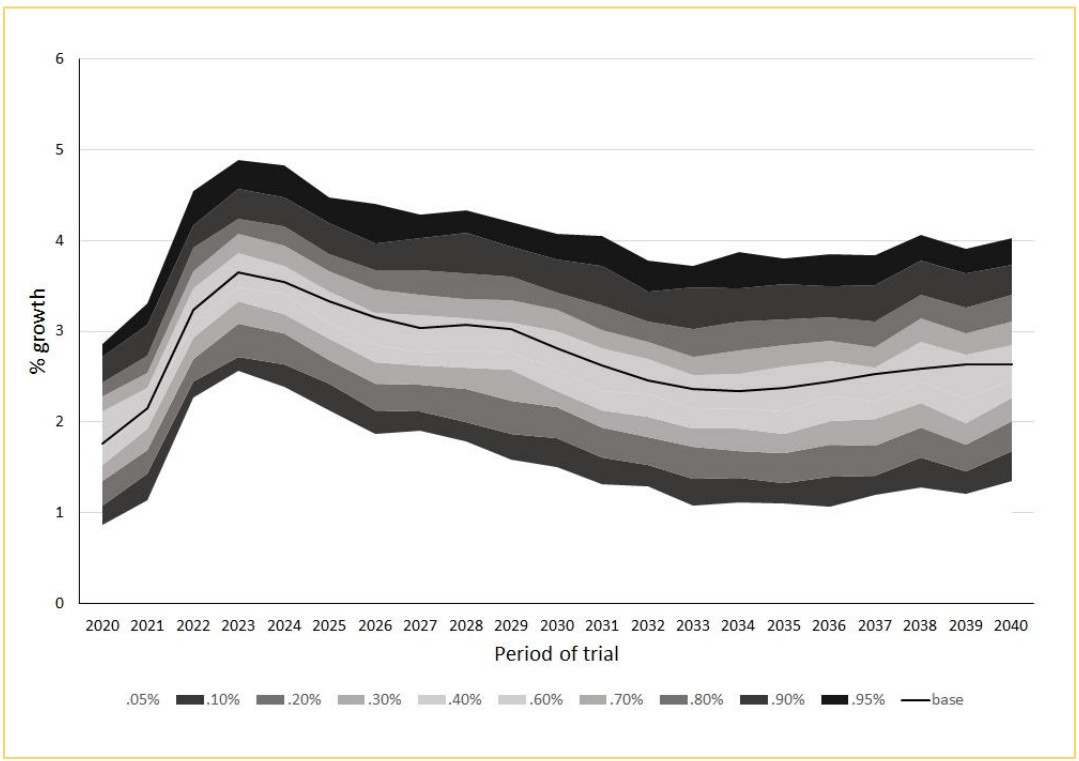
Our starting point was to establish the link between extreme weather events and the destruction to the capital stock and population. For that we use data from the Global Climate Risk Index (CRI) 2019 (Eckstein et al., 2018), a database that quantifies the human and economic losses that occur in response to extreme weather events. The Global CRI analysis is itself based on Munich Re's NatCatSERVICE, a well-known and reliable database of extreme weather events.

The CRI database is restricted to weather-related extreme events such as storms, floods, extreme temperature and heat and cold waves. It excludes geological events such as earthquakes, tsunamis and volcanic eruptions. The CRI data shows that low-income countries are particularly vulnerable in terms of lives lost, but the absolute economic loss is larger in more wealthy countries. We use results from Cavallo et al. (2010), which are based on the EM-DAT database, to randomly define the extreme event coupled with the size of the shock denoted from the CRI.

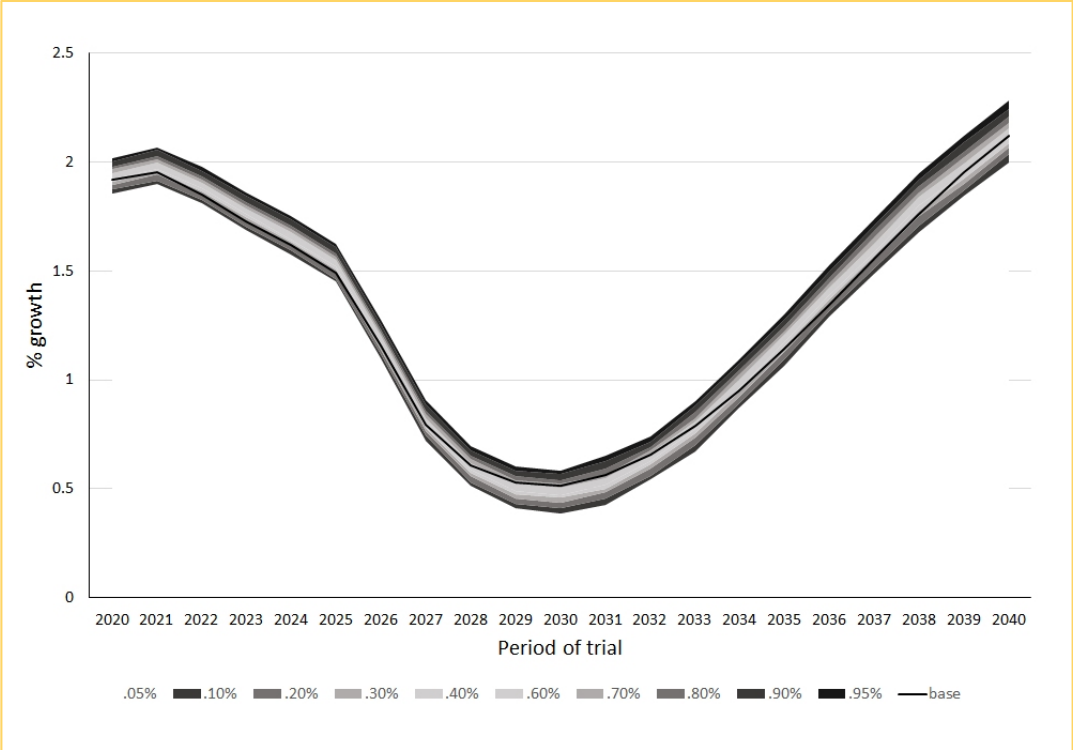
The model generates a distribution around the central projection for a wide variety of macroeconomic variables including GDP, inflation, employment, interest rates etc., for all the countries and regions that are covered in NiGEM. A snapshot of the results examining the impact of extreme natural events based on the distribution around a central forecast for Europe (a), Singapore (b) and the United States (c) are shown below.



a. Europe



b. Singapore



c. United States

The charts show the distribution of the impact on GDP (level, relative to baseline projections) for each country, with each shaded band reflecting 10 per cent probability. The negative bands represent the impact of extreme events in that country or spillovers from elsewhere and the positive bands are driven by the healing and recovery process. Our analysis shows that the impact of natural events on GDP is bigger in small countries such as Singapore (b) because of population density, the frequency of these events in that region and the ability for that country to rebuild from the capital shock.

Further reading authored by INSPIRE researchers:

Hurst, I., Kara, A., Liadze, I., Forthcoming. *An investigation of carbon taxes in a large macroeconometric model*.

PROJECT

Assessing forward-looking climate risks in investors' portfolios: from theory to practice

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

Climate-related financial risk is characterised by endogeneity and deep uncertainty. The inadequacy of standard financial risk approaches to deal with these dimensions is a challenge for a smooth transition to a low-carbon economy. A recent stream of work addresses this issue with a framework for climate financial risk management under uncertainty (Battiston, 2019; Battiston et al., 2017; Battiston and Monasterolo, 2019). This framework has been applied to the analysis of climate risk of financial portfolios in collaboration with financial supervisors (Battiston et al., 2019a, 2019b).

This INSPIRE project aims to mainstream such a framework in microprudential and macroprudential policies implemented by financial supervisors and financial institutions belonging to the NGFS. We are engaging with relevant NGFS stakeholders to co-develop narratives related to two main questions:

- How can best use be made of the available scientific knowledge on climate mitigation to identify relevant scenarios of disorderly low-carbon transition?
- What are the implications of scenario selection for investors' decisions and for financial stability?

We have conducted a series of semi-structured interviews:

- In bilateral meetings with financial supervisors: Banque de France, Bank of England, Banca d'Italia, Oesterreichische Nationalbank (OeNB), European Central Bank (ECB), European Insurance and Occupational Pensions Authority (EIOPA), European Securities and Markets Authority (ESMA), Bank for International Settlements (BIS)
- During three focus groups with investors and financial supervisors in the context of the Austrian Climate Research programme projects RiskFinPorto and GreenFin
- During international conferences: International Monetary Fund-World Bank Annual Meeting, Washington DC, 18 October 2019; EIOPA Seminar on Quantitative Techniques in Financial Stability, Frankfurt, 26–27 September 2019; Joint Research Centre of the European Commission and the European Banking Authority (EBA) Workshop on Banking Regulation and Sustainability, Ispra, 18–19 November 2019; ECB-European Systemic Risk Board-OeNB event 'The future of stress-testing', Vienna, 6 December 2019; University of Zurich Sustainable Finance 2020 Conference, 16–17 January 2020.

As preliminary results, we have identified the following lines of progress and challenges:

- ***Scenarios for stress-testing:*** Most NGFS stakeholders acknowledge that the notion of disorderly transition comes with 'deep uncertainty' and 'risk endogeneity' and requires to go beyond the standard financial risk management approach. They appreciate the value of a framework that does so while bridging approaches already in use, such as scenario analysis, sensitivity analysis, risk monitoring and stress-testing.

  Challenges: There is a limited understanding of how financial institutions' solvability is sensitive to the climate scenarios. This could have major implications on financial stability at the individual and systemic level, as our recent analytical results show (Battiston and Monasterolo, 2019). Financial stability objectives could require institutions to test their portfolios against a wide range of feasible climate scenarios.

- ***Climate transition trajectories*****:** There is a growing consensus among NGFS stakeholders on the fact that energy technology and output trajectories generated by Integrated Assessment Models (IAM) can provide valuable input for estimating financial shocks in a disorderly transition (as initially proposed in Battiston et al., 2017).

  Challenge: There is limited understanding within the NGFS community of the implications of using IAM trajectories. Since IAM cannot account for the financial sector, its complexity and its amplification effects, the financial risk associated with the transition can be largely underestimated.

The results will be consolidated in a policy paper that will be presented and discussed at future NGFS events. The paper will be accompanied by online interactive infographics to illustrate the results of the climate financial risk framework under uncertainty on example portfolios of corporate and sovereign bonds characterised by different degrees of exposure to climate-policy-relevant sectors. Data on sector- and country-specific climate policy scenarios are based on the CD-LINKS database and our ongoing collaboration with the International Institute for Applied Systems Analysis. Portfolio selection builds on results from the EU Taxonomy Impact Assessment Report (Alessi et al., 2019). The project output is relevant for the NGFS workstream 2, for stress-testing exercises conducted at EBA, ECB and EIOPA, and for the policy discussions on Markets in Financial Instruments Directive (MIFID) II and Solvency II.

Further reading authored by INSPIRE researchers:

Alessi, L., Battiston, S., Melo, A.S., Roncoroni, A., 2019. *The EU sustainability taxonomy: a financial impact assessment.* EUR 29970 en, Publications Office of the European Union, Luxembourg http://dx.doi.org/10.2760/347810

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Battiston, S., Jakubik, P., Monasterolo, I., Riahi, K., van Ruijven, B., 2019a. Climate risk assessment of the sovereign bond portfolio of European insurers, in: *EIOPA Financial Stability Report,* December 2019. European Insurance and Occupational Pensions Authority, Luxembourg. http://dx.doi.org/10.2854/785

Battiston, S., Mandel, A., Monasterolo, I., 2019b. *CLIMAFIN handbook: pricing forward-looking climate risks under uncertainty*. http://dx.doi.org/10.2139/ssrn.3476586

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Battiston, S., Monasterolo, I., 2019. *A climate risk assessment of sovereign bonds' portfolio*. Working paper. Oesterreichische Nationalbank, Vienna, Austria. http://dx.doi.org/10.2139/ssrn.3376218

Dunz, N., Naqvi, A., Monasterolo, I., Forthcoming. Climate Transition Risk, Climate Sentiments, and Financial Stability in a Stock-Flow Consistent approach. *Journal of Financial Stability*. ISSN: 1572-3089

Monasterolo, I., Forthcoming. Climate Change and the Financial System. *SSRN Journal* 12. https://doi.org/10.2139/ssrn.3479380

Monasterolo, I., de Angelis, L., 2020. Blind to carbon risk? An analysis of stock market reaction to the Paris Agreement. *Ecological Economics* 170, 106571. https://doi.org/10.1016/j.ecolecon.2019.106571

Roncoroni, A., Battiston, S., Escobar Farfán, L.O.L., Martinez Jaramillo, S., 2019. Climate Risk and Financial Stability in the Network of Banks and Investment Funds. *SSRN Journal*. https://doi.org/10.2139/ssrn.3356459

PROJECT

Prudential instruments to scale up green finance: simulating the impact of green prudential regulations in an agent-based macrofinancial model

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

The existing financial regulatory framework has made notable progress in detecting, assessing and containing systemic risks. However, it still overlooks the possibility that systemic risk arises in the case of a low-carbon economic transition. Moreover, integrating climate-related risk analysis into financial stability monitoring and prudential supervision poses remarkable challenges because of the distinctive features of climate change impacts and mitigation strategies (D'Orazio and Popoyan, 2019a).

A closer investigation of existing prudential instruments shows that several regulations under Basel III contain an intrinsic 'carbon bias' that creates barriers to aligning the financial sector with sustainable transition roadmaps. In particular, on the one hand, existing capital and liquidity regulations underestimate the risks related to so-called green assets and potentially undermine the resilience of the financial system. On the other hand, they limit the bank capital available for green assets and favour brown assets.

By taking into account the current state-of-the-art, we highlight the lack of a comprehensive framework that is needed to analyse the impact of green prudential regulations. This INSPIRE research project aims at building such a framework and studying how prudential regulations could deal with risks to financial

stability arising from climate change. In particular, our project aims to answer the following research questions:

- Which 'green' macroprudential instruments are more suitable to achieve both financial stability (or not harm financial stability), and canalise green investments in the economy?
- What is the effectiveness of different combinations of 'green' macroprudential tools?
- Which role could 'green' macroprudential policy play in addressing climate-related financial risks, aligning financial stability and sustainability objectives, incentivising green investments, and contributing to a low-carbon transition?

By building on previous theoretical research carried out by D'Orazio and Popoyan (2019a; 2019b; forthcoming), this INSPIRE research project aims at developing a tool to assess the implications of the implementation of different green prudential instruments under different macrofinancial scenarios. We will use the agent-based modelling approach (ABM) (D'Orazio, 2017) to build up a macrofinancial model populated by a heterogeneous production sector, heterogeneous consumers, a banking sector, and a central bank. ABMs are particularly fruitful as policy laboratories as the approach allows for the study of the emergence of major crises and the stability/instability paths in case of transition from a carbon-intensive to a low-carbon economy (see D'Orazio, 2019; D'Orazio and Valente, 2019; Popoyan et al., 2017 for recent applications of ABMs within a financial sector).

On a more general level, our proposed framework can be used to evaluate:

- The macroeconomic implications of physical and transition risks, and their channels of transmission to both the macroeconomy and the financial system
- The role of central banks and supervisors in scaling up green finance

In particular, the analysis carried out in macroeconomic-financial ABM could help in understanding, on the one hand, whether climate-related macroprudential tools lead either to market distortions or financial instability. On the other hand, it could assist in detecting which are the main factors that hinder or contribute to the effectiveness of such instruments. In this respect this INSPIRE research will contribute to the activities of NGFS workstreams 2 'Analysing the macrofinancial impact of climate change' and 3 'Scaling up green finance', respectively (NGFS, 2019a).

Further reading authored by INSPIRE researchers and referenced above:

D'Orazio, P., 2019. Income inequality, consumer debt, and prudential regulation: An agent-based approach to study the emergence of crises and financial instability. *Economic Modelling* 82, 308–331. https://doi.org/10.1016/j.econmod.2019.01.015

D'Orazio, P., 2017. Big data and complexity: Is macroeconomics heading toward a new paradigm? *Journal of Economic Methodology* 24, 410–429. https://doi.org/10.1080/1350178X.2017.1362151

D'Orazio, P., Popoyan, L., 2019a. Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics* 160, 25–37. https://doi.org/10.1016/j.ecolecon.2019.01.029

D'Orazio, P., Popoyan, L., 2019b. Dataset on green macroprudential regulations and instruments: Objectives, implementation and geographical diffusion. *Data in Brief* 24, 103870. https://doi.org/10.1016/j.dib.2019.103870

D'Orazio, P., Popoyan, L., Forthcoming. *Taking up the climate change challenge: Does the central bank governance matter for greening the financial sector?* (Working paper)

D'Orazio, P., Valente, M., 2019. The role of finance in environmental innovation diffusion: An evolutionary modeling approach. *Journal of Economic Behaviour & Organization* 162, 417–439. https://doi.org/10.1016/j.jebo.2018.12.015

Popoyan, L., Napoletano, M., Roventini, A., 2017. Taming macroeconomic instability: Monetary and macro-prudential policy interactions in an agent-based model. *Journal of Economic Behavior & Organization* 134, 117–140. https://doi.org/10.1016/j.jebo.2016.12.017

PROJECT

What are the options for sustainable crisis response measures?

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[a] Third Generation Environmentalism (E3G), London, UK; [b] South East Asian Central Banks (SEACEN) Research and Training Centre, Kuala Lumpur, Malaysia; [c] SOAS Centre for Sustainable Finance, SOAS, University of London, UK; [d] German Development Institute, Bonn, Germany; [e] Bennett Institute for Public Policy, University of Cambridge, UK

Research commissioned following July 2019 call for proposals

Research status: Ongoing

This INSPIRE research project investigates response measures that could be deployed by central banks and other financial institutions in the context of the current COVID-19 crisis in a way that contributes to sustainability. Originally conceived to develop a framework for policy responses for the *next* financial crisis, the project concept was updated to consider policy options for both the stabilisation and the recovery phases of the current crisis. In the course of this project we will review and assess existing and novel proposals and present a menu of post-crisis management tools for central bankers, financial regulators and governments, with an evaluation of their sustainability-related risks and benefits, taking particular note of the environmental and social equity dimensions. The project will consider the suitability of different response options in Europe, Asia and North America based on available knowledge about tools used in prior crises and in this crisis so far. Policy options for different areas will be discussed in a series of closed and public webinars, and policy recommendations will be published in a policy brief series that will form the basis of an overall summary report.

Further reading authored by INSPIRE researchers:

Aghion, P., Hepburn, C., Teytelboym, A., Zenghelis, D., 2019. Path Dependence, Innovation and the Economics of Climate Change. In: Roger Fouquet (Ed.), *Handbook on Green Growth*, Cheltenham: Edward Elgar.

Dikau, S., Volz, U., 2020. *Central Bank Mandates, Sustainability Objectives and the Promotion of Green Finance* (No. 232), SOAS Department of Economics Working Paper. SOAS, University of London, UK. https://www.soas.ac.uk/economics/research/workingpapers/file145514.pdf

Durrani, A., Rosmin, M., Volz, U., 2020. The role of central banks in scaling up sustainable finance – what do monetary authorities in the Asia-Pacific region think? *Journal of Sustainable Finance & Investment* 10, 1–21. https://doi.org/10.1080/20430795.2020.1715095

Stanley Center for Peace and Security and E3G, 2020. *Global Financial Crisis and Climate Change: A Playbook for Action*, https://stanleycenter.org/wp-content/uploads/2020/03/v9- RRCC-GlobalFinance320.pdf

Triggs, G., Healy, C., 2020. *Global Finance: Emergency measures for a time of emergency*. E3G | Third Generation Environmentalism. https://www.e3g.org/library/global-finance-emergency-measures-for-a-time-of-emergency

Theme 3: Evaluating risk differentials based on environmental factors

The discussion of climate change-related risk differentials depends mainly on the understanding and conceptualisation of how environmental factors and climate change can translate into financial risk. The identification and quantification of risk differentials between 'green' and 'brown' assets can be related to the development of a taxonomical classification of 'green' and 'brown' assets or could start by investigating the correlation and causal relationship between climate- and environment-related aspects of assets and their financial risk in general. The investigation of risk differentials, on the one hand, has implications for the calibration of prudential policy and, on the other hand, can be related to the scaling-up of green finance through the identification of economic sectors and activities that contribute to the transition to a sustainable and low-carbon economy.

The current policy-focused debate is particularly shaped by considerations to introduce a 'green supporting factor' and 'brown penalising factor', which generally refers to the specification of the capital adequacy ratio whereby banks would have to hold less capital against loans that helped finance 'green' projects. However, it is important to differentiate in the discussion of a 'green supporting factor' and 'brown penalising factor' between a political, normative and environmental preference of one type of asset over the other and a purely risk-based calibration of prudential instruments based on underlying climate-related risk differentials.

Three INSPIRE research projects explore this agenda. The first investigates the relation between the 'greenness' of bank loans and their associated risk. The second INSPIRE project assesses the value of building a 'brown' investment taxonomy based on credit risk. The final project within this theme provides an empirical study assessing the impact of physical risk on mortgage loans.

Future research will have to investigate the existence and nature of risk differentials, namely the correlation and causal relationship between climate- and environment-related metrics and financial risks policy, as well as the associated policy implications for the calibration of central banks' and supervisors' instruments. Furthermore, the investigation of the benefits of taxonomies developed based on a political and socioeconomic process for the assessment of risk differentials and the facilitation of risk analysis needs to be advanced. On the more policy-oriented side, the development of taxonomies will have to be informed by research that gives indications about how it can be ensured that taxonomies are detailed enough to prevent greenwashing, and enable the classifications of green assets as well as the calibration of prudential regulatory instruments, such as capital requirements.

PROJECT

Is credit risk lower for banks' green assets?

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Given the pressing demand for sustainable development, the European Commission is exploring the introduction of a 'green supporting factor' (GSF) in an attempt to enhance green investment. In opposition, banking supervisors argue that financial institutions' capital requirements should be determined solely by the underlying credit quality. If not, the proposal of lowering capital charges on green lending poses a threat to financial stability. This leads to the question of whether credit risk is lower for banks' green assets.

The objective of this INSPIRE project is to perform a granular analysis on the risk implications of the environmentally-friendly (green) property of bank loans in the context of a comprehensive international

bank loan dataset (Thomson Reuters' DealScan). We plan to address three key research questions related to the discussion of the adoption of a GSF:

- Is the risk of banks' green loans lower globally?
- If the risk is lower, what are the possible channels/mechanisms through which the green property exerts this effect?
- How can the green impact be calibrated into the green supporting factor and how can the empirical effect of the green supporting factor on banking systemic risk be quantified at the country level?

Our research questions directly address the research priorities of the NGFS workstream 1 – microprudential and supervision (NGFS, 2019a).

To address our first and second research questions, we plan to conduct an empirical analysis, utilising the detailed global loan-level data from the LoanConnector database. We will adopt three distinct criteria to identify green loans: (1) firm-level environmental score; (2) green industry classifications; (3) the proceeds of bank loans. Based on the empirical findings, we plan to compose a single-period model to analyse the impact of a GSF on bank risk profiles. In the model, we allow a bank to choose between green and non-green loans after considering a GSF at the beginning. Then, we use the calibration to address our third research question and to gauge the extent to which a GSF changes bank loan risk at the end of the period where the equilibrium is reached. The calibration results quantify the impact of a GSF on bank loan risk profiles and the stability of financial markets as a whole.

Our expected findings will provide a systematic understanding of the linkage between green loans and their associated risk, which will help policymakers to quantify a green supporting factor and to understand the sensitivity of this factor to varying lender and borrower characteristics.

Further reading authored by INSPIRE researchers:

Wang, J., Chen, X., Li, X., Yu, J., Zhong, R., 2020. The market reaction to green bond issuance: Evidence from China. *Pacific-Basin Finance Journal* 60, 101294. https://doi.org/10.1016/j.pacfin.2020.101294

Zhou, X., Caldecott, B., Hoepner, A., Wang, Forthcoming. *Bank Green Lending and Credit Risk: An Empirical Analysis of China's Green Credit Policy.*

PROJECT

Using credit risk as an empirical basis for the development of 'brown' investment taxonomies

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Green taxonomies are designed to highlight investment opportunities for a transition to a low-carbon economy. While useful for many purposes, they fail to capture risks. Banking supervisors are now pressing for the development of brown taxonomies as a way of quantifying potential stresses in the financial system associated with climate change. Our project considers how integration of climate risk assessment and credit risk assessment can form a transparent and replicable methodology for accomplishing this goal.

A useful brown taxonomy should be able to identify assets and firms whose adaptive capacity limits their ability to navigate physical and transition risks. The analysis will be forward-looking and rely on scenarios. Perhaps most crucially, the outputs of the taxonomy should be clearly traceable to major input assumptions. In contrast to green taxonomies, one cannot say *a priori* what is brown. Much depends on an unknowable set of policy interventions, technological developments, and localised events that will occur in the future.

To gain a transparent and replicable brown taxonomy, this INSPIRE project will proceed by organising asset- and firm-level impacts into three major categories: adaptation risks; mitigation risks; and natural capital risks. These risks will be analysed within an integrated assessment model (IAM) that we have combined with a structural economic model. We adopt three transition scenarios: business as usual; early (and slow) adoption of transition measures; and late (and rapid) adoption of transition measures. These scenarios are examined across three-time horizons: short term, i.e. 0–3 years; intermediate, i.e. 4–10 years; and long-term, i.e. 11-plus years.

We test our methodology on firms in the European energy sector. The sample comprises over 100 European publicly traded firms, most with a rating by a major credit rating agency (CRA). The time period for the analysis is 2020–2050. For each option in our scenario/time horizon matrix, the structural model incorporates changes in firms' financial health as they invest to meet energy transition/climate resilience goals. The outputs from the model establish the materiality of risk factors. Tracing clearly from inputs to outputs allows for changes in credit quality to be observed for individual firms. The work will reveal, for example, whether events such as the weakening of coal producers and the utilities sector over the past decade are idiosyncratic, or representative of a 'new normal' under a transition to a low-carbon economy.

In summary, our research will seek to reduce the complexity of risk assessment for brown (i.e. impaired) assets and firms. Depending on their view of the likelihood of these risks, financial institutions and regulators can then take a more informed view on capital adequacy.

Further reading authored by INSPIRE researchers:

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Cormack, C., Donovan, C., Köberle, A., Ostrovnaya, A., Forthcoming. *Estimating Financial Risks from the Energy Transition: Potential Impacts from Decarbonisation in the European Power Sector*, in submission.

Donovan, C., Hardy, J., Hindle, J., Mac Dowell, N., Ostrovnaya, A., 2019. *Lending to Low Carbon Technologies*. HSBC Centre of Sustainable Finance, London, UK. https://www.sustainablefinance.hsbc.com/carbon-transition/lending-to-low-carbon-technologies

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Realmonte, G., Drouet, L., Gambhir, A., Glynn, J., Hawkes, A., Köberle, A.C., Tavoni, M., 2019. An inter-model assessment of the role of direct air capture in deep mitigation pathways. *Nature Communications* 10, 1–12. https://doi.org/10.1038/s41467-019-10842-5

Roncoroni, A., Battiston, S., Escobar Farfán, L.O.L., Martinez Jaramillo, S., 2019. Climate Risk and Financial Stability in the Network of Banks and Investment Funds. *SSRN Journal*. https://doi.org/10.2139/ssrn.3356459

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PROJECT

Estimating the impact of climate physical risks on default probability of mortgage loans

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

There is a growing consensus among the scientific community that global warming will lead to changes in the occurrence and patterns of future weather and climate events, such as typhoons, floods and heat waves. These climate-related physical risks will result in considerable damages, many of which could be unexpected, to the real economy and to the financial sector that provides financing for economic activities. These losses incurred by the real economy and the associated impact on the financial sector could be huge. Against this backdrop, the international financial community has been calling for attention and actions to integrate climate-related physical risks into financial decision-making by financial institutions. To manage environmental and climate risks, the primary step is to quantify these risks. However, literature that quantifies the implication of climate-related physical risks for the financial sector is very limited.

In this INSPIRE research, we present an analytical framework for measuring the impact of climate-related physical risks on the default risk of bank loans. We applied this method to quantify the increase in the Probability of Default (PD) of mortgage loans for properties in China's coastal cities, caused by the increased intensity and frequency of exacerbated typhoons under four commonly used climate scenarios defined by the Intergovernmental Panel on Climate Change (IPCC).

The preliminary findings of this INSPIRE study show that future typhoon events exacerbated by climate change along the coast of China could potentially lead to a considerable increase in PD for mortgage loans, with a possible accumulation of incremental PD for more than 5%. This analytical framework can also be applied to many other scenarios of environmental and climate risk analysis for banks if the data required are available, such as impacts of floods and water shortages on credit risk of loans to sectors that are sensitive to such risks.

Further reading authored by INSPIRE researchers:

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Sun, T.Y., Forthcoming. *Quantifying the impact of physical risks on default probability of bank loans*. NGFS ERA Occasional Paper.

Theme 4: Monetary policy, direct and indirect monetary instruments, climate change and the environment

The necessity to incorporate climate- and environment-related risks into monetary policy frameworks and the implications of climate change for price stability are increasingly acknowledged by central banks. Hence, the implications of climate change for central banks can be differentiated into two aspects.

First, climate change may affect central banks' ability to attain their traditional core objectives of price stability by having a sizable impact on macroeconomic and financial variables, including food and energy prices, inflation expectations, economic growth and productivity.

Second, the impact of central banks' own operations on climate change and the mitigation thereof are of concern. At one end of the spectrum, central banks' operations may have an unintended carbon bias, which has been investigated for the Bank of England's and European Central Bank's quantitative easing programmes (Matikainen et al., 2017). Furthermore, a lack of integration of climate risks into monetary policy instruments such as collateral frameworks may expose policy portfolios to unacceptable levels of financial risks and to the inclusion of asset classes, which would not be of eligible investment grade if climate risks were fully accounted for. At the other end of the spectrum, some central banks might be mandated to play a more active role in scaling up green finance. Particularly relevant in the context of the developing and emerging market economies, where some central banks continue to rely on direct monetary policy instruments, policies that intervene in the allocation of credit have historically been dominant and are, in some cases, extended to include green or sustainability-enhancing objectives.

The INSPIRE research portfolio on monetary policy, direct and indirect monetary instruments and climate change includes three projects, which investigate the topics of how transition risk can affect monetary policy, how climate risks can be incorporated in monetary policy instruments such as the collateral framework, and, in the developing and emerging market context, how some central banks are mandated to utilise their direct instruments to scale up green finance.

With regard to future research, investigating the implications of climate change for central banks' price stability and sustainability-related mandates, as well as the impact of climate- and environment-related risks on different monetary policy frameworks, remain central topics. In order to enable central banks to effectively reach their inflation targets, further research on the impacts of climate change and environmental factors on macroeconomic variables, such as short-term price dynamics and the output gap, as well as longer-term productivity and the natural rate of interest, and inflation expectations, is needed. A further important research area is the analysis of the role of collateral frameworks in greening monetary policy and aligning it with the Paris Agreement and sustainable development, as well as the implications of such an overhaul for financial stability.

With regard to the use of direct interventionist instruments by some developing and emerging economy central banks, with the aim of affecting the allocation of credit, trade-off between distortive side-effects and the potential impact on scaling up green finance requires further research.

PROJECT

The role of monetary policy under a low-carbon transition

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

This INSPIRE research will assess the implications for monetary policy action under a low-carbon transition. The transition to a low-carbon economy via more stringent climate policy can result in both demand- and supply-side shocks. Demand-side shocks could originate from a contraction in investment in high-carbon

sectors and in low-carbon sectors, as government investment in low-carbon technologies could 'crowd out' private investment. Supply-side shocks could stem from a reduction in energy resources in the near term, likely leading to slower growth and inflationary pressure, and therefore causing monetary authorities to face a trade-off. We seek to provide insights on the potential monetary policy responses to a climate policy shock by modelling the economic impacts using the multi-country, multi-sector model of the global economy, G-Cubed.

Historically, the main functions of monetary authorities have been to maintain price stability by ensuring low and stable levels of inflation over time. However, unstable economic relationships and external factors have made price stability increasingly difficult to maintain and have led to other strategies, including placing weight on growth, employment and exchange rate targets. We will review monetary policy remits and monetary policy responses following past shocks in order to better inform our approach to modelling a climate policy shock.

To assess the potential responses of central banks in smoothing the impact of a zero-carbon transition, a range of monetary policy rules will be considered in the modelling. To define robust rules, we draw on those outlined by the Federal Reserve (2018) and by McKibbin et al. (2017), including the Henderson-McKibbin-Taylor rule, which places equal weight on inflation and the output gap, as well as other rules such as strict inflation targeting and nominal GDP targeting.

We will use the G-Cubed model employed in Lui et al. (2019) to model the economic impact of a climate policy shock, including monetary policy responses. In particular, our work will model an increase in carbon prices broadly consistent with a 2˚C-of-warming scenario. In addition to varying monetary policy rules, we will explore how the monetary authority's response to the climate policy shock is affected by a simultaneous shock to government spending on low-carbon infrastructure.

The results of this INSPIRE research will identify the sectors most exposed to transition risk and most impacted by a change in monetary policy. The 20-sector structure of G-Cubed allows us to assess the sectoral impacts of a low-carbon transition, including the sectors exposed to fossil fuels and those employing green technologies. The G-Cubed scenario results will also yield information on the sectors most impacted by a change in monetary policy, thus providing key insights on the potential for monetary authorities to exacerbate or smooth the effects of a low-carbon transition.

The model output will include region-specific results which will help to gauge which areas are most likely to be impacted by the transition and the corresponding monetary policy response. The 10-region structure of G-Cubed enables us to quantify differences in regional impacts due to different industry compositions, emissions intensity within industry and technologies employed. We will also be able to assess the extent to which the impact is exacerbated or offset by the response of monetary authorities.

Further reading authored by INSPIRE researchers:

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PROJECT

Greening the Eurosystem collateral framework

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

The collateral framework of the Eurosystem is a crucial component of the Euro area financial system, since it determines the way that commercial banks obtain central bank liquidity and affects the credit conditions facing the non-financial sector. However, in its existing form it does not capture climate risks and is not conducive to the decarbonisation of the Eurozone economies. This INSPIRE project investigates how the Eurosystem collateral could become greener, as well as what implications this would have for credit conditions and investment in the Eurozone.

Our project first analyses the degree of 'brownness'/'greenness' and the climate-related transition risks of the existing corporate securities that are part of the Eurosystem eligible assets. It does so by using alternative methodologies, based on company data from Thomson Reuters Eikon and the NACE classification of the sectors that issue eligible securities. We then explore alternative ways of greening the Eurosystem collateral framework using a combination of (i) haircut adjustments according to the brownness and greenness of corporate securities; (ii) removal of securities that are considered to exhibit too high climate risks; and (iii) inclusion of green securities of high credit quality. In the development of the different versions of a climate-aligned collateral framework the recently developed EU taxonomy is also taken into account. Finally, based on econometric analyses, the project investigates how the yields of corporate securities, as well as the bond issuance and investment of non-financial corporations, could be affected under the different suggested versions of a green collateral framework.

Our preliminary analysis shows that about 60% of the eligible corporate securities are issued by companies that belong to climate-policy-relevant sectors, based on the taxonomy of Battiston et al. (2017). This suggests that the existing collateral framework fails to capture climate-related transition risks.

We have provisionally examined how a green collateral framework can be developed following four steps. In the first step, we increase the haircut of those securities that are characterised by high 'brownness' and high climate risk. This leads to an increase in the average haircut that corresponds to corporate securities and thereby to a reduction in the liquidity that commercial banks can obtain by using corporate securities as collateral. In the second step, securities with excessively high climate risks are excluded. This exclusion reinforces the liquidity effect. In the third step, the haircut of the green bonds that are already included in the collateral framework is reduced. This has only a limited positive effect on the potential liquidity that commercial banks can obtain. This is the case because the proportion of green bonds that are part of the existing Eurosystem collateral framework is small. In the fourth step, we include in the collateral framework both green bonds of high quality and securities that are linked with mitigation activities that are potentially EU taxonomy-eligible. This seems to have a more substantial impact on attenuating the liquidity effect. However, the extent to which these securities are green and are characterised by lower climate risk is now being explored in greater detail.

This INSPIRE project is highly relevant for the NGFS and it will contribute to workstream 3 by illuminating a range of ways through which a climate-aligned collateral framework could be developed in practice, as well as by assessing the effects that the different versions of a green collateral framework could have on the financing of non-financial corporations and decarbonisation. The project is of particular interest to the European Central Bank (ECB), since it will provide the first integrated analysis of the potential design and implications of an ECB climate-aligned collateral framework. This INSPIRE research is also relevant for

other central banks, since the project develops methodologies that can be adopted by banks wishing to investigate what the development of a green collateral framework would mean in practice.

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PROJECT

Central Banks' mandate in green credit guidance: beyond prudential regulation

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

The transition to a low-carbon economy will require the mobilisation of significant financial resources around the globe, which are estimated to amount to around US$90 trillion for infrastructure investments in the next 15 years and an estimated US$500 billion investments annually in developing countries between the year 2020 and 2030 (New Climate Economy, 2014). Despite the critical importance of climate finance in enabling this important transition to a low-carbon economy, relatively little attention has been paid to the potential role of the financial sector and in particular the role of central banks and commercial banks in promoting this transition. While financial flows directed towards climate change mitigation and adaptation are increasing, they still remain significantly below those required under the Paris Agreement. This points to the need to leverage private sector finance in order to mitigate this funding gap.

This INSPIRE research assesses the potential role for central banks in implementing green credit guidance for commercial banks to mobilise the much-needed climate finance.

Given the enormity of the green financing gap and the need to align private financial flows with climate objectives as required under the Paris Agreement, central banks arguably have a role to play in redirecting private sector capital flows from high-carbon sectors to low-carbon sectors. This potential role of central banks is due to a variety of factors including that central banks are at the heart of financial systems all over the world; they have various and powerful macroprudential instruments at their disposal; they are public institutions that have a responsibility to further public or social good; and climate risks pose a threat to financial stability, a central objective for most central banks.

Most of the literature and debates primarily focus on prudential concerns given that maintaining financial stability is well within the legal mandates of most central banks around the globe. A more supportive or promotional role of central banks in mobilising and scaling up the much needed climate finance has, however, been more controversial and has not been considerably explored (Dikau and Volz, 2020). Part of the reason for this reluctance and controversy has been attributed to a variety of arguments including that (i) central banks are not democratic institutions and that this role would better be performed by

democratically elected governments (Tucker, 2018); (ii) that it would create market distortions; and (iii) that adding to the responsibilities of central banks will distract them from their core responsibilities of price stability and monetary policy (Volz, 2017). We agree that most of this hesitation is a function of the traditionally narrow focus of central bank mandates and there is a need to overcome the collective amnesia over central banks' role in the past that stands in the way of having proactive central banks (Braun and Downey, 2020).

Through this INSPIRE research we critically assess the various objections against green credit guidance by central banks and argue for a promotional role. The paper is premised on the hypothesis that there is a glut of private sector finance that may be easily directed towards green sectors and the further argument that current initiatives are grossly underestimating the scale and urgency of the climate emergency and will barely be adequate to meet the planet's climate objectives.

Drawing on the credit creation theory of banks (Werner, 2014), law and economics, the concept of the environment as a public good (Nordhaus, 1999), and the precautionary principle of environmental policy (Chenet et al., 2019), we argue that since commercial banks are 'franchisees' licensed by the public under the finance franchise framework to create and extend loans (Hockett, 2019), they have a responsibility to further societal good. We collect and analyse primary data through key stakeholder interviews in selected central banks and commercial banks and supplement the findings through document analysis of banks' financial reports and other relevant academic literature. The empirical findings serve to highlight the concerns and views of the affected stakeholders. Arising out of the findings, the project presents a framework to explain the divergent views and justifies the argument that central banks have a potential role in green credit guidance, potentially necessitating a re-evaluation of central banks' legal mandates.

Theme 5: Sovereign bonds and climate- and environment-related risk

In the context of macrofinancial risks, the investigation of sovereign bonds as one of the largest asset classes with regard to the implications of climate change and environment-related risks is fundamental. The assessment of sovereign bonds and risk, which also serves as a general market benchmark in the financial system, can have far-reaching implications for financial stability and prudential regulation, as well as for monetary policy and the calibration and operationality of conventional and unconventional policy instruments in the context of climate change and environmental degradation.

First, the identification of the related transmission channels through which climate and environment-related risks affect sovereign risk is of vital importance. In this context, the identification and incorporation of climate- and environment-related risks into sovereign bond risk assessments can be seen as a fundamental enabling step.

With regard to policy implications, highly liquid sovereign bonds are a significant element of central banks' monetary policy operations and their risk assessment of sovereign debt securities relies on credit rating agencies (CRAs) and central banks' internal risk evaluation processes. It is therefore important that financial regulators and central banks integrate these climate-related sovereign risks into their operational monetary and prudential policy frameworks. The development of standardised disclosure frameworks and the inclusion of these risks in the assessment of CRAs offer starting points. Furthermore, a climate-conscious assessment of sovereign risks also has implications for prudential authorities' microprudential instruments and for stress-testing frameworks.

The INSPIRE research portfolio on sovereign bonds and climate- and environment-related risk includes three projects, which investigate how well CRAs take climate risks in ratings into account, the value of economies' performance on the Sustainable Development Goals as an indicator for sovereign bond spreads, and the transmission mechanism from climate-related risks to sovereign risk, and the related regulatory policy implications.

With regard to future research areas, further investigation of the impact of climate- and environment-related risks on the performance of sovereign debt as well as on the costs of sovereign borrowing and sovereign spreads is needed to inform monetary and prudential policy frameworks and to enable central

banks and supervisors to effectively achieve their core objectives. The investigation of the involved transmission mechanisms on how climate- and environment-related risks affect fiscal health and therefore sovereign bonds is therefore a central task for future research.

PROJECT

Climate change and sovereign credit ratings

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

Financial markets face increasing pressure to factor climate risks into decision-making. Enthusiasm for 'greening the financial system' is welcome, but a fundamental challenge remains: investors lack the necessary information. This creates a potential conflict of interest and information asymmetry: sovereigns want cheap access to capital and have an incentive to downplay climate risk, while investors want to manage climate exposure but do not know how much risk they face. Without a standardised framework and regulatory requirement for disclosing climate risk, organisations face little incentive to provide such information accurately to investors.

Existing climate risk disclosures are rare, ad hoc, voluntary, unregulated and generally based on internal assessments rather than climate science. Credit ratings agencies (CRAs) are key intermediaries between investors and investment opportunities, serving an important role by rating the creditworthiness of potential investments. They use established and published methods to combine publicly available information with an 'inside look' to measure the ability of the issuer to repay its debt obligations. Ultimately, their role is to help reduce information asymmetries, overcome conflicts of interest, and provide investors with standardised information about risk.

This INSPIRE project examines how well ratings agencies – which assess the creditworthiness of investments – 'capture' climate risks in ratings. We investigate how well the financial system factors in climate-related risk and makes such information available to investors. First, using historical evidence we determine whether past ratings have factored in observed climate-related losses. Next, we combine forward-looking climate models with the ratings methodology from a major CRAs to compare sovereign creditworthiness in a world with climate change, versus a counterfactual world without warming (in which temperatures are held constant at their 1980–2010 average). These results are relevant to regulators, governments, policymakers, investors, banks (including central banks), insurers, and CRAs. Finally, we mobilise our extensive network in finance, climate science and economics to develop a provocative position piece on the state of green finance and future priorities.

Further reading authored by INSPIRE researchers:

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PROJECT

The impact of country Sustainable Development Goals performance on sovereign bond spreads

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Research commissioned following July 2019 call for proposals

Research status: Ongoing

The traditional relation between sovereign bond spreads and macroeconomic fundamentals appears to be weak since the financial crisis (Capelle-Blancard et al., 2019). In search of additional determinants, scholars shifted their attention towards intangible factors related to Environment, Social and Governance (ESG) dimensions (e.g. Crifo et al., 2015). Country ESG ratings are used to measure a country's sustainability level, but often solely provide information about a country's policy towards these intangible factors (Gonenc and Scholtens, 2017). We believe that the United Nations Sustainable Development Goals (SDGs) can provide a better measure for sustainability of a country. The strength of the UN SDGs is that all goals are interlinked; governments are unable to cherry-pick their favourite goal. Unlike ESG ratings, the SDGs can be seen as a measure of the transition of the country towards full sustainability and are therefore output- and future-oriented. In addition, the SDGs are a direct measure of a government's pledge to achieve social inclusion and environmental protection by 2030.

We are interested in the impact of SDG performance on sovereign bond spreads. Governments that are unprepared will increase the risk of unforeseen future SDG-related government expenses. An increase in government expenditures will negatively impact a government's budget and its likelihood to repay its debt. Investors may demand to be compensated for this higher perceived country risk, influencing borrowing costs for governments.

We use the online available dataset of the latest Sustainable Development Report (see Sachs et al., 2019). In total there are 17 SDGs and 88 indicators. The dataset includes an overview of the countries' performance by SDG. This includes spillover scores and raw country data for the indicators over the time period of 2000–2019. We will use a broad range of low- and high-income countries. This means we will have government bonds issued in different currencies. We define the sovereign bond spread as the difference between a government borrowing costs and either the German zero curve for countries that are part of the European Monetary Union or the US Treasury curve (Crifo et al., 2015). We will obtain interest rates from Bloomberg for different maturities.

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PROJECT

Sovereign risk and climate change

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Research commissioned following March 2019 call for proposals

Research status: Ongoing

Our project for INSPIRE investigates how climate risks impact on sovereign credit risk and debt sustainability and assesses the implications from a financial regulation and central banking perspective. In particular, we address the following two sub-questions:

- Through which channels can climate-related risks affect sovereign risk and how important are their respective impacts?
- What are the regulatory and supervisory implications for financial supervisors and central banks?

The research is conducted in two parts. First, we develop a conceptual framework that characterises the transmission channels between climate risk and sovereign risk, stressing the importance for financial regulators and central banks to integrate these risks into their operational frameworks in achieving their mandated objectives. Second, and building on this conceptual work, we assess the climate-sovereign risk nexus for the 10 member countries of the Association of Southeast Asian Nations (ASEAN), a group that includes four NGFS members (Indonesia, Malaysia, Singapore, Thailand). Southeast Asian countries are among those most heavily affected by climate change, with devastating impacts on the economy that are increasing at a faster pace than in other regions. We assess macrofinancial and sovereign risk stemming from climate change for ASEAN countries and consider possible policy responses by financial regulators and central banks. Building on the research team's previous empirical work on the pricing of sovereign risk and the impact of climate risk on the cost of sovereign borrowing in climate-vulnerable countries, we combine different approaches to assess the impact of climate-related risks on fiscal health and sovereign risk, and how these impact on macrofinancial stability. The results will inform stress-testing exercises to understand and identify different thresholds and layers of risk. In partnership with policymakers, these exercises will inform choices around public risk management and financing strategies, and adequate prudential policy responses.

The research feeds into the NGFS workstream 2 and contributes to an improved understanding of sovereign risk in developing and emerging markets for policy purposes. Notably, this research will feed into the design of stress testing and scenario analysis which need to take account of sovereign risk and potential feedback loops between climate-induced fiscal vulnerability and financial sector instability. Central banks and financial supervisors ought to monitor fiscal positions and debt sustainability closely, as well as the exposure of financial institutions to sovereign risk. Moreover, the research provides insights into policy coordination between the central bank and government in order to optimise public debt

management. Our research may also inform the macrofinancial surveillance work of the International Monetary Fund (IMF) and other international organisations advising on macrofinancial stability and climate-related fiscal risks. Finally, it informs treatment of sovereign risk in the Basel capital framework, and how microprudential supervision can support financial institutions to integrate climate factors into financial decision-making, including assessments of their vulnerability to climate risk via exposure to sovereign debt and the mispricing of credit in markets with worsening sovereign credit profiles. This aligns with the goals of NGFS workstream 1.

Further reading authored by INSPIRE researchers:

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Theme 6: Assessing the effectiveness and impact of central bank and supervisory policies in greening the financial system

The assessment of the effectiveness and impact of different existing policy measures on greening the financial system, and mitigating the climate change and related financial risks, has been identified by INSPIRE as a key research priority area that necessitates further rigorous study. Based on the third call for papers, released in March 2020 and INSPIRE's first single-issue targeted call, further research on this topic is set to be commissioned from June 2020 onwards. The investigation of the impact and effectiveness of measures can thereby be seen as a key cross-cutting theme, which is emerging as a critical issue on the frontier of central bank and financial regulation action to green the financial system. This topic cuts across all three of the NGFS workstreams and is set out to supply central banks and regulators with information on the absolute and relative effectiveness of different existing policy measures.

With its third call, INSPIRE seeks to encourage proposals on the impact and effectiveness of microprudential and supervisory aspects, macrofinancial topics, and the scaling up green finance in the real economy, among other issues outlined in detail below. The call can be seen as a response to the rapid growth in actions by central banks and supervisors to mitigate climate- and environment-related financial risks and green the financial system. The challenge is no longer to make the case for central bank action but to identify interventions that have impact across the three key dimensions of policy performance, namely on:

- Effectiveness and the question of whether the policy measure achieves its goals
- Efficiency and the question of whether the policy measure achieve its goals at reasonable cost
- Equity and the question of whether or how the benefits and costs of the measure are distributed and who is involved

Central banks and financial supervisors have a range of policy options to foster the transition to a low-carbon, resilient and sustainable economy across prudential and monetary policies. Yet, in spite of the

increasing interest of central banks and supervisors in these policy options, the understanding of how instruments impact environmental, financial and economic variables remains at an early stage.

Many policy interventions have focused on improving disclosure of environmental factors, but there remains limited understanding of the effectiveness of disclosure to drive changes in financial market behaviours and what types of disclosure have real economic impact. In addition, some central bankers, for example, have indicated interest in ways to green monetary policy operations, but have also argued that the expected impact would be marginal. These examples illustrate the need for an improved empirical understanding of the impact and effectiveness of measures to green the financial system. Against this background, the third INSPIRE call, currently under review, shall commission innovative research on assessing the environmental, financial and economic impacts of central banks' and financial supervisors' policies and operations. The scope of impact includes both the performance of the financial system and changes in the real economy. This focus on impact is set to be increasingly important for central banks, and supervisors focus on the contribution they can make in implementing the Paris Agreement goal of making financial flows consistent with the transition to low-carbon and resilient development pathways.

This call for proposals encouraged research submissions that not only focused on the financial impacts of monetary and financial policies, but also investigated their effect on economic and environmental variables. More specifically, INSPIRE welcomed research proposals that identify specific financial and monetary policy options to green the financial system and that assess policies' (intended and unintended) real world impact on (i) environmental outcomes, (ii) financial stability, (iii) financial flows and (iv) the economy (among other possible dimensions).

Within this broad framework, specific research topics on which submissions are encouraged under the third call include:

- The development of conceptual frameworks for evaluating policy measures' effectiveness in different dimensions – e.g. environmental outcome, financial stability, financial flows, economic outcome. These frameworks can possibly be focused on a specific region or market.
- The identification of prudential, financial and monetary policies that are the most effective in delivering an orderly transition to a low-carbon and resilient economy.
- The exploration of how policy measures to green the financial system could be designed or re-designed in order to enhance their effectiveness.
- The evaluation of the data gaps that hold back the assessment of effectiveness of policy options, as well as the identification of ways of overcoming these.
- The assessment of the impact that sustainable financial, prudential and monetary policies have on environmental factors, financial flows, the funding of firms and households, and ultimately, on economic activities in the short and the long term.
- The investigation of the effect and effectiveness of how climate risks are priced in by financial institutions the evaluation of risk management techniques (for climate financial risks) and the impacts of supervisory policy on climate risk management by financial institutions.
- The assessment of possible trade-offs and synergies between financial, prudential and monetary policies aimed at fostering the transition to a low-carbon economy and other objectives in the mandate of central banks and financial supervisors.
- The assessment of possible trade-offs and synergies between monetary and fiscal policies, for example in the form of carbon taxes, which are expected to have a significant impact on the economic environment that central banks operate in.
- The assessment of the impacts of a reallocation of the assets in central bank policy portfolios on financial asset prices, funding flows to the real economic activities and on the real economy more broadly. Changes in central bank asset purchases, in their lending policies and in collateral frameworks are examples of such policies. The identification and description of the transmission channels that lead to these impacts is also of interest.

In response to the third call, 31 proposals were received and are currently under review. An overview of projects commissioned from this call and future research calls will be published later in the year.

3. Future research themes and plans for INSPIRE

COVID-19 has precipitated a profound health and economic crisis. Central banks and supervisors have been quick to respond, with unprecedented measures to stabilise financial markets across the world. What has also been striking is the speed with which leading policymakers and financial actors have signalled that the world must 'build back better' from the crisis (G20, 2020), ensuring that efforts to avoid instability today do not compound the risks posed by climate change and environmental degradation tomorrow. Indeed, post-COVID recovery packages can help to accelerate the transition to a green, resilient and inclusive low-carbon economy (Thallinger and Robins, 2020). Here, central banks and supervisors will play a critical role, deepening the incorporation of sustainability risk factors throughout their operations and making sure that their crisis response measures do not lock in the unstable high-carbon economy of the past. INSPIRE is currently in dialogue with the NGFS to identify ways in which the 'toolkit' of policy measures for a green recovery can be supported, and over the next year INSPIRE's work will be framed by this strategic imperative of a sustainable recovery. Already a rich agenda of research topics lies ahead.

Commissioning

INSPIRE seeks to further extend its research portfolio through the commissioning of research based on more targeted single-issue calls that aim to direct research efforts towards cutting-edge topics as identified by INSPIRE, the NGFS and the wider research community. Based on the three previous calls and the dialogue with central banks, supervisors and researchers, INSPIRE has identified a rich and expanding international research agenda on various topics relating to the overall questions of the implications of climate change and environmental sustainability for central banks, financial supervision and the greening of the financial system. Key elements of this research agenda are set out in the box on the next page. INSPIRE also plans to evolve its commissioning process to publish more targeted, single-issue calls that aim to direct research efforts towards cutting-edge topics as identified by INSPIRE, the NGFS and the wider research community.

The facilitation of joint research between NGFS members and other researchers, potentially through the funding of secondments of researchers to NGFS member institutions, are further potential future activities for INSPIRE.

This is an ambitious programme of work and INSPIRE will seek to commission research across many of these themes during 2020.

Convening

For the future, INSPIRE is planning to jointly host a series of webinars with INSPIRE researchers and NGFS members. Targeted workshops alongside the major meetings with the NGFS will be organised to further facilitate the exchange of ideas, research findings and policy implications. We will also host further independent INSPIRE network forums that will bring together NGFS members with the INSPIRE research community to discuss findings and policy implications of the INSPIRE-funded projects.

Emerging priority research themes for greening the financial system

- Assessing firms' exposure to transition risks and the impact of mandatory disclosure on financial institutions, including non-banks
- The limitations of traditional risk management concepts and of backward-looking analysis, and the benefits of forward-looking scenario-based analysis
- The regulatory implications of the adoption and management of sustainable and responsible investment practices
- The design of investment benchmarks aligned to climate goals
- The development of new asset classes such as long-term, low-carbon emission assets
- Reflecting on the concept of market neutrality in the era of climate emergency
- The modelling of systemic climate-related risks and long-term supervision
- The building of common scenarios for assessing the exposure of assets, institutions and systems to climate and wider environmental threats
- The risk effects of environmental factors beyond climate change (e.g. loss of biodiversity, ecosystem degradation)
- Understanding the role of central banks and supervisors in connecting green goals with the need for a just transition to an inclusive and balanced economy
- Financial regulation, supervision and the implications of climate risks and empirical studies on climate risks and stress-testing applications
- Mechanisms to link global climate finance and the stability of the international financial and monetary system
- The development of conceptual frameworks to ensure effective coordination among prudential, monetary and fiscal policies
- Comparing scenarios where prudential, monetary and fiscal policies are optimised jointly for climate purposes and scenarios where these diverge
- The implications of the transition to a sustainable economy for core policy tools such as inflation targeting, exchange rate targeting and GDP targeting
- The impact of monetary and financial policies on environmental outcomes even in the absence of green objectives
- Greening monetary policy and accounting for climate risks in central banks' own operations (e.g. greening collateral frameworks)
- The implications for unconventional monetary policies for the environment
- In the context of developing countries, the assessment of financial firms' adaptive capacity to respond to climate-related monetary and financial policies
- Evaluation of the impact of measures to green the financial system in terms of effectiveness, efficiency and equity
- More interdisciplinary research, drawing from political economy/cultural and institutional dynamics/ behavioural economics

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INSPIRE – the International Network for Sustainable Financial Policy Insights, Research and Exchange – has been created to enhance research efforts that can inform the work of the Central Banks and Supervisors Network for Greening the Financial System (NGFS), its workstreams and its members. This report provides an overview of these research efforts and of the 21 projects that INSPIRE has commissioned up to spring 2020. The first preliminary results presented in this report point towards important policy implications, as well to the need for further research and exchange between researchers and central banks and supervisors.

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