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Bank of Japan
Financial System and Bank Examination Department

Summary of the International Research Workshop on Climate-related Financial Risks: Interactions of Climate Change and the Financial System

I. Introduction

The Financial System and Bank Examination department of Bank of Japan held "International Research Workshop on Climate-related Financial Risks" online on March 25 and 26, 2021.[1] The workshop attracted about 500 registered participants from financial authorities, academics, and financial institutions all over the world.

The workshop began with opening remarks by Haruhiko Kuroda (Bank of Japan), followed by a keynote speech by Jeffrey Sachs (Earth Institute, Columbia University). The paper presentation session opened with an introductory session by Hibiki Ichiue (Bank of Japan), followed by paper presentations by Winta Beyene and Steven Ongena (University of Zurich), Matthew E. Kahn (Johns Hopkins University), Patrick Bolton (Columbia University), and Miyuki Hino (University of North Carolina at Chapel Hill). The policy panel discussion moderated by Masazumi Wakatabe (Bank of Japan) was comprised of three panelists: Sarah Breeden (Bank of England), Sabine Mauderer (Deutsche Bundesbank), and Kevin Stiroh (Federal Reserve Board of Governors: FRB). Concluding remarks were made by Ryozo Himino (the Financial Services Agency: JFSA).

II. Welcome Remarks

In his opening remarks, **Kuroda** delivered a speech titled "Addressing Climate-related Financial Risks--From a Central Bank's Perspective--," which provided an overview of efforts to address climate-related financial risks from a central bank perspective.

He pointed out that climate change brings dangers that could have a profound effect on society and the economy around the globe, and that the reduction of greenhouse gas emissions is essential for the sustainable development of civilization. At the same time,

[1] See the following link for the program. Affiliations of the participants are as of March 25-26, 2021.
https://www.boj.or.jp/en/announcements/release_2020/rel201224b.htm/

he mentioned that while setting a course toward reducing greenhouse gas emissions is primarily the responsibility of governments, central banks must take necessary measures against the impact of climate change, given its powerful influence over economic activity and the financial system in the medium to long term.

Then, he mentioned there has been remarkable progress in the understanding and management of climate-related financial risks due to the work along with policy makers, academics, and the private sector, including financial institutions. Specifically, he pointed out: (i) the deeper understanding about the transmission channels of climate-related financial risks; (ii) the progress in the methodology for measuring climate-related financial risks; (iii) the establishment of the framework to help firms understand climate-related financial risks and encourage disclosures; and (iv) the acceleration of international cooperation to improve the methods for understanding and managing climate-related financial risks. At the same time, he mentioned that challenges have also become apparent, such as the complexity of transmission channels, the insufficiency of data and the length of time horizons for scenario analysis.

He presented the following three points as the Bank of Japan's basic approach how central banks should address climate-related financial risks. First, the size and number of challenges is no reason to delay addressing this issue. Rather, central banks must take forward-looking steps and make steady progress in overcoming these issues in cooperation with other stakeholders; second, when central banks respond to climate change issues, they have to respond in line with their mandates. In the context of climate-related financial risks, any response must be considered in line with the central bank's responsibility to ensure the stability of the financial system; third, in discussing specific measures to address climate-related financial risks, central banks must choose the best option based on their knowledge and the data available at that moment. He added that, bearing these basic ideas in mind, the Bank of Japan has been so far engaged in active dialogue with financial institutions on how to grasp and manage climate-related financial risks and the Bank intends to further accelerate these initiatives.

He concluded his opening remarks by expressing his hope that the discussions in this workshop will help to deepen our understanding of the relationship between climate change and finance.

III. Keynote Speech

In his keynote speech, **Sachs** discussed the need for transition towards the decarbonized economy, challenges associated with such transition process, and the actions that should

be taken by central banks, financial authorities and governments to achieve a decarbonized economy. He began by noting that the global average temperature in 2020 was 1.2 degrees Celsius above the pre-industrial level, making it the hottest year on record along with 2016, and that even if the world achieves transition to a decarbonized economy by mid-century, the Paris Agreement of aiming to limit the temperature increase up to 1.5 degrees Celsius above the pre-industrial level may not be achieved. In this context, he welcomed the political movement among governments worldwide that commit to achieving a decarbonized economy by the middle of this century.

Against this background, as risks associated with climate change, he cited the risk that large investments by banks in fossil fuel companies will turn into bad loans as a result of transition toward a decarbonized economy, the risk that climate change damages corporates' valuations, and the risk of bearing significant costs in adapting to possible large-scale natural disasters (such as reinforcement of infrastructures and flood protection). He then pointed out that these risks need to be reflected in corporates' balance sheets.

He also argued that financial supervision is one of the key tools in taking on the unprecedented challenge of transitioning to a decarbonized economy. Specifically, he stressed that banks need to be provided with the right information about climate-related risks. As an example, he noted that it is important to promote awareness through supervision that investments in fossil fuels are likely to lead to incurring the risk of holding stranded assets in future. On the other hand, he emphasized that the most important policies in tackling climate change must be led by governments, not by either central banks or other financial supervisory authorities. Since the reforms needed to achieve a decarbonized economy are large and far-reaching, he argued that they cannot be accomplished by the market power alone, and that tools such as public investment and regulation will be critical in supporting them.

Finally, he highlighted the importance of building global trust by promoting international cooperation in forming regional energy network, designing globally consistent regulations, and developing rules for international trade, in order to achieve a decarbonized economy. He concluded his speech by emphasizing that the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to be held in November this year is one of the deadlines to show the way forward to achieve a decarbonized economy by the middle of this century.

IV. Introductory Session: How Does Climate Change Interact with the

Financial System? A Survey

Ichiue presented his and his coauthors' survey paper on the interaction between climate change and the financial system, and mentioned that their survey also highlights the shorter-term impacts of climate-related natural disasters and the causal link from the financial system while recent discussions often focus on the relatively long-term impacts of climate change on the financial system. Following this, to build a common understanding and facilitate discussion among participants, he gave a relatively detailed explanation of transmission channels and potential policy measures.

Regarding transmission channels, he presented an overview of transmission channels and explained that i) climate-related risks can largely be classified into physical risks and transition risks, ii) when these risks materialize, the financial system is affected through, direct channels, and indirect channels, iii) once the financial system is affected, feedback loops between the real economy and the financial system may start to operate, and iv) there are also transmission channels in the opposite direction through which the financial system affects climate change and its impacts on the real economy.

As for potential policy measures, he noted that i) carbon pricing is widely regarded as the first best option, but insufficient in the eyes of leading economists, ii) recent discussions provide some support for the use of financial policy measures, such as climate-related stress tests and the enhancement of disclosure requirements, and iii) policy makers and scholars are more cautious about policies to actively promote greening, such as lower and higher risk weights for "green" and "brown" loans, respectively.

Regarding the interaction between climate change and the financial system, he pointed out following three issues.

First, regarding the extent to which asset prices factored in climate-related risks, he showed that many recent studies, including a paper by **Hino** and **Burke**, find that property prices do not adequately reflect the physical risks. A large number of studies show that stock prices to some extent incorporate transition risks, although several studies find evidence of mispricing of physical risks. When asset prices do not adequately factor in risks, they can hinder adaptation and mitigation actions. Many studies also demonstrate the effects of information disclosure. For example, several studies provide evidence that a lack of disclosure leads to the overpricing of properties.

Second, as to the relationship between natural disasters and bank behavior, he pointed out that when the area in which banks operate is affected by a natural disaster, the borrowing

demand by affected companies increases while banks' financial soundness deteriorates, and the supply of loans decreases, especially to new and small businesses. Banks also reduce lending in unaffected areas, leading to a negative impact on the real economy in those areas. There is considerable heterogeneity in the impact that natural disasters have. For instance, local banks in affected areas are more likely to continue lending, and the effects were less severe when banks have high capital ratios. He added that while public support through Government Sponsored Enterprises (GSEs) and other instruments mitigate the impact of a disaster, it has the negative side effect of distorting resource allocation.

Third, he argued that insurance mitigates the impact of disasters and complements bank finance, and pointed out three challenges. The first challenge is to increase insurance coverage. According to Swiss Re, worldwide, more than 70 percent of natural disaster losses are not covered by insurance. The second challenge is to maintain financial health of insurers. A possible consequence of large disasters is that the solvency of insurance firms is affected. Even if insurance firms remain solvent, they may conduct a fire-sale of assets in order to meet insurance claims. Another concern is that insurers may raise premiums or even stop providing insurance. The third challenge is to avoid the problem of moral hazard. The literature finds that public insurance is too cheap and too insensitive to risk, causing moral hazard and impeding adaptation to climate change.

He concluded the session by referring three policy implications. First, asset prices, in particular real estate properties, do not adequately price in physical risks. This indicates that asset prices may decline significantly as climate change risks materialize. Meanwhile, several studies provide evidence that disclosure helps alleviate such problems. Second, natural disasters restrict the credit supply of banks even in unaffected areas. Public support to address the adverse effects potentially distorts resource allocation. Also, regulatory frameworks originally intended to be against non-climate shocks are effective with regard to climate-related risks. Third, while insurance mitigates the adverse effects of climate change, the literature also points to challenges. It is important for policy makers to be aware of the benefits and challenges when they design monitoring and supervisory frameworks.

V. Paper Presentation Session 1: Impacts of Climate-related Financial Risks on Banking Sector

A. Mortgage finance in the face of rising climate risk

In the process of adapting to climate change, it is important to understand how various

economic entities incorporate climate-related financial risks into their behaviors. On this point, **Kahn** presented his work on how bank's mortgage lending behaviors change after severe natural disasters, using an event-study approach with fifteen major hurricanes observed in the United States. The work is carried out with a framework that models the bank's profit maximizing behavior such that: the bank issues loans and then must decide whether to hold these loans or securitize them; if the residential loans are "conforming", meaning that they meet certain level of standards, the bank can securitize and sell them to the GSEs; GSEs do not discount for climate risks when they purchase loans from the bank. The result shows that, in the aftermath of hurricanes, banks are more likely to originate mortgages that can be securitized and bunch these loans to the amount just below the limit that can be purchased by the GSEs. The result implies that banks have assessed the climate-related financial risks more thoroughly after experiencing natural disasters and transferred such risks to GSEs using their information advantage.

As the discussant, **Cortés** appreciated the work for evoking the importance for banks and public sectors to recognize climate related financial risks, and praised that the analysis had been undertaken in a sophisticated manner. She then emphasized the need for further discussing the implication of the obtained results, clarifying specific issues associated with banks transferring risks associated with natural disasters to GSEs by securitizing such loans. **Kahn** appreciated the comments made and replied that further work would be pursued taking those issues into account.

From the floor, there was a question about a potential impact on housing markets if banks would start to price climate risks in their mortgage lending. **Kahn** replied that banks' adaptation to climate risks would induce households to choose houses on higher grounds, and pointed out that more houses would need to be built on such grounds and supplied, so that households would be able to choose to live on those grounds when banks do start adapting to climate risks.

B. Fuelling fossil fuel: Bond to bank substitution in the transition to a low-carbon economy

In the transition process to a low-carbon economy, fund providers play an important role as they can channel funds away from fossil fuel. Even if bond markets require high interest rates on stranded asset projects, such projects may still be maintained if banks provide lending with lower interest rates. With this motivation, **Ongena** and **Beyene** presented the result of their analysis that first, compared the sensitivity of interest rates to a change in transition risk, between bond markets and bank lending, and second,

examined whether, to fulfill their financing needs, fossil fuel firms increasingly rely less on bonds and more on banks with increasing stranded assets risk. The analysis is carried out with a proxy for fossil fuel firms' risk of stranded assets (consisting of fossil fuel reserves and the potential willingness to implement stricter climate policies by the country in which the firm is located) as an explanatory variable. The result shows that, in response to a rise in stranded assets risk, corporate bonds become more expensive, but the same is not the case for syndicated bank loans. This suggests that banks incorporate climate-related financial risks into their lending rates by less than bond markets. Further, the results show that fossil fuel firms increasingly substitute bonds for syndicated bank loans when banks price the risk of stranded assets less than the bond market. The result implies that a substitution mechanism between bond and bank financing could mitigate the capital constraints on fossil fuel firms imposed by markets.

As the discussant, **Tanaka** praised this paper as a valuable piece of work that attempted to analyze how banks and bond markets price stranded assets. Tanaka then made some technical suggestions for improving the analytical procedures taken by examining the plausibility of some measures used in their analysis. Tanaka also pointed out the need for assessing the reasons why banks are less likely to factor climate-related financial risks into their interest rates than the bond market despite that banks assess the risks of borrowers in their screening and monitoring process. **Ongena** and **Beyene** appreciated these comments and replied that they will continue to look into these issues in order to enhance the robustness of their results.

From the floor, the possibility was pointed out that asset managers have influenced the difference in funding costs between the bond market and bank lending: in the bond market, asset managers discriminate stranded assets and other assets, but banks may not be making such discrimination. **Ongena** and **Beyene** acknowledged this comment and replied that further research would be needed for understanding the factors creating the difference in interest rates between these two funding markets.

VI. Paper Presentation Session 2: To What Extent Do Asset Prices Reflect Climate-related Financial Risks?

A. Carbon premium around the world

Against the background of global economy shifting from the use of fossil fuels to renewable energy, an issue arises as to what extent the transition risk has been priced in financial assets. **Bolton** reported on a study that estimated the market-based risk premium for carbon emissions using a sample of 14,400 companies in 77 countries. Specifically,

he conducted a regression analysis with the risk premium as the dependent variable and carbon emissions as the explanatory variable.

The results show that the risk premium is higher for companies with higher carbon emissions in all of Asia, Europe, and North America. This suggests that investors demand a carbon premium for companies with higher transition risk. He then examined the degree of the carbon premium by country where the companies in sample are located. He found that (i) the degree of economic development does not affect the carbon premium, but (ii) the carbon premium is lower in countries with a higher degree of democratization and rule of law, and (iii) the carbon premium is also lower in countries with a higher share of renewable energy. This result can be interpreted as that in countries such as (ii) and (iii), environmental policies have already been strengthened and the future transition risk has already been reduced.

As the discussant, **Hsu** praised the paper as an ambitious analysis that comprehensively demonstrated the existence of a carbon premium by constructing a large-scale dataset that includes carbon emissions at individual company level. He then pointed out that since the carbon emissions data used in this paper (Greenhouse Gas Protocol) is based on voluntary disclosures, robustness checks using other emissions data based on disclosure requirements is worth considering. **Bolton** appreciated these comments and replied that other data on emissions were not used in this study because they do not account for emissions on the supply chain.

From the floor, there was a question about a possibility that the carbon premium may be affected by the degree of openness of financial markets. **Bolton** responded by sharing a result that, when institutional investors divest in response to an increase in carbon emissions, they divest in foreign countries rather than in their own country, although the effect of such behavior on the carbon premium had not been tested.

B. Does information about climate risk affect property values?

As floods and other natural disasters continue to increase, excessive land development in high-risk areas can be prevented if asset prices properly factor in climate risks. **Hino** reported on a study that measured the impact of new information about flood risk on house prices in the U.S. Specifically, she conducted a regression analysis using house prices as the dependent variable and flood risk based on floodplain maps produced by the U.S. government as the explanatory variable. The results showed that the discount rate for flood risk estimated from housing market was smaller than the discount rate estimated from insurance premiums of the National Flood Insurance Program (NFIP). This suggests

that the U.S. housing market has not fully factored in flood risk. Moreover, the discount rate for flood risk estimated from housing market is larger: (i) when buyers have commercial purposes; and (ii) in states where there are more regulations related to disclosure requirements for flood-related information. She explained the implication of these results as the flood risk being more strongly incorporated into housing prices when buyers have more information on flood risk.

As the discussant, **Hartley** praised the study for using comprehensive data. He then suggested (i) to check the robustness by adding geographic data such as altitude difference and distance from rivers as control variables in order to estimate the discount rate of flood risk more accurately, and (ii) to describe in more detail the procedure for estimating the discount rate of flood risk from NFIP premiums. He also commented that a careful verification of the discount rate of flood risk estimated from NFIP premiums being more accurate than the discount rate estimated from housing market would be beneficial in order to argue that housing prices are overvalued in relation to flood risk. In response, **Hino** appreciated these comments and replied that in order to answer the questions accurately, it is necessary to examine in more detail what information buyers use to calculate flood risk when houses are sold.

VII. Policy Panel

In the policy panel discussion, moderated by Wakatabe, three panelists, Breeden, Mauderer, and Stiroh, expressed their views on the ongoing efforts on climate-related financial risks and future challenges.

A. Remarks by Panelists

Breeden began by introducing the Bank of England's efforts in recent years. She explained that they initially focused on physical risks for insurance firms and had a limited understanding of transition risks when they first started considering climate change in 2015. She also mentioned that, when the Bank of England next conducted an analysis of banks, they found that many of them either saw it as part of their corporate social responsibilities or only reacted in a responsive way, and that only about 10% of banks had a strategic, forward looking and holistic approach to climate-related financial risks. Against this backdrop, she explained that the Bank of England introduced supervisory expectations in April 2019 for all supervised banks to take a strategic, forward looking and holistic approach to manage climate-related financial risks, stressing that such measure is essential for all financial institutions to take the right approach to climate-related financial risks.

She then explained that, after the release of the supervisory expectations, the Bank of England has been focusing on identifying risks at the level of the financial system and disclosures. With regard to risks at the level of the system, she emphasized the usefulness of scenario analysis for risks with large uncertainties, and mentioned two projects on scenario analysis that she is involved with. The first is reference scenarios of Network for Greening the Financial System (NGFS), which she argued reflect the best available methodology at the moment despite the many issues related to scenario analysis. The second is the Bank of England's climate stress test, scheduled to take place in June this year for the first time, which aims to identify risks and business opportunities associated with climate change, and to improve banks' risk management. She added that the work progress and test results will be made public as needed for reference by other authorities and the financial industry. With regard to disclosures, she mentioned that climate-related disclosures are going to be made mandatory in the United Kingdom by 2025, and explained that the Bank of England itself made its first disclosure in accordance with Task force on Climate-related Financial Disclosures (TCFD) last year.

Finally, she explained that the Bank of England was given a new mandate to take into account transition to a decarbonized economy in March this year and hence will review its corporate bond purchases accordingly.

Mauderer discussed the roles that the public and the private sectors should play in the transition to a decarbonized economy. Regarding the public sector, she stressed that the role of central banks, which typically cannot take direct measures to contribute to the decarbonization of the economy, is to act as a catalyst, and that the most important role falls to governments. As specific measures that governments could take, she highlighted developing an appropriate carbon pricing framework, putting in place regulations such as disclosure requirements, and public investments. She emphasized the importance of reducing carbon emissions without sacrificing economic growth by promoting innovation.

As for the private sector, she expressed her expectation that they work together with the public sector to facilitate innovation and leverage the knowledge of academia for their businesses.

She concluded by emphasizing the importance of the role of capital markets in financing decarbonization, referring to a recent study by the ECB showing that carbon emissions per capita decrease faster in economies that are relatively more equity-funded.

Stiroh first discussed climate-related financial risks from a micro-prudential perspective and then mentioned about efforts by the Supervision Climate Committee (SCC), which

was established within the FRB in January this year, and efforts by the Task Force on Climate-related Financial Risks (TFCR) of the Basel Committee on Banking Supervision.

He began by noting that climate change is a material concern for both the authorities and banks themselves, and that while there is a wide range of actions depending on business model and size, U.S. banks, mainly major ones, are starting to incorporate climate-related financial risks into existing risk management frameworks such as scenario analysis and to consider disclosures related to climate change. However, he added that it is extremely difficult to understand climate-related financial risks due to the long time horizon and data gaps.

He then explained that the SCC's objective is to ensure the robustness of supervised financial institutions against climate-related financial risks, and that the SCC will consider reviewing financial supervision programs to ensure that banks properly incorporate these risks into risk management frameworks. He added that the program will be tailor-made to reflect differences in the size and characteristics of financial institutions, but that it was currently in the early stages of review and did not yet have a specific outlook. He also mentioned that it will examine the usefulness of scenario analysis in assessing climate-related financial risks.

Regarding the TFCR, he highlighted its intention to take a gradual and sequential approach and, as such, he explained that it first carried out a stocktaking of the efforts by member jurisdictions to address climate-related financial risks, and then conducted analysis on transmission channels and measurement methodologies for climate-related financial risks. He added that the taskforce plans to examine how climate-related financial risks are incorporated into the existing Basel framework and to identify effective supervisory practices to mitigate those risks as the next phase of work.

He concluded by noting that efforts to understand climate-related financial risks are still in their infancy and that a great deal of work needs to be done, and that it is important for the public and private sectors to work together to make the financial system robust against climate-related financial risks.

B. Discussion Among Panelists

After presenting their own remarks, panelists commented on each other's.

Breeden agreed with the other panelists about the importance of cooperation between the public and private sectors to achieve a decarbonized economy, and argued that it is important to take the "roughly right" actions now, rather than waiting until we know what

actions are "exactly right."

Mauderer agreed with Breeden's comment that we cannot wait until we have perfect data and measurement methodologies on climate-related financial risks, and argued that central banks can serve as a catalyst by providing analytical tools they have to support other public sectors such as the Treasury.

Stiroh pointed out that improving data on climate change, developing assessment methodologies such as scenario analysis, and promoting disclosures will contribute to a wide range of policy objectives, including both micro and macro prudential policies, and emphasized the importance of continuing current efforts.

C. General Discussion

After the exchange among the panelists, **Wakatabe** asked them for their views on the role that central banks should play in relation to various economic entities such as governments and the private sector.

Breeden argued that the role of central banks is to ensure that financial institutions are aware of the risks and business opportunities associated with climate change, and are robust to these risks ("Greening Finance"), while governments should play a role in providing funds ("Financing Green") and implementing regulations such as carbon pricing to promote transition to a decarbonized economy.

Mauderer referred to the results of a survey among central banks that are members of the NGFS and pointed out that while the mandates of central banks vary widely, most members indicated that there is room to incorporate climate change factors into their operations.

Stiroh argued that adhering to a given mandate gives a central bank legitimacy, independence, and credibility, and noted that the FRB will focus on financial supervision to ensure that financial institutions manage risks appropriately in accordance with the mandate given by the Congress.

Finally, **Wakatabe** asked the panelists about what kind of research they, as officials, would like to see engagement by academia in the future. **Breeden** said she would like them to shed light on the complex transmission channels of climate-related financial risks on macro economies. **Mauderer** said she would like to know how carbon pricing would affect economic growth. **Stiroh** said it is crucial to study how to incorporate climate-related financial risks into existing risk models and how to predict risks in the face of

climate change, which is a phenomenon that continues to evolve into the future.

VIII. Concluding remarks

Himino expressed his satisfaction with the rich discussions held through the two days of workshop on interactions between climate-related financial risks and financial sector. He described the outlook for the role of the financial sector and regulators in the transition to decarbonized economy.

He began by pointing out that emission associated with corporate activities entails negative externalities and could lead to the tragedy of the commons and the tragedy of the horizon, and argued that stakeholders could act to make emitters internalize the externalities through voting and purchasing choices. He continued that investors could facilitate the internalization through their investment choices and engagement with invested companies, and that the financial sector could help the internalization by providing choices and stewardship to investors.

Regarding the role of financial authorities, he pointed out that authorities could help the proper pricing of climate-related financial risks by providing scenarios with longer time horizons for stress testing or scenario analysis and by encouraging financial institutions to manage climate-related financial risks properly. He mentioned the establishment of the Working Group on Climate Risk by the Financial Stability Board (FSB), which reviews regulatory and supervisory approach to addressing climate risks, and the ongoing climate-related scenario analysis jointly conducted by the JFSA, the Bank of Japan and major financial institutions in Japan.

He also argued that developing guidelines on sustainable financial instruments would provide reliable and transparent investment choices and enable proper pricing of climate-related financial risks. With respect to efforts made in Japan, he mentioned the Green Bond Guidelines established by the Japanese Ministry of Environment in 2017, and the development of a basic guideline for climate transition finance by the JFSA the Ministry of Economy, Trade and Industry (METI) and the Ministry of Environment.

Furthermore, he pointed to the important role of disclosures by corporates and financial institutions and pointed out that enhanced disclosures on climate-related financial risks could contribute to promoting pricing of climate-related financial risks. He noted that one of the key elements of the forthcoming revision of the corporate governance code is the enhanced disclosures on sustainability, and that more specific principles will be introduced into the corporate governance code.

He mentioned the Expert Panel on Sustainable Finance, which the JFSA established in December 2020, and ended his remarks by noting the importance of thinking further and clarifying the roles of the financial sector and financial policies in addressing climate-related risks.