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and the Global Economy”
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Chairman Whitehouse, Ranking Member Grassley, and Members of the Committee: Thank you for inviting me to address the risks and economic costs of climate change.

During my terms as Governor of the Bank of England and Chair of the G20’s Financial Stability Board, I chaired expert committees with responsibility for understanding and addressing the principal risks to financial stability. About a decade ago, these bodies became increasingly concerned about the rising economic and financial risks from climate change, and the fact that the financial system lacked the information, tools, and markets to manage them. For example, although the Bank of England oversees the world’s largest international financial center, including the world’s fourth largest insurance sector and the largest reinsurance market, Lloyds of London, we realized that the system did not have access to clear, consistent, and decision-useful information on climate risks.

Recognizing this was a global challenge, in 2015, the G20 Presidency tasked the Financial Stability Board with assessing the financial stability risks from climate change. Over the following years, a wide range of regulatory authorities and private financial institutions have worked to develop the fundamental building blocks the financial system needs to begin to manage climate-related risks on behalf of their depositors, pensioners, clients and shareholders. This is leading to better climate-related financial disclosure, stress tests and transition planning. Many leading financial institutions are improving their climate risk management and channeling capital to make companies more competitive through investments to reduce their emissions.

However, while the pace of change has picked up, it is not yet commensurate with the scale of the challenge in America or globally. Due to the undiversifiable nature of climate risks, governments will bear many of the costs of extreme weather and adaptation. Moreover, the longer adjustment is delayed, the greater the impact of climate change on financial stability, inflation, jobs and growth. Conversely, transitioning to a low-carbon economy will reduce the impact of climate change, create the jobs of the future, and promote a resilient financial system.

Physical impacts of climate change are rising

Globally, each of the last four decades has been warmer than the decade that preceded it.¹ The past eight years were the warmest on record, with each of those years exceeding 1 degree Celsius of warming—or about 1.8 degrees Fahrenheit—over pre-industrial levels.² The average sea level has risen faster since 1900 than over any preceding century in at least 3000 years.³ Extreme heatwaves have become more frequent and more intense since the 1950s, as have heavy precipitation events and major storms.

Data collected by the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration (NOAA), and NASA, among others, provide a snapshot of how climate change is already impacting the United States. To summarize:

- Since the 1970s, unusually hot summer days have become five times more common on average across the U.S., and unusually hot summer nights have become almost ten times more common.⁴
- Since the 1960s, heatwaves in the U.S. have become more common, more intense, and longer lasting. The average annual frequency of heatwaves in the U.S. has tripled since the 1960s, with each heatwave lasting an average of 30% longer.⁵
- While the incidence of drought varies across the country, the western U.S. is experiencing a mega-drought that has persisted for over two decades, making it the most intense in at least 1200 years.⁶ In May 2022, almost three quarters (72%) of the land in western states was classified as under either severe, exceptional, or extreme drought conditions.⁷

¹ IPCC, Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.*

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

² World Meteorological Organization, "Past eight years confirmed to be the eight warmest on record," 12 January 2023. <https://public.wmo.int/en/media/press-release/past-eight-years-confirmed-be-eight-warmest-record>

³ IPCC, Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis.*

⁴ U.S. Environmental Protection Agency, Climate Change Indicators: High and Low Temperatures.

<https://www.epa.gov/climate-indicators/climate-change-indicators-high-and-low-temperatures>

⁵ U.S. Environmental Protection Agency, Climate Change Indicators: Heat Waves, 2022.

<https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves>

⁶ A. Park Williams et al. "Rapid intensification of the emerging southwestern North American megadrought in 2020–2021," *Nature Climate Change* 12, March 2022. [https://www.nature.com/articles/s41558-022-01290-](https://www.nature.com/articles/s41558-022-01290-z.epdf?sharing_token=uEvEu-)

[z.epdf?sharing_token=uEvEu-o1TVRtz4qqcSFXhtRgN0jAjWei9jnR3ZoTv0OkweMbawmVFM1UCLmLxuyBpGKtFJa1_BxzJ7UFQSQZ6HoKWiVpxr-PXXpBdXS0aLJYrb-T2bjp5Y_Cku7vSenHblt81qi9olu_1s3zBCVWxhOj7h1yPvukczp8OW-fMlnax-64l97Ydyz8yOYptdpaLuUfk5JMXGjlcK0iPR_bAbZezMr6HR87nF1y-C5ApXrPDDheDZbRuS7KnTcwWcPIrhf0J4AhCj_Wfnpfu1E0v7CpjtzkM_mV8MDsJdSgKcZ_ooLr6EFhE-v6Qhk1ivl&tracking_referrer=www.npr.org](https://www.nature.com/articles/s41558-022-01290-z.epdf?sharing_token=uEvEu-o1TVRtz4qqcSFXhtRgN0jAjWei9jnR3ZoTv0OkweMbawmVFM1UCLmLxuyBpGKtFJa1_BxzJ7UFQSQZ6HoKWiVpxr-PXXpBdXS0aLJYrb-T2bjp5Y_Cku7vSenHblt81qi9olu_1s3zBCVWxhOj7h1yPvukczp8OW-fMlnax-64l97Ydyz8yOYptdpaLuUfk5JMXGjlcK0iPR_bAbZezMr6HR87nF1y-C5ApXrPDDheDZbRuS7KnTcwWcPIrhf0J4AhCj_Wfnpfu1E0v7CpjtzkM_mV8MDsJdSgKcZ_ooLr6EFhE-v6Qhk1ivl&tracking_referrer=www.npr.org)

⁷ NOAA National Centers for Environmental Information, "Annual 2022 Drought Report," 12 January 2023. <https://www.ncei.noaa.gov/access/monitoring/monthly-report/drought/202213>

- Median sea levels along the U.S. coast have increased by about 9 inches since the early 20th century, increasing the frequency of high-tide flooding for U.S. coastal communities by five to ten times since the 1950s.⁸
- The intensity of hurricanes and tropical storms affecting the east coast of the U.S. has risen significantly over the past twenty years, making the period since 1995 the longest stretch on record of above-average hurricane seasons in terms of NOAA's Accumulated Cyclone Energy Index.⁹
- Across the western United States, there has been “a profound increase in forest fire activity” in recent decades, driven by persistent drought and temperature increases in these regions.¹⁰ The Congressional Budget Office analyzed trends in wildfires and found that on average, 8 million acres burned in wildfires annually between 2017 and 2021, more than double the average thirty years ago.¹¹

Climate Change is having increasing impact on Americans

- **Weather-related damages:** Adjusted for inflation, the number of billion-dollar disasters has risen six-fold from an average of three per year during the first half of the 1980s to an average of 18 per year over the past five years. The average annual inflation-adjusted costs of these disasters have risen seven-fold from \$18 billion to \$120 billion.¹² I know from my time as an insurance supervisor that, globally, these increases in insured losses are even higher, and that uninsured losses continue to set new records.
- **Sea-level rise and property destruction:** At least \$1.4 trillion worth of American homes and businesses sit within one-eighth of a mile of the coasts, and shoreline counties have almost 50 million housing units, housing over 40% of the U.S. population.¹³ As noted, increased flooding and coastal erosion are already causing significant damage, with an estimated \$15.8 billion of eastern seaboard property value eroded between 2005 and 2017,¹⁴ and it is estimated that, absent massive spending on adaptation, over \$500 billion

⁸ U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*, 2018. <https://nca2018.globalchange.gov/chapter/1/>

⁹ U.S. Environmental Protection Agency, Climate Change Indicators: Tropical Cyclone Activity, 2022. <https://www.epa.gov/climate-indicators/climate-change-indicators-tropical-cyclone-activity>. Alan Buis, “How Climate Change May Be Impacting Storms over Earth’s Tropical Oceans,” NASA Jet Propulsion Laboratory, March 2020. <https://climate.nasa.gov/ask-nasa-climate/2956/how-climate-change-may-be-impacting-storms-over-earths-tropical-oceans/>

¹⁰ U.S. Global Change Research Program, Droughts, floods, and wildfires. In: *Climate Science Special Report: Fourth National Climate Assessment, Volume I*, 2017. <https://science2017.globalchange.gov/chapter/8/#section-3>

¹¹ Congressional Budget Office, Wildfires, June 2022. <https://www.cbo.gov/publication/58212>

¹² In 2022, there were 18 separate billion-dollar weather and climate disaster events—11 severe storms, three tropical cyclones, flooding in Kentucky and Missouri, the late December winter storm, and the heatwave and drought in the west and Midwest, including the western wildfires—with costs estimated at \$165 billion, making it the third costliest year in terms of extreme weather damages. 2022 was the eighth consecutive year with 10 or more billion-dollar disaster events. NOAA, Billion Dollar Weather and Climate Disasters, 2023. <https://www.ncei.noaa.gov/access/billions/time-series>

¹³ U.S. Global Change Research Program, Coastal Effects. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*, <https://nca2018.globalchange.gov/chapter/8/>

¹⁴ First Street Foundation, “Rising Seas Erode \$15.8 Billion in Home Value from Maine to Mississippi,” February 2019, <https://assets.floodiq.com/2019/02/9ddfda5c3f7295fd97d60332bb14c042-firststreet-floodiq-mid-atlantic-release.pdf>

worth of real estate in the U.S. could be below sea level by 2100 under a higher warming scenario.¹⁵

- **Increased homeowner insurance costs:** Increases in weather-related disasters have led to insurance becoming less available and more expensive for American families. For example, the National Flood Insurance Program has been the insurer of last resort for most Americans living in flood zones since 1968. Since the 2005 hurricane season, the NFIP has been unable to cover its payouts with premiums.¹⁶ Federal flood premiums are expected to increase significantly as the program adjusts its risk ratings. More broadly, with property losses from natural disasters increasing, policy premiums are expected to increase significantly for American families, with one reinsurer estimating that climate-related risks will result in a 22% increase in global property insurance premiums over the next 20 years.¹⁷
- **Agricultural output:** As anyone who grew up in a farming area—as I did—knows, extreme weather has an acute impact on agricultural production. The increased frequency of drought, heatwaves, freezes, and flooding is likely to significantly impair agricultural production, reducing incomes for American farmers and raising food costs for American families.¹⁸
 - For example, a NASA study projects that, absent action, corn yields globally will begin declining over the next twenty years.¹⁹ Variability of yields will also increase. So while studies project that every Iowa county will experience production declines of 10% or more by 2050, declines will reach 25% in some counties by 2030 and over 40% in 2050.²⁰ This is because, while growing-degree days are expected to increase by a modest amount, killing-degree days will increase by significantly more—an expected 57% by 2030 and 94% by 2050.
 - Warming is already estimated to have contributed \$27 billion, or almost 20%, of national crop insurance losses between 1991 and 2017.²¹

¹⁵ U.S. Global Change Research Program, Coastal Effects. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, <https://nca2018.globalchange.gov/chapter/8/>

¹⁶ Renee Cho, “With Climate Impacts Growing, Insurance Companies Face Big Challenges,” Columbia Climate School State of the Planet, November 2022. <https://news.climate.columbia.edu/2022/11/03/with-climate-impacts-growing-insurance-companies-face-big-challenges/#:~:text=Raising%20premium%20rates&text=The%20property%20losses%20from%20natural,increase%205.3%20percent%20per%20year.>

¹⁷ SwissRe, Global property & casualty insurance premiums expected to more than double to USD 4.3 trillion by 2040, Swiss Re Institute forecasts, September 2021. <https://www.swissre.com/press-release/Global-property-casualty-insurance-premiums-expected-to-more-than-double-to-USD-4-3-trillion-by-2040-Swiss-Re-Institute-forecasts/66cbcf70-d69f-4e5e-8d87-1b389dbf9491>

¹⁸ U.S. Global Change Research Program, Agriculture and Rural Communities. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II. <https://nca2018.globalchange.gov/chapter/10/>

¹⁹ Ellen Gray, “Global Climate Change Impact on Crops Expected Within 10 Years, NASA Study Finds,” Nov 2021. <https://climate.nasa.gov/news/3124/global-climate-change-impact-on-crops-expected-within-10-years-nasa-study-finds/>

²⁰ EDF, *How Climate Change Will Impact U.S. Corn, Soybean and Wheat Yields: A county-level analysis of climate burdens and adaptation needs in the Midwest*, 2022. <https://www.edf.org/sites/default/files/2022-10/climate-impacts-midwest-crop-yields.pdf>

²¹ Noah S Diffenbaugh et al, “Historical warming has increased U.S. crop insurance losses,” *Environmental Research Letters*, 16: 8, 2021. <https://iopscience.iop.org/article/10.1088/1748-9326/ac1223>

- **Supply chain disruptions:** The increased frequency and intensity of flooding and disasters can disrupt or damage critical infrastructure, and in turn supply chains, hurting American businesses and raising costs for American families. For example, the Texas deep freeze in February 2021²² caused the worst involuntary blackout in U.S. history, closing three major semiconductor plants, which in turn slowed the production of new cars in the U.S.²³ In the same vein, in December 2021, an extreme typhoon damaged a large Malaysian port, shutting off semiconductor shipments from Taiwan, leading to semiconductor shortages that caused U.S. car manufacturers to suspend operations.²⁴

Physical impacts will worsen over time

These trends are expected to worsen. As the U.S. Global Change Research Program concluded in its most recent National Climate Assessment, “the severity of these projected impacts, and the risks they present to society, is greater under futures with higher greenhouse gas emissions.”²⁵ There is ample scientific evidence that with each additional fraction of a degree of warming, extreme weather becomes more frequent and more intense.²⁶ In the U.S., this means more frequent and more intense hurricanes; more frequent and deeper coastal flooding; hotter, more frequent, and longer-lasting heat waves; longer-lasting and more frequent droughts, and more of the wildfires that accompany them.²⁷

There are thresholds beyond which warming—and therefore extreme weather—is likely to accelerate rapidly due to unlocking feedback loops, such as the thawing of Arctic permafrost, which would lead to rapid release into the atmosphere of carbon that’s currently frozen.²⁸ There may also be certain warming thresholds beyond which catastrophic physical impacts are locked in irreversibly—so called “tipping points.” These include the collapse of the Greenland or Antarctic ice sheets, or the significant dieback of the Amazon rainforest, which could alter the earth’s water cycle.²⁹

Scientific modeling has assessed the likeliest temperature and broader climate outcomes under different collective country policy responses. If governments cut emissions in line with their current, stated climate policies, the world will be on track for warming of 2.4 degrees Celsius (or

²² Judah Cohen et al, “Linking Arctic variability and change with extreme winter weather in the United States,” *Science* 373: 6559, September 2021. <https://www.science.org/doi/10.1126/science.abi9167>

²³ Jacques Leslie, “How Climate Change Is Disrupting the Global Supply Chain,” *Yale Environment* 360, March 2022. <https://e360.yale.edu/features/how-climate-change-is-disrupting-the-global-supply-chain#:~:text=Scientists%20say%20that%20such%20climate,and%20perhaps%20more%20%E2%80%94%20by%202100.>

²⁴ Leslie, “How Climate Change Is Disrupting the Global Supply Chain.”

²⁵ U.S. Global Change Research Program, Overview. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, 2018. <https://nca2018.globalchange.gov/chapter/1/>

²⁶ IPCC, Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis*

²⁷ U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, 2018. <https://nca2018.globalchange.gov/>

²⁸ IPCC, Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis*.

²⁹ IPCC, Impacts of 1.5°C global warming on natural and human systems, in *Special Report: Global Warming of 1.5 °C*. 2018. <https://www.ipcc.ch/sr15/chapter/chapter-3/>

4.3 degrees Fahrenheit) over pre-industrial levels by 2100.³⁰ If all governments were to achieve their net-zero objectives on the timelines they have outlined, warming would be limited to 1.8 degrees.³¹ Even in this optimistic scenario, there would be a substantial increase in extreme weather and economic costs facing America and the world, but we would be less likely to hit irreversible tipping points or activate critical feedback loops.³²

Potential impacts on GDP and beyond

The insured and uninsured losses noted above measure the value destruction of the stock of assets. GDP is a measure of the flow of income. At the global level, estimates suggest that, over the balance of this century, climate change could reduce the level of global GDP per capita by 10-20% without efforts to limit warming, the equivalent of a decade of no economic growth.³³ Similar estimates have been found for the United States.³⁴

While GDP represents a single year's worth of value added in the economy, estimates of the impact of the economic impacts of climate change project that what is lost is likely to stay lost, making climate change the curse that keeps on taking. In other words, these are level effects on GDP that are not recovered, unlike for nearly all other shocks to the economy.

As economically significant as these estimates are, it is instructive to examine what is not included in them, both 'assets' outside the market economy—such as biodiversity and human health—as well as critical economic channels that have not been modelled, including disrupted supply chains, the very real challenges to monetary and financial stability that increasing climate change will present, and the potential economic impact of rising risks to national security.

Increased temperatures, increased frequency and severity of extreme weather events, and greater sea level rise can all negatively influence human health, including through heat-related illnesses like cardiovascular complications; easier spread of vector-borne pathogens like West Nile virus; and increased transmission of water-borne illness like diarrheal disease.³⁵ For example, hot days affect human health through several channels, with the most extreme effects—including increased mortality—felt by vulnerable populations such as the elderly and pregnant women. Comparing higher and lower warming scenarios, an EPA analysis found that under a lower-warming scenario, expected additional deaths from extreme heat in 2090 could be cut by half, saving over 4,500 lives and \$80 billion in damages per year compared to a higher-warming scenario.³⁶

³⁰ Climate Action Tracker, *Warming Projections Global Update*, November 2022. https://climateactiontracker.org/documents/1094/CAT_2022-11-10_GlobalUpdate_COP27.pdf

³¹ Climate Action Tracker, *Warming Projections Global Update*, November 2022

³² IPCC, *Avoiding Regional Tipping Points by Achieving More Ambitious Global Temperature Goals*, in *Special Report: Global Warming of 1.5 °C*. 2018. <https://www.ipcc.ch/sr15/chapter/chapter-3/>

³³ Mark Carney, 2022 Volcker Lecture at National Association of Business Economists Conference. March 2022.

³⁴ Candace Vahlsing and Danny Yagan, "Quantifying Risks to the Federal Budget from Climate Change," April 2022. <https://www.whitehouse.gov/omb/briefing-room/2022/04/04/quantifying-risks-to-the-federal-budget-from-climate-change/>

³⁵ U.S. Global Change Research Program, *Human Health*. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. <https://nca2018.globalchange.gov/chapter/14/>

³⁶ U.S. Environmental Protection Agency, "Multi-Model Framework for Quantitative Sectoral Impacts Analysis," May 2017. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OAP&dirEntryId=335095

Over time, the extreme impacts of climate change are set to make large areas of the world, currently home to large populations, uninhabitable. With livelihoods and lives of over a billion people directly affected by the spread of lethal climatic conditions, there are very real prospects for significant increases in involuntary migration and conflict over increasingly scarce resources and arable land.³⁷

Government budgets will need to adjust to climate impacts

As temperatures increase and extreme weather events worsen, the costs to governments—local, state, and federal—will increase further.³⁸ Ultimately, governments bear costs that private households, businesses, and markets are unable to shoulder. That is most evident for natural disasters, with local, state, and federal governments being forced to devote an increasing share of their budgets for meeting emergency needs, financing disaster recovery, and building resilience to future disasters.

Adapting and building resilience to the changing climate can help minimize some of the worst impacts, but it will be costly. Adaptation will require a wide range of investments in infrastructure and technology to withstand higher temperatures, higher sea levels, more flooding, more droughts, and worse storms. For example, ports will need to be protected against sea level rise and increased storm surge, with total potential costs for these improvements at over \$200 billion through 2100, or \$100 million per year for the port of Los Angeles.³⁹

Addressing climate change creates major economic opportunities

To conclude, the costs to property, agriculture, and livelihoods are already high and are expected to grow materially. The potential hit to GDP growth from unmitigated climate change is expected to be significant. And many of the most severe impacts—to human health, to livelihoods, and our natural heritage—are not included in these calculations.

But there is one final risk from climate change—a negative risk—better known as an opportunity. Increasing recognition of the risks of climate change is now galvanizing global efforts to address the issue. In recent years, the number of countries committed to achieving net zero has risen from less than one third of global emissions to over 90%.⁴⁰ In response, many companies are developing net-zero transition strategies, and private financial institutions managing balance sheets representing almost 40% of private financial assets are doing the same. With climate policies, such as the U.S. Inflation Reduction Act and RePowerEU, becoming increasingly impactful, and with capital widely available to finance investments for

³⁷ IPCC, Summary for Policymakers, in *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 2022. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

³⁸ Candace Vahlsing and Danny Yagan, “Quantifying Risks to the Federal Budget from Climate Change,” April 2022. <https://www.whitehouse.gov/omb/briefing-room/2022/04/04/quantifying-risks-to-the-federal-budget-from-climate-change/>

³⁹ George Van Houtven et al, “Act Now or Pay Later: the Costs of Climate Inaction for Ports and Shipping,” March 2022. <https://edf.org/sites/default/files/press-releases/RTI-EDF%20Act%20Now%20or%20Pay%20Later%20Climate%20Impact%20Shipping.pdf>

⁴⁰ Climate Action Tracker, 2023. <https://climateactiontracker.org/global/cat-net-zero-target-evaluations/>

emissions reductions, both carbon efficiency and climate resilience are becoming increasingly important determinants of company and national competitiveness.

Last year, over \$1 trillion was invested in the energy transition, representing over 1% of global GDP. These investments are expected to rise significantly in the coming years⁴¹, contributing to more jobs and higher incomes. For example, the IEA estimates that multiplier effects from the clean energy investment boom will lead to 4% higher GDP by the end of this decade.⁴²

In short, while ignoring climate change will lead to significant costs, climate solutions are becoming one of the greatest commercial opportunities of our time. In seizing them, as in so many other respects, the United States remains the indispensable nation.

Thank you again for the invitation to testify. I would be pleased to answer your questions.

⁴¹ BloombergNEF, "Global Low-Carbon Energy Technology Investment Surges Past \$1 Trillion for the First Time," January 2023. <https://about.bnef.com/blog/global-low-carbon-energy-technology-investment-surges-past-1-trillion-for-the-first-time/#:~:text=London%2C%20January%2026%2C%202023%20%E2%80%93,new%20report%20from%20research%20firm>

⁴² International Energy Agency, Net Zero by 2050 A Roadmap for the Global Energy Sector, 2021. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf