

Central Banks and Climate Risks

Some researchers look at climate change and see economic uncertainty. Central banks are beginning to take notice

By Molly Harnish

Temperatures are rising. The National Academy of Sciences estimates that global average surface temperatures have risen by 0.8 degrees Celsius (1.4 degrees Fahrenheit) since 1900. According to data from the National Oceanic and Atmospheric Administration (NOAA), the National Air and Space Administration (NASA), and the climate research center Berkeley Earth, global surface temperatures in the past 40 years have consistently surpassed the 1951-1980 average. (See chart.)

This is not the first time global temperatures have risen. Long-run global temperatures have fluctuated historically, from the high temperatures of the Medieval Climate Anomaly (950-1250 A.D.) to the low ones that characterized the Little Ice Age (1450-1850 A.D.). In addition,

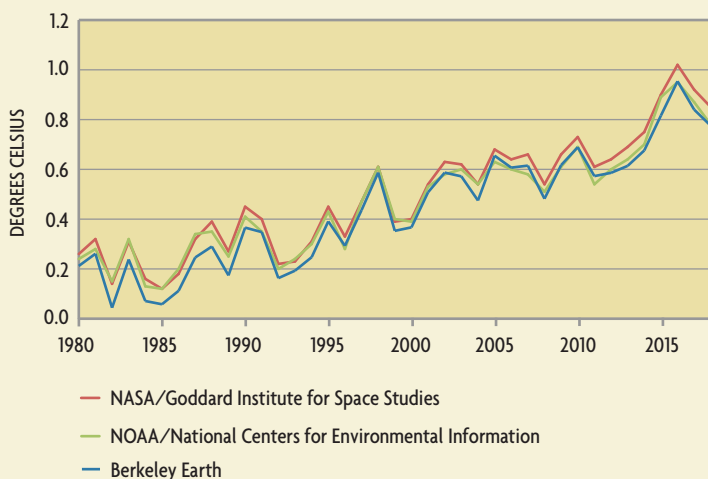
the pace of warming slowed significantly from 1998 to 2012, which climate scientists at NOAA hypothesize was a result of natural climate fluctuations allowing the deep oceans to absorb more excess heat. Yet since 2012, the pace of temperature increases has picked up again, with 2016 holding the title of the warmest year on record.

While some dispute the claim that humans are responsible for the higher temperatures, a recent study found that upward of 90 percent of published climate scientists attribute most of the recent warming to human activities. These activities include burning fossil fuels, which emit greenhouse gases (GHGs). According to the Environmental Protection Agency, global atmospheric concentrations of GHGs such as carbon dioxide, methane, fluorinated gases, and nitrous oxide have increased over the last few centuries. Climate scientists hypothesize that these gases contribute to higher temperatures by absorbing heat, preventing it from escaping Earth's atmosphere. The Intergovernmental Panel on Climate Change estimates that human-caused global warming is increasing by 0.2 degrees Celsius per decade and warns that consequences of continued warming include more frequent and intense precipitation in some regions and more frequent and intense droughts in others, as well as hotter extreme temperatures and rising sea levels.

These changes have led policymakers and economists to examine what climate change may mean for communities, governments, and the economy. More than 3,000 economists recently signed a statement in support of a carbon tax (see sidebar), and a leading finance journal hosted two conferences in 2017 and 2018 to promote research on the financial risks related to climate change. And as the discussion surrounding climate change heats up, central banks around the world are attempting to understand and prepare for its potential risks.

Global Temperatures Are Rising

Estimates of global surface temperature relative to 1951-1980 average



NOTE: Chart shows estimated temperature anomalies relative to base period. An increase of 1 degree Celsius is equivalent to an increase of 1.8 degrees Fahrenheit.

SOURCES: NASA/GISS, NOAA/NCEI, and Berkeley Earth

Challenges to Economic Growth

In a recent article, Riccardo Colacito of the University of North Carolina, Bridget Hoffmann of the Inter-American Development Bank, and Toan Phan of the Richmond Fed found that rising temperatures are associated with reduced economic growth. They analyzed temperature and output growth by season and industry, finding that for every 1 degree Fahrenheit increase in the average summer temperature, the annual growth rate of state-level output decreases by 0.15 to 0.25 percentage points on average. When combined with future temperature projections, their findings indicated that U.S. economic growth could decrease by as much as one-third over the next hundred years if this association continues.

Rising temperatures could influence growth through several different mechanisms. In their article, Colacito, Hoffmann, and Phan pointed to reductions in the growth rate of labor productivity as one such mechanism, citing previous research as well as their own data. Phan suggests that changes in labor productivity alone can't explain their findings, however.

“One potential mechanism could be hotter summer temperatures coming along with more intense disasters like heat waves or wildfires,” Phan says. “The effects of disasters can be twofold. If disasters damage physical capital or crops or property, that’s one immediate channel. Another channel is through making people more attentive to future risk, which is reflected in asset prices.”

He points to a working paper by Piet M. A. Eichholtz of Maastricht University, Eva Steiner of Cornell University, and Erkan Yönder of Concordia University. These authors examined commercial real estate prices after Hurricane Sandy, which hit New York City in 2012, and found that the prices of properties exposed to flood risk appreciated more slowly after Sandy than they did in regions unaffected by flood risk. Remarkably, this trend held not only in New York, but also in Boston, which experienced no physical damage from Sandy. The authors argued that this effect can be explained by a persistent increase after Sandy in the salience of flood risk to investors in coastal areas of Boston.

Taxing Away the Problem

In January 2019, more than 40 economists, including 27 Nobel laureates and four former Federal Reserve chairs, signed the Economists’ Statement on Carbon Dividends. The statement calls for a tax on carbon dioxide emissions to combat what it describes as the “serious problem” of global climate change. This tax would increase annually and replace “cumbersome regulations,” and its revenues would be redistributed to U.S. citizens. More than 3,500 economists have signed the statement since its publication.

The economic logic behind a carbon tax is simple. A majority of published climate scientists believe that human activities, namely emissions of carbon dioxide and other greenhouse gases (GHGs), are primarily responsible for recent global warming. But this cost to society as a whole is not factored into the private cost of GHG emissions, making those emissions an externality.

Almost 100 years ago, the economist Arthur Pigou argued that taxing an externality at the amount equivalent to its marginal social cost would “internalize the externality” by equating marginal social and private costs. By Pigouvian logic, taxing emissions of CO₂ and other GHGs would ensure that the price of those emissions reflected their social cost. In theory, this tax would also encourage firms to transition from carbon-intensive to carbon-neutral technologies and energy sources. And it wouldn’t just tax carbon dioxide emissions: Other GHGs, such as nitrous oxide and methane, are also included under the umbrella of a “carbon tax.”

But the question of how to move from theory to practice is far from settled. The first area of disagreement is the dollar value of the externality, known as the

social cost of carbon (SCC). That amount depends on the discount rate: the interest rate used to determine the present value of future benefits. A higher discount rate indicates a lower value placed on future benefits and a lower SCC. Choosing this rate is difficult, especially since it requires answering the ethical question of how much the present generation’s welfare is worth relative to that of future generations.

Some economists also argue that a national carbon tax alone will not be enough. Joseph Stiglitz, 2001 Nobel laureate, wrote in a 2019 National Bureau of Economic Research working paper that because the market is imperfect, optimal climate policy will include other interventions in addition to a carbon tax, such as regulations and differential pricing. William Nordhaus argued in his Nobel Prize lecture last year that because climate change is a global externality, any policy designed to remedy climate change requires international cooperation. Without it, each nation has little incentive to tax CO₂ emissions, because other nations will enjoy most of the benefit while the emission-taxing nation bears all of the cost.

As of 2018, despite these differences over optimal policy, 45 national governments have carbon tax initiatives. In the United States, however, the adoption of carbon taxes has made little headway. Washington state attempted to implement one in 2016, but voters rejected it, in part because environmental groups opposed the bill’s proposal to redistribute the revenue to businesses and consumers. Instead, they wanted to use the revenue to support green infrastructure projects and help low-income communities.

— MOLLY HARNISH



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In addition to their aggregate findings, Colacito, Hoffmann, and Phan analyzed the influence of rising temperatures on output growth at the industry level. They found that higher summer temperatures negatively affected most industries, even those where most work takes place indoors. The most negatively affected sector was, as it happens, the so-called FIRE sector: finance, insurance, and real estate. For central banks, especially those specifically tasked with maintaining financial stability, this result is especially relevant. But how exactly could climate change affect the financial system?

Is Financial Stability at Risk?

Some economists contend that climate change imposes physical and transition risks on the financial system, threatening its stability. In a January 2018 working paper, Sandra Batten, senior economist at the Bank of England, wrote that physical risks arise from a combination of adverse climate-related events and systemic vulnerabilities. These risks, she argued, include both demand- and supply-side shocks to the financial system. For example, on the demand side, rising sea levels might decrease demand for coastal homes, while on the supply side, changes in precipitation patterns could affect crop yields. Climate change may also shift investment patterns by diverting resources to adaptation investments instead of the productive investments that would have been made otherwise.

Extreme weather events, such as droughts, wildfires, and hurricanes, are often named as key sources of physical risk. A recent article in the *Journal of Financial Stability* by Jeroen Klomp of Wageningen University & Research in the Netherlands supports such a connection. In an analysis of data on commercial banks from over 160 countries, Klomp found that natural disasters are associated with a higher likelihood of bank default, although not of system-wide crisis. The extent of climate change's influence on natural disasters, the study of which is known as event attribution, is an active area of research. A 2016 report by the National Academies of Sciences, Engineering, and Medicine indicates that scientists are most certain when attributing extreme heat and cold, drought, and precipitation to climate change, since these can be directly traced back to temperature changes. Scientists are less confident, however, about the extent of climate change's impact on extratropical cyclones, wildfires, and severe convective storms.

In a recent publication, Glenn Rudebusch, senior policy advisor and executive vice president at the San

Francisco Fed, included extreme weather events as one source of future climate-related economic transformation. Rudebusch wrote that an increase in the frequency and severity of extreme weather events, as well as higher temperatures and other consequences of climate change, could adversely affect the economy and financial system by reducing business profitability and asset values, disrupting operations, damaging infrastructure, and weakening labor productivity.

"I think of climate change as a problem multiplier, even where it's not the sole cause. For example, we've always had hurricanes, but a changing climate is going to exacerbate them — and the same is true for economic insecurity and inequality," Rudebusch says.

Along with physical risks, some economists also note the transition risks from a shift toward low-carbon energy sources. In a 2016 report for the German Federal Ministry of Finance, Martin Stadelmann of the South Pole Group, a Swiss consulting firm in the area of climate finance, and Viola Lutz, now at Institutional Shareholder Services, wrote that transition risks present a much greater threat to financial stability than physical risks. Batten wrote that, were emissions-reduction policies to be implemented, short-term output would likely fall as carbon-intensive firms adjust. In fact, some estimates of global losses from transition risks are as high as \$20 trillion. And transition risks could also affect monetary policy. In a 2018 speech, Benoît Cœuré, a member of the Executive Board of the European Central Bank (ECB), indicated that a transition to low-carbon policies would affect relative energy prices. He said that this, in turn, could shift inflation expectations, which are directly relevant to monetary policy.

George Economides and Anastasios Xepapadeas of the Athens University of Economics and Business modeled the impacts of climate change on monetary policy in a 2018 working paper. They found that climate change presents shocks to total factor productivity, a measure of how efficiently an economy uses its labor and capital inputs. This means that in the presence of climate change, economic fluctuations tend to be both longer and more frequent than in its absence. But a decrease in output resulting from these shocks also decreases demand for fossil fuels, which boosts productivity by slowing the pace of temperature increases. Finally, they found that while a carbon tax curbs short-run output, it increases long-run output. Their findings indicate both physical and transition risks from climate change and policy.

What We Don't Know Could Hurt Us

Another key feature of climate change is uncertainty about its extent and its economic effects. One area of uncertainty is the extent of temperature increases and the probability of catastrophe. Martin Weitzman, an economist at Harvard University who passed away in August, researched "fat tail" probability distribution functions, in which catastrophic climate change — and thus, catastrophic economic

damage — is more likely than is typically assumed in climate models. In a 2011 article, Weitzman argued that, because of the lack of substantive historical data on past catastrophes, it is possible that extreme events are more likely than most models assume. He concluded that cost-benefit analyses of climate change should incorporate this structural uncertainty.

“A fat-tailed model increases tail risk generally. There’s more weight in the tails relative to what’s expected,” Weitzman told *Econ Focus*. “The huge problem is that nobody knows the probability or consequences.”

Uncertainty also affects models of climate change’s economic impact. Economists commonly use integrated assessment models (IAMs), which feature both climate science and economic modules, to analyze this issue. The climate science modules project future GHG emissions and resulting global temperatures, while the economic modules estimate the economic consequences of unmitigated climate change and the costs and benefits of emissions-reduction policies. In a 2013 article, Robert Pindyck, a professor at the Massachusetts Institute of Technology, identified significant flaws in these models. First, because they are calibrated only to small temperature increases, they are not informative about the economic effects of a climate catastrophe such as an extreme rise in temperature. Second, they rely on arbitrary constructions of the damage function, an element of the model that estimates economic losses from climate change. Because of these flaws, Pindyck argued, “IAMs are of little or no value for evaluating alternative climate change policies.” In a later op-ed, he noted that his critique is an argument not against taking action but for improving the models in order to better guide that action and imposing a carbon

tax as a form of insurance in the meantime.

Yet another source of uncertainty is how well societies will adapt to climate change, which could offset some of its downside risks. Stadelmann and Lutz suggested that while large storms could raise insurance premiums, the insurance sector’s ability to gradually adjust those premiums could allow it to adapt fairly well to climate change in the short to medium term. This could change in the long term, though, especially if temperatures increase by more than 2 to 3 degrees Celsius. In that case, Stadelmann and Lutz wrote, there is too much uncertainty to reject the possibility of more severe systemic effects. In her paper, Batten gave several examples of adaptation efforts, including investing in physical capital to accommodate new temperature and weather patterns and innovating GHG-removal technology. Adaptation might also entail planting more heat-resistant crops, updating infrastructure in order to better withstand floods, or enacting transition policies such as a carbon tax.

Still, some researchers and officials argue that uncertainty alone does not remove the need for action. “If anything, standard economic theory points us to the fact that when uncertainty rises, we insure against the worst-case scenario,” Phan says.

Central Banks’ Response

In 2015, Mark Carney, governor of the Bank of England, deemed climate change “the tragedy of the horizon.” He warned that “once climate change becomes a defining issue for financial stability, it may already be too late.” Four years later, central banks are beginning to incorporate climate-related risks into their economic forecasts. Some are even taking policy steps to mitigate those risks. (See table.)

Central Banks Are Preparing for Climate Change

Selected responses of central banks to potential climate-related risks

Bank	Actions
Bank of England	Plans to perform stress tests for resilience to climate change’s physical and transition risks by 2021, expects regulated insurers and banks to have plans for managing climate-related financial risks, and established the U.K. Climate Financial Risk Forum, which includes private- and public-sector partners
Banque de France	Published its own climate-related risk exposure and evaluates the financial sector’s exposure to climate-related risks with the help of the French Prudential Supervision and Resolution Authority
People’s Bank of China	Issued the first guidelines for green finance (defined as the use of financial services that support environmental improvement and climate change abatement efforts), created the Green Finance Study Group at the 2016 G-20 summit, and established five “pilot zones” throughout China for green finance initiatives
Banco de Mexico	Analyzing measures to better diagnose and communicate the risks posed by environmental factors, including climate change, to the financial system
Deutsche Bundesbank	Assesses the financial system’s ability to respond to physical and transition risks of climate change
Monetary Authority of Singapore	Incorporates climate-related risks into stress tests and encourages implementation of the recommendations of the Financial Stability Board’s Task Force on Climate-related Financial Disclosures (TCFD)
De Nederlandsche Bank	Has asked insurers and banks to evaluate climate-related risks in their risk assessments

NOTE: Includes all central banks that were founding members of the Network of Central Banks and Supervisors for Greening the Financial System

In December 2017, a group of central banks and other institutions founded the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). Today, the organization has 42 members, including the European Central Bank and the People’s Bank of China, and eight observers, including the World Bank. Since its founding, the NGFS has focused on defining and sharing best practices for climate-related risk management and green finance. In April 2019, it issued its first comprehensive report, which contained six recommendations for central banks. Those recommendations included accounting for climate-related risks in financial supervision, considering sustainability in portfolio management, disclosing climate-related risks, and sharing data and knowledge.

Central banks and central bank officials have also expressed concern about climate change’s potential effect on the financial system. In a 2019 speech, Sabine Mauderer, member of the Executive Board of the Deutsche Bundesbank, called addressing climate change “a key factor for economic and financial systems.” The Bank of Canada listed climate change as an economic

vulnerability in its 2019 Financial System Review, citing physical damages and the costs of transitioning to a low-carbon economy. Speaking at the Official Monetary & Financial Institutions Forum in 2019, Sarah Breeden of the Bank of England called for immediate action on climate change given its broad and foreseeable risks. And while Coeuré of the ECB noted in his 2018 speech that “views and opinions certainly differ here,” he argued that “the ECB, acting within its mandate, can — and should — actively support the transition to a low-carbon economy.”

In some cases, these concerns have translated into policy. One example is the purchase of green bonds — debt securities issued to finance environmentally friendly investments. The first green bond was issued by the European Investment Bank in 2007. Over the past few years, the market has grown rapidly, counting some central banks among its investors. As of 2018, the Eurosystem — which includes the ECB and the central banks of member states — holds about a quarter of eligible public-sector green bonds and almost a fifth of eligible corporate green bonds.

Other steps have focused on disclosing and mitigating risk. The Task Force on Climate-related Financial

From the Director of Research

Changes to the Earth’s climate matter to monetary policymakers.

First, appropriate monetary policy depends fairly directly on the growth potential of the economy. A faster-growing economy means a higher average level for the appropriate central bank interest rate, and vice versa. Any force that changes this potential, as climate change certainly could, therefore matters for our approach to policy.

Second, changes in risks to the financial system matter to taxpayers who ultimately insure depositors and who occasionally, during crises, have bailed out creditors more generally. As a primary regulator of banks and other financial institutions, it is critical for the Fed to understand all the risks, including climate-related ones, that these entities face.

Notice that for a central bank, climate change can be viewed as simply one force among many that changes the growth potential of the economy and the risks to it. But unique or not, its implications need to be understood.

The Fed’s role also has significance for how it should think about climate change. The political system, not the Fed, selects fiscal and regulatory policies (apart from some specific areas of financial regulation that Congress has delegated to us). These policies as a whole, implicitly and explicitly, balance the well-being of different groups in our society: Think, in particular, about policies that affect the rich and poor differently, or people who are currently old versus those currently

young or yet to be born. Thus, the Fed’s role is to take those verdicts of the political process and do the best it can to pursue its dual mandate to deliver price stability and maximum employment.

There is, however, an exception where it may be appropriate for the Fed to do more. This is the extent to which we think climate change leaves *all* of us — young, old, rich, poor — worse off. In this instance, and perhaps only in this instance, we would be on firm ground in suggesting changes. One example is that by raising the risk to coastal cities, of which there are many in the Fifth Federal Reserve District, unabated climate change exposes us to losing significant economic and cultural “capital” that cities appear to deliver through the geographic concentration of talent and companies. Additionally, so long as public programs like flood insurance are not priced to reflect climate risks, building patterns will place all taxpayers at risk. Understanding and publicizing such distortions is valuable. Indeed, the nonpartisan nature of our institution places it well to look impartially at thorny issues with potentially significant economic implications.

There is much to be learned about the effects of climate change and how individuals and institutions should respond to it. I hope you’ll find the accompanying article helpful as you think about these issues.

— **Kartik Athreya is executive vice president and director of research at the Federal Reserve Bank of Richmond.**

Disclosures (TCFD), which was formed in 2015, develops standards for climate-related risk disclosures for financial companies. Central banks including the Bank of England and the Monetary Authority of Singapore have indicated their support of TCFD standards. In addition, the Bank of England indicated in its July 2019 Financial Stability Report and Record that it planned to perform stress tests focused on climate-related physical and transition risks.

These procedures are not standard practice, however. In a 2019 survey of central banks conducted by the news source Central Banking and the European asset management company Amundi, 32 of the 34 responding institutions indicated that they don't include climate-related risks in their stress tests, and 29 said they do not ask banks to disclose their exposure to those risks. Moreover, only six respondents, of which more than half were from industrial countries, viewed climate change as a major risk to financial stability. Only three central banks, all from industrial countries, indicated that they were actively responding to climate change, although 21 indicated that they were monitoring it as a concern.

Climate Change and the Fed

The extent of a central bank's response to climate change depends partly on its mandate. "Some mandates consider macroeconomic stability, and others are more focused on price stability or low inflation," Rudebusch says. "And there's additional disparity in whether and how a central bank's mandate addresses financial stability."

For its part, the Fed's dual mandate of ensuring maximum employment and price stability is silent on climate change, although the Fed does play a supervisory role in the financial system. Perhaps as a result, the Fed's response to climate change has been narrower in scope than that of its peers. It is not a member of the NGFS, nor does it purchase green bonds. (Apart from those

issued or guaranteed by a federal agency, the extent to which the Fed is legally authorized to purchase green bonds is unclear.) In January 2019, Sen. Brian Schatz of Hawaii wrote a letter to Fed Chair Jerome Powell asking how the Fed planned to address climate-related risks. Powell responded that while directly addressing climate change is outside of the Fed's authority, its role does include preparing for and responding to financial risks from extreme weather events.

Aside from its mandate, a number of other factors could deter the Fed from acting. One could be a desire to preserve its monetary policy independence. Actions taken by the Fed in response to concerns about climate change, if perceived by Congress as too much or too little, could be regarded by Fed leaders as weakening political support for the Fed's traditional independence in the making of monetary policy. Moreover, climate change, like many issues, may be viewed as a matter for fiscal policy — the province of the political branches — rather than monetary policy.

Another factor could be that climate change and monetary policy have historically had different time horizons: Monetary policy is concerned with near- and medium-term trends, while some climate-related risks are decades out and others' timelines are completely uncertain. However, some economists argue that climate change, like demographics, is a long-term economic trend that should be taken into account during deliberations over monetary policy, even if that policy doesn't aim to mitigate climate-related risk.

"There have been some big trends in the macroeconomy in the past few decades. Some of them include rising inequality, slowing productivity growth, and increasing industry concentration. And one very important trend is the changing distribution of weather events," Phan says. "This is a very important driving, underlying factor of the macroeconomy, so of course I think the profession will have to pay attention." **EF**

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