S. HRG. 118–235

INVESTING IN THE FUTURE: SAFEGUARDING MUNICIPAL BONDS FROM CLIMATE RISK

HEARING

BEFORE THE

COMMITTEE ON THE BUDGET UNITED STATES SENATE

ONE HUNDRED EIGHTEENTH CONGRESS

SECOND SESSION

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C O N T E N T S

WEDNESDAY, JANUARY 10, 2024

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INVESTING IN THE FUTURE: SAFEGUARDING MUNICIPAL BONDS FROM CLIMATE RISK

WEDNESDAY, JANUARY 10, 2024

COMMITTEE ON THE BUDGET,
U.S. SENATE,
Washington, DC.

The hearing was convened, pursuant to notice, at 10:00 a.m., in the Dirksen Senate Office Building, Room SD–608, Hon. Sheldon Whitehouse, Chairman of the Committee, presiding.

Present: Senators Whitehouse, Merkley, Kaine, Padilla, Grassley, Johnson, Braun, Kennedy, and R. Scott.

Also present: Democratic Staff: Dan Dudis, Majority Staff Director; Melissa Kaplan-Pistiner, General Counsel; Matthew Bolden, Climate Policy Advisor.

Republican Staff: Chris Conlin, Deputy Staff Director; Krisann Pearce, General Counsel; Jordan Pakula, Professional Staff Member; Ryan Flynn, Staff Assistant.

Witnesses:

Mr. Thomas G. Doe, President and Founder, Municipal Market Analytics

Ms. Megan N. Kilgore, City Auditor, Columbus, Ohio

Dr. Chris Hartshorn, Advisor, Zeus AI

Dr. Matthew Kahn, Provost Professor of Economics and Spatial Sciences, University of Southern California

Dr. Eric Leeper, Paul Goodloe McIntire Professor in Economics, University of Virginia

OPENING STATEMENT OF CHAIRMAN WHITEHOUSE [1]

Chairman WHITEHOUSE. My distinguished colleague and Ranking Member, Senator Grassley, has an obligation to check in on another Committee before he comes here, and that starts at 10:00, so he's going to be here fairly soon, and I have his staff's permission to begin the hearing, so let me gavel it into order.

And I welcome the witnesses, welcome all colleagues to the first hearing of the Senate Budget Committee in 2024, and what is our 12th hearing on the looming fiscal and economic dangers of climate change. In the year since we started, climate economic warnings have just gotten worse.

We are barreling past warning sign after warning sign. The facts are bad.

[1] Prepared statement of Chairman Whitehouse appears in the appendix on page 28.

Last year was the hottest year on record. It set a new record for billion dollar disasters, including the deadliest wildfire in modern United States (U.S.) history, and a new worst for global fossil fuel emissions. Climate change disrupted global food markets with flooding, persistent drought and shipping bottlenecks, and raised sugar, cocoa, and olive oil prices as just a few examples, causing climate inflation around the world.

Shattered weather records battered insurance markets. Vermont and New York's once in a thousand year storms triggered deadly floods. California saw its first ever tropical storm warning. El Paso had 44 consecutive days at or above 100 degrees, topped by Phoenix's 55 days at or above 110 degrees. The Dallas fed estimated the summer heatwave cost Texas $24 billion.

Insurance companies are already cutting their losses and exiting markets on the frontline of climate change in Louisiana, Florida, and California. Follow the real estate economics here. Without insurance it's hard to get a mortgage. But if you can't get mortgages, property markets suffer, causing pain to families, communities, and ultimately the entire U.S. financial system.

Look at when the 2008 mortgage crisis cascaded into the Great Recession. As this current insurance crisis spirals into a mortgage crisis, and then spills over into housing markets, property values will suffer. The former Chief Economist at Freddie Mac warned this Committee that in this mortgage crisis, "Unlike during the experience of 2007–2008, these homeowners will have no expectation that the values of their homes will ever recover."

I share my colleague's debt and deficit concern about the impending budgetary and fiscal crisis facing our nation. One front of that impending crisis is climate change's economic threat. A threat to families, neighborhoods, banks, federal housing lenders, real estate developers, insurers, investors, and to state and local tax bases, which brings us to the topic of today's hearing, the $4 trillion municipal bond market.

Municipal bonds, much like the 30-year mortgage, are a bedrock of our American economic systems, enabling local governments to make investments that are essential for their communities. Basic public services, like water service, sewage treatment, electricity and roads. Local government bonds finance more than 70 percent of U.S. infrastructure, including airports, bridges, railways and seaports.

Climate change now threatens that bond market. Historically, municipal bonds have a sterling reputation among investors with default rates of less than 1 percent. Investors lend their dollars to build a new school or highway, and typically receive a tax exempt stream of interest for the next 15 or even 30 years.

These bonds, secured by government revenues, are among our most stable investments. Climate change undermines the stability in two ways. More intense storms, wildfires, droughts, heatwaves and floods impose higher costs on state and local governments, putting pressure on the spending side.

And on the revenue side storm damage and insurance risk can undermine the municipal tax base. Already climate change is making it harder for municipalities to service their bond payments, and

making it harder for governments to raise new capital for needed climate investments.

After a disaster, communities' local tax bases can be devastated. 5 years after the Camp Wildfire, only ⅓ of the population has returned to Paradise, California. Hurricane Matthew undermined tax bases across small towns in North Carolina. After a disaster, population declines mean revenues decline, and bond markets are watching. 15 or 30 year municipal bonds start to look less safe.

Moody's has already given notice to coastal communities. This risk comes home to roost in the federal budget. Over 40 percent of our national debt relates back to crises we did not prepare for adequately, like the mortgage meltdown and the COVID pandemic.

Today we'll hear more evidence that climate change is just such a crisis, an impending budgetary and fiscal crisis facing our nation. It could well be the worst yet. We've heard warnings about a coastal properties values crash. A similar collapse in wildfire adjacent areas, a bursting of the international carbon bubble, of turmoil in insurance markets, of climate inflation, and now danger to a pillar of American investment, the municipal bond.

Nothing says that these all don't come to pass. Ignoring all of this is akin to financial negligence. And if there's one thing the Budget Committee should be able to agree on is that we oughtn't be negligent, and with that I will turn to my distinguished Ranking Member, and also wish him a Happy New Year. This is the first time we've seen each other in person since the New Year.

OPENING STATEMENT SENATOR GRASSLEY[2]

Senator GRASSLEY. And I'm going to wish you in turn a Happy New Year, and your family as well. And as you would expect, I'm going to say that I have enjoyed the first year we've had, even though we've had some disagreement on the agenda of the Committee, and so I'm going to probably start out where you would expect me to start out.

The purpose of the Budget Committee and the——

Chairman WHITEHOUSE. Understood.

Senator GRASSLEY [continuing]. Fiscal problems of our nation. One of my hopes for the year is for this Committee to turn its attention to the pressing fiscal challenges that we face as a nation. Our unsustainable fiscal outlook is a bipartisan problem because both parties talk about it, and it's going to require a bipartisan solution to resolve.

That was the crux of the letter that Senator Scott and I, along with all the Republican members of this Committee, sent you in December. Your December 7th response suggests that you agree that reducing the federal deficit and shrinking national debt are good ideas, and yet you rejected our request to hold a bipartisan hearing focused on that matter.

Yes, we do disagree on the merits of many policies and proposals, but for the good of our nation we must begin to find common ground to address a national debt that recently topped $34 trillion, and is growing at a historic pace. Yesterday the Congressional

[2] Prepared statement of Senator Grassley appears in the appendix on page 30.

Budget Office (CBO) warned that the federal budget deficit totaled $509 billion in just the first 3 months of fiscal year 2024.

That's $87 billion more than this time last year, and that's despite the fact that revenues are coming in 8 percent higher than a year ago. The Treasury Department recently reported that we ran a $1.7 trillion deficit in 2023, larger than all but 6 deficits recorded since 1946, as a share of gross domestic product (GDP). Now we now that Fitch Ratings has downgraded our credit rating, and Moody's Investor Service recently placed a negative outlook on the U.S. sovereign credit rating.

This morning the Budget Committee holds its 13th climate change hearing this Congress. This has prevented us from discussing ways to improve our immediate and dire economic position. Climate discussion is always worthy of our time as legislators, and must be considered, and debated, and discussed.

But climate change doomsday isn't just around the corner. Recent adaptation is the key to coping with any climate change. Today's hearing is about the role of climate change in the municipal bond market. The $4 trillion municipal bond market is very resilient according to Moody's. Over 99 percent of municipal bonds issued by cities, school districts, states and other local governments, are categorized as investment grade.

The infrequency of general government defaults reflects a key feature of state and local governments. That is, they have the power to raise revenue through taxation unlike private sector counterparts. State and local governments understand the risks their jurisdictions face, and they're uniquely qualified to so adapt.

Where there have been defaults in municipal bonds it's been in places that have been mismanaged for decades, such as the City of Detroit, and I haven't looked at Detroit lately, but I think they're making some progress coming out of the hole that they dug for themselves. In fact, according to Moody's they've never seen a bond that they rated default due to natural disasters.

This includes rated bonds for Paradise, California, which suffered near complete destruction in 2018 California wildfire. Paradise has made every scheduled bond payment. I agree that municipal bond issuers face challenges. A big one is the extent to which municipalities rely on the federal government for transfers.

Let's face it, we're broke. I welcome all today's witnesses, and look forward to hearing each of their testimonies. Thank you, Mr. Chairman.

Chairman WHITEHOUSE. Thank you, Senator Grassley. Let me take a moment to introduce our witnesses. I'll introduce all of you together, and then we'll go through your testimony. As you know, the practice in this Committee is to hold your statement to 5 minutes, have your complete testimony made a part of the record, and by adhering to that we give more time for the Senators who are present to ask questions, so thank you for accommodating us with that.

Our first witness is Mr. Thomas Doe. Mr. Doe is the Founder and President of Municipal Market Analytics, a leading independent strategy, research, and advisory firm for the municipal bond industry. Clients include major investment firms, banks, securities dealers, financial advisers, bond issuers, and regulators.

Mr. Doe served on the Municipal Securities Rulemaking Board (MSRB) from 2002 to 2005, and he's previously testified on the health of the industry to the Senate Banking Committee, and to the Securities and Exchange Commission. Welcome back to Washington, Mr. Doe.

Our second witness is Ms. Megan Kilgore, the City Auditor of Columbus, Ohio. As City Auditor, she oversees a nearly $5 billion debt portfolio, and a $2 billion investment portfolio, and she administers the collection of approximately $1 billion in revenue every year.

Prior to elected office, Ms. Kilgore was a Municipal Advisor, helping cities, counties, school districts, and economic development districts all over the country navigate complicated financing transactions. Ms. Kilgore, thank you for being with us today.

Our third witness is Dr. Chris Hartshorn. Dr. Hartshorn is currently an adviser to Zues AI, a National Aeronautics and Space Administration (NASA) spinoff focused on next generation weathering modeling and forecasting, as well as a number of other environmental data science startups and a venture capital firm.

Previously, Dr. Hartshorn helped build risQ and Level 11 Analytics, which became the leading providers of physical climate risk data for the municipal bond market, until their acquisition by Intercontinental Exchange in 2021. Thank you for being here today, Dr. Hartshorn.

Following Dr. Hartshorn is Dr. Matthew Kahn. Dr. Kahn is a Provost Professor of Economics and Spatial Sciences at the University of Southern California. Dr. Kahn is also a visiting Fellow at the Hoover Institution, and a Research Associate at the National Bureau of Economic Research (NBER), and a Research Fellow at the Institute of Labor Economics (IZA). Dr. Kahn's research focuses on urban and environmental economics.

He previously taught at Columbia, the Fletcher School at Tufts, the University of California, Los Angeles (UCLA), Harvard, Stanford, and the National University of Singapore. Thank you for being with us, Dr. Kahn.

Our final witness is Dr. Eric Leeper, the Paul Goodloe McIntire Professor in Economics at the University of Virginia (UVA)—my at least law school alma mater, if that actually counts in UVA. You know, they take the undergrad and the law school differentiation pretty seriously. Dr. Leeper is also a distinguished visiting scholar at the Mercatus Center, a research associate at NBER, Director of the Virginia Center for Economic Policy at UVA, and external Advisor to the Swedish Central Bank, and a member of the Research Council of the Bundesbank.

His work focuses on theoretical and empirical models of macroeconomic policy, with special emphasis on monetary, fiscal policy interactions. Fair description? Yes. That's good. Okay. Welcome, Dr. Leeper. Mr. Doe please proceed.

STATEMENT OF THOMAS G. DOE, PRESIDENT AND FOUNDER, MUNICIPAL MARKET ANALYTICS[3]

Mr. DOE. Thank you, Chair Whitehouse, Ranking Member Grassley, and members of the Committee for inviting me here today. My discussions with state and local sustainability and resilience officers have revealed woeful ignorance regarding the capital markets essential role in financing their climate adaptation needs.

My name is Tom Doe. I'm Founder and President of Municipal Market Analytics, and I've also served on the MSRB as Chair Whitehouse noted. I also serve on the Advisory Board of the Center of Municipal Finance at the University of Chicago's Harris School. Municipal bond issuance can serve as the initiative-taking financing tool to reduce the federal government's burden in responding to catastrophes via the Federal Emergency Management Agency (FEMA).

To date, municipal investors have been able to downplay the climate issue because of FEMA's historical presence to backstop areas impacted by extreme weather events, and rating agencies' limited credit outlook to a few years into the future. Investors' positive expectations have inhibited issuers' proactive action to reduce the consequences of future climate-related risks.

The Administration and Congress climate initiatives have been laudable. However, the federal government has emphasized mitigation over adaptation, and still, as Chair Whitehouse knows, global mitigation efforts to date will not halt the breech of the earth's 1.5-degree warming barrier. As a result, U.S. citizens will rely on state and local governments to execute needed adaptation and resilience measures.

It is fair to characterize the municipal market as the best form of partnership between state, local, and federal governments. Municipal bonds have financed 75 percent of U.S. public infrastructure. They provide low-cost capital for state and local infrastructure needs, both large and small.

Since 2004, the municipal market has raised an annual average of $400 billion for a variety of purposes. Its stability has created investor confidence, steady regulation has improved markets' integrity, state revolving fund programs have served as a shining example for financing future resilience needs.

The pandemic reiterated that in the U.S. the avoidance of taxes is a motivational force for investors. Over the past 3 years states with population increases have an average state income tax of approximately 3 percent, while those who have lost population have a tax rate of approximately 7 percent. Ironically, the movement has been to states that have the greatest climate risks.

These areas and elsewhere will need to finance adaptation projects to improve stormwater management, provide clean water, cool educational and healthcare facilities, secure the provision of electricity, make transportation systems resilient, while also anticipating catastrophic events. Municipals' tax exemption not only incentivizes high earners to invest in infrastructure, but also allows state and local governments to apply capital to where it is most needed.

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[3] Prepared statement of Mr. Doe appears in the appendix on page 32.

Once again, largely because of FEMA's historical backstop, investors and rating agencies have not significantly penalized the most climate-vulnerable state and local governments with lower prices or ratings. Hence, in the absence of the penalty, this provides a current opportunity for issuers to invest now before greater investor sensitivity evolves.

State and local governments have an extremely low default rate, both on absolute and relative basis. Ninety percent of the $4 trillion public outstanding municipal bond debt is investment grade, suggesting that too great of an emphasis may have been placed on government officials' aspirations for the highest credit rating, instead of efficient market utilization.

In other words, state and local governments could assume a greater debt burden to address climate risk. Greater debt might result in a possible lower rating today, but could put an issuer in a better position to stabilize or improve its future rating. This is admittedly a difficult needle to thread because climate instability poses an unprecedented systemic risk to municipals' hallmark credit quality.

The Committee's prior hearings have revealed data sources to inform investors of climate risk and security offering documents. Fortunately, the government-financed Officer's Association in 2021, led in part by Florida's debt leadership, provided best practice guidance for climate disclosure. Also, the U.S. Securities and Exchange Commission (SEC) is continually reviewing state and local borrowing disclosure practices, which have been disappointingly inconsistent or silent regarding climate change's specific risks, and the plans to address them.

It is egregious that state and local governments' easily-quantified climate risks are not clear to investors who deliver capital, and to the federal government who provides the critical subsidy. I appreciate your invitation to join you today, and look forward to the questions and discussion.

Chairman WHITEHOUSE. Thank you very much, Mr. Doe. Ms. Kilgore, please.

STATEMENT OF MEGAN N. KILGORE, CITY AUDITOR, COLUMBUS, OHIO [4]

Ms. KILGORE. Chairman Whitehouse, Ranking Member Grassley, members of the Committee, thank you for inviting me here today. My name is Megan Kilgore. This marks my 20th year in the public finance industry. For the last 6 years, I have had the privilege of serving as the elected City Auditor of the City of Columbus, Ohio.

My office is responsible for debt issuance, capital planning and rating agencies strategy, and investor relations. I am proud to say that we are the largest city in America to maintain the highest credit rating possible, Triple A from Standard & Poor's (S&P), Moody's, and Fitch, respectively.

Prior to my elected service, as the Chair noted, I worked as a municipal Financial Advisor, helping clients, cities, counties, school districts, community colleges, all across the country plan for and finance their infrastructure. Any time we have a major initiative in

[4] Prepared statement of Ms. Kilgore appears in the appendix on page 43.

our industry, local governments ask a number of good questions. Why? How? What? When? And who will pay for it?

In my conversation, the why has been fairly evident, and local governments are becoming increasingly aware of the economic and societal risks of climate change. The remaining questions are where I would like to focus my time today, as my objective is to leave this Committee with solutions for increasing climate oriented project financing and implementation, both mitigation and adaptation.

To date, of the hundreds and hundreds of bond issues that I have worked on, I have not issued, nor have I advised that a client issue, bonds that are designated as green, even if the projects could earn that designation. The primary reason for that is lack of definitive financial benefit.

I have also not found there to be any incentive from a rating agency standpoint. Green debt is still considered debt, and carries no quality—credit quality advantage. In other words, municipal debt that is financing a renewable energy project with sizable long-term economic benefit is still on parity with a community pool.

Our objectives at the City of Columbus are to get the best deal possible, and to maintain affordability for our residents. So in addition to the traditional municipal debt market, we also consider available federal funding. The good news is that there are incredible levels of federal programs available today.

The Inflation Reduction Act (IRA), programs like Water Infrastructure Finance and Innovation Act (WIFIA), Transportation Infrastructure Finance and Innovation Act (TIFIA), rural specific programs, and numbers of other acronyms exist, but we lack a user friendly resource that wholly connects the dots. I can attest that even a Triple A, like the City of Columbus with a deep bench of experts, working through this complexity has been difficult, let alone many of my former clients who lack the similar financial and technical resources.

So how do we get these necessary projects underway? I'd like to share opportunities that I see that could eliminate barriers to local governments' participation in more climate oriented projects. One, provide clear financial incentives for both local governments and investors. For instance, consider broadening the definition of municipal backed bonds, tax exemption for projects that reach certain climate metrics, and growing climate related opportunities with things like private activity bonds.

Number two, help local governments overcome human capacity barriers by creating a federal office to serve as the single point of knowledge. There are over 50,000 local governments who issue debt, making it incredibly difficult to generate transformational change using a one size fits all approach.

I am inspired by how the websites America is All In, and Rewiring America have done this using technology to create highly personalized tools that estimate, for instance, how much money homeowners can save by employing clean technologies.

Which types of tax credits the homeowner may be eligible for, and how to go about applying. Similar to President Eisenhower's Public Roads Administration, we need this one stop shop to help local governments with project analysis, regional design, implemen-

tation, as well as a place to collect, analyze and communicate information regarding grant loan and financing sources and uses.

Just imagine if a single source of information was available to my small hometown on the Ohio River. A site where users could see their location-specific estimates of physical climate risk exposure, alongside potential economic loss, types of projects that would best benefit that area, and corresponding funding opportunities.

Number three, help smaller and lower credit communities achieve total funding needs. I saw a ton of success with the Super-Build America Bonds (BAB)-type structure under the Recovery Zone Economic Development Bonds. Such a reinvented program could help these local governments, especially those seeking last mile funding, use bonds to spread the costs of projects over a reasonable number of years, while keeping affordability in check.

The solutions I see are big, transformative, and require our federal government to take action at a scale commensurate with the opportunities before us. Thank you for the time.

Chairman WHITEHOUSE. Thank you, Ms. Kilgore. Dr. Hartshorn.

STATEMENT OF DR. CHRIS HARTSHORN, ADVISOR, ZEUS AI[5]

Dr. HARTSHORN. Good morning, Chairman Whitehouse, Ranking Member Grassley, and members of the Committee. Thank you for inviting me to testify at this hearing. It is an honor to do so, and to represent the hard work of many colleagues and collaborators.

My name is Chris Hartshorn. I currently advise numerous entities operating at the finance industry and sustainability nexus. More relevant for this hearing, are my many years fully dedicated to building market leading capabilities focused on climate risk to U.S. fixed income debt instruments, including municipal bonds.

Firstly, it is importantly to note that the municipals as defined by the municipal bond market, are a vast diaspora of overlapping debt issuers covering states, counties, utilities, school districts, transit systems, airports, hospitals, charter schools, retirement communities and many others.

The implications of climate action to the population are broad and stark under this financial market municipal definition. With respect to climate risk, it is easiest for most to conceptualize property destroying, evacuation invoking perils, hurricanes, wildfires, floods and the like. As these acute events happen quickly, catalyze local, and often federal emergency responses, have quantified economic consequences and costs, and leave single named scars, Katrina, Sandy, Paradise, to name just three.

Such climate risks are material to municipal finance, taking wildfires as one example. In the 5 years after a fire, the net fiscal effect of wildfires on a municipality is a decline in excess revenues of $97 per capita, equivalent to 11 percent of the per capital budget size, and a 25 percent increase in the probability of a budget deficit.

For hurricanes, local governments experience significant declines in revenues, expenditures, and debt. In the 10 years after a hurricane strike these are initially offset by intergovernmental transfers, but ramp up 10 to 16 years after post—after a hurricane. The

[5] Prepared statement of Dr. Hartshorn appears in the appendix on page 45.

impacts of past floods also litter the official statements of the bond issuing community.

Across these acute perils, rebuilding costs have been underpinned by FEMA Disaster Relief Fund (DRF) funding that has been on a bumpy, but nonetheless upward trajectory over recent decades. Another key constituent of post-disaster recovery has been property insurers that help re-establish property value. Noting that property taxes are a key revenue stream for many municipal bond issuers.

It is noteworthy therefore, that in higher climate risk states, Florida, Louisiana, California, that major insurers are withdrawing from those markets. And those that remain are ramping up policy premiums, an outcome that will inevitably lead to a decrease in coverage, and anecdotally already has.

The diminishing of this historically critical pillar of past disaster recovery, will only heighten the post-disaster financial pressure on the municipal and federal system. Other perils must be accounted for, for which the impacts are more chronic in nature. Heat, drought, sea level rising effects on water supply in many coastal areas.

Heat is a good example, given we've just experienced the hottest year on record globally, and cities such as El Paso and Phoenix shattered their own records. This is a critical issue across much of the municipal U.S. for the health and safety of these served populations, and the municipal workforce, and for municipal infrastructure.

Municipal sectors beyond cities also feel this heat. For example, school districts exposure to heat risk is already apparent. Temperature has been shown to have a direct impact on educational performance, noting that September, the start of a typical U.S. school year also set new records in 2023.

In schools without functioning air-conditioning, a 1 degree Fahrenheit hotter school year reduces test scores by 1 percent versus expected learning gains. By some estimates, around $40 billion of new air-conditioning installation is required across U.S. K through 12 schools to address this.

These K through 12 schools represent around 15 percent of the municipal bond market, while access to debt has shown to improve K through 12 educational outcomes, there is now a climate driven educational performance imperative to add to this mix.

In reality, any combination of a given climate peril in a given sector within the municipal universe can be explored for underlying materiality, but the themes of present and future climate risk and cost would remain. Critically, mitigation funding can save the nation $6 in future disaster costs to every $1 spent on hazard mitigation.

That 6x multiple needs to be seen in the context of the U.S.' estimated $2.6 trillion infrastructure deficit over the next 10 years.

The question is how to maximize the upfront dollars to address this risk. This does not need to be a monolithic draw on the federal purse. The municipal bond market has held steady around $4 trillion over the last 15 years, but this is misleading. There is an undoubtedly willing capital just sitting on the sidelines.

Again, thank you for the opportunity to address the Committee. I look forward to your questions.

Chairman WHITEHOUSE. Thank you, Dr. Hartshorn. Dr. Kahn.

STATEMENT OF DR. MATTHEW KAHN, PROVOST PROFESSOR OF ECONOMICS AND SPATIAL SCIENCES, UNIVERSITY OF SOUTHERN CALIFORNIA[6]

Dr. KAHN. Good morning, Chairman. Thank you Ranking Member Grassley and members of the Committee for inviting me to testify. I'm relentlessly optimistic about the way cities can adapt to the climate challenges. Climate change is not a catastrophic threat to the municipal bond market.

Bond buyers have an incentive to do their due diligence.

If a municipality faces rising climate impacts that imperil its abilities to repay debt, bond buyers will recognize this, and they will offer lower prices for bonds. The places that fail to adapt to new risks will pay higher interest rates, and higher insurance rates.

To see why climate risk does not imperil the financial system, via municipal bond defaults, let's play out a hypothetical doomsday scenario. What does it take for a climate event to cause a financial crisis? The year is 2034. Over the last decade the climate has gotten worse.

Storms are more frequent. The City of Chicago continues to issue new municipal debt. Chicago has huge public pension obligations. The city's bonds are rated as barely investment grade quality. Suppose a hedge fund buys these Chicago bonds, using money borrowed short-term from several banks. An unprecedented storm hits Chicago.

Infrastructure is flooded and damaged. The city appeals to the federal government for disaster relief, but none arrives. Tax revenue plummets, a local economic depression ensues. The city defaults on all of its bonds. The hedge fund, who owns the bonds, goes under. Banks who lent Chicago bond buyers money now own worthless collateral and they fail.

Still, only a few banks have failed. Depositors at other banks worried about the hidden risks run. The federal government does not bail out the banks or the depositors. Finally, we have a crisis. Folks, elementary economics shows that this scenario is implausible. Why?

First, local property owners seek to enhance the value of the assets. They have an incentive to lobby local leaders to invest in resilience to reduce default risks. Property owners recognize that a municipal default leads to lower local quality of life and higher property taxes.

Second, over the last 40 years, hurricane strikes have had a minor impact on municipal bond prices, and their impact on default rates has been tiny. While federal disaster relief helps cities to recover from shocks, this reduces bond default risk. It is arguable that the federal government has been too generous with respect to state and local aid, and this creates perverse incentives for local investment in resilience.

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[6] Prepared statement of Dr. Kahn appears in the appendix on page 50.

Third, portfolio theory warns against putting all your eggs in one basket. Meaning super bond investors tend to be high net worth individuals and pension plans. They do not hold concentrated investments in any one city's bonds. A city's default will not cause these investors to fail. They invest in a spatially diversified asset portfolio.

Fourth, climate science progress offers ever improving real time geo-coded predictions. These models inform predictions concerning which cities face severe medium-term climate risks. Cities predicted to face rising risks will experience rising insurance costs, and they will pay higher interest rates on their long-term debt relative to their short-term debt.

The expectation of facing higher insurance prices, and higher interest rates provides an incentive for municipalities to invest their own money in adaptation. Fifth, as we grow richer, property owners are willing to pay more for safety, for products that enhance their safety, such as anti-flood equipment, and stronger windows.

Firms have a profit motive to design these climate resilient products. My own research agenda has been this focus of how we unleash free markets, the profit motive to create a new menu of products that help us to adapt. Competition in adaptation product markets leads to lower prices.

As more of a city's property owners make these investments, the overall local real estate capital stock becomes more resilient to disaster shocks. Going forward, Senators, big city municipal bond risk will mainly be determined by public pension obligations, and day to day quality of life concerns, leading to suburban flight, not by a change in the frequency of bad weather events beyond that which cities and bond investors are already planning for, thank you.

Chairman WHITEHOUSE. Thank you very much, Dr. Kahn. Dr. Leeper.

STATEMENT OF DR. ERIC LEEPER, PAUL GOODLOE MCINTIRE PROFESSOR IN ECONOMICS, UNIVERSITY OF VIRGINIA[7]

Dr. LEEPER. Chairman Whitehouse, Ranking Member Grassley, Committee members, thank you for inviting me to talk today. Good morning. I'm Eric Leeper from the University of Virginia. Today I'd like to talk about federal budget policy and its implications for financing expenditures associated with climate change.

I draw on consensus economic theory about optimal public finance at the macroeconomic level, and talk about growing weakness in the market for treasuries. Weakness that stems in large part from fiscal uncertainty in Washington. Treasury securities and municipal bonds, like any assets, derive their value from expected future payoffs discounted to the present.

For government issued bonds, those payoffs are budget surpluses, excluding interest payments, what we call primary surpluses. Higher expected payoffs raise demand for and the value of bonds, so governments can borrow on more favorable terms. Bonds lose value as they have the last 4 years, when investors worry that surpluses don't lie in the future.

[7] Prepared statement of Dr. Leeper appears in the appendix on page 59.

Optimal public financial avoids sharp swings in tax rates and spending, swings that distort behavior and reduce social welfare. Large, temporary bursts in spending that arise from say a war, call for increased borrowing. When spending needs subside, policy generates primary budget surpluses to support the new debt. The expectation that surpluses will rise maintains the value of that debt.

George Hall and Tom Sargent document that U.S. policymakers largely followed this advice after the two world wars. Hall and Sargent also examined the fight against COVID in this light. Large COVID related spending was financed by new debt issuance, marketable treasury debt grew by more than $7 trillion over the 3 years starting January of 2020.

What we haven't seen is the follow through that optimal policy requires. The Congressional Budget Office projects primary deficits for the next 30 years. This tells us that nothing about today's budget process ensures that policy will generate the required surpluses.

Budgetary consequences of climate change won't resemble the large, temporary spending bursts associated with wars or COVID. Instead, climate change seems likely to entail sustained elevated spending levels. Permanently higher spending on something new requires either permanently lower spending on something else, or permanently higher tax revenues.

Ever increasing borrowing, whether in the muni or the treasury market, cannot be the answer. The lack of clear fiscal plans harms the economy today, and we're seeing some evidence of that in the treasury market. The price of the treasury bond portfolio has declined 18 percent since early 2020. The last time we saw declines like this was in the 1970s.

Interest payments on outstanding debt are growing rapidly. Treasury has had to auction new bonds in weak markets to meet those payments. If as now, there are no prospects for future surpluses, it's hard to see inflation returning to the Fed's 2 percent target.

Fiscal priorities change with every new administration or Congress. That's as it should be in a representative democracy. But to achieve those priorities there must be some constancy in fiscal behavior. If bond market weakness continues, the federal government may find it increasingly costly to borrow—to finance its priorities.

The only fiscal constancy we have in the United States comes from a set of norms that have evolved informally over the country's history, and owe much to Alexander Hamilton. The Hamilton norm springs from his first report to Congress in 1790. He argued that proper provision for the public debt arises "when it is well funded, and has acquired an adequate and stable value."

By following this norm, the United States has earned a reputation for repaying its debt. Is that reputation now in jeopardy? If century's old norms can be wantonly tossed aside, then they're powerless to prevent fiscal policy from becoming a source of instability in the economy.

Perhaps the time has come to institutionalize the norms through rules and procedures that have bite. Thank you very much.

Chairman WHITEHOUSE. Thank you very much. Let me start if I may, with Mr. Doe. You've suggested that the short horizon that bond rating agencies tend to look at, plus the surge of FEMA fund-

ing that comes into a community after a disaster creates a sort of an artificial, if you will, zone that doesn't contemplate the full risk.

And Dr. Hartshorn suggested after that FEMA funding passes, there's a secondary period where municipal revenues and spending are affected by the disaster, but the federal support has been pulled, and that's a more fiscally challenging period for the municipalities, if I properly understood your testimony.

Mr. DOE. Well, thanks for the question. The—first of all, it is one of the challenges that the rating agencies are of course critically important to the financial marketplace. Unfortunately, the outlook that they have with their rating is maybe 2 to 3 years, maybe 5 in some instances. It doesn't mean they're not considering long-term impacts, but the changes in that all important letter, right, that conveys the risk to an investor, is pretty stable for a short period of time. So the real challenge is——

Chairman WHITEHOUSE. That's a short period of time in which federal FEMA support is likely to be present, but not for long in the municipal.

Mr. DOE [continuing]. And what the reality has been regarding FEMA is in place such as when a hurricane hits, when Katrina hit New Orleans. What happens is that the initial response by the municipal market is prices of those securities in the affected area are declining, and then afterwards the expectation, or the rebuilding that comes from the federal government via FEMA actually increases those prices.

Chairman WHITEHOUSE. Ms. Kilgore, do you see that in your experience as well? You live on the ground with this setup all the time.

Ms. KILGORE. Senator, certainly, the rating agencies right now do have a shorter, in my opinion, horizon of which they're looking at our climate related projects. But again, I would say they're on parity with any other type of basic infrastructure, recognizing a little bit that we are seeking to plan for the future, but we would like to see there be more focus on that.

Chairman WHITEHOUSE. More focus on the period once the immediate surge of FEMA funding has pulled away, and you now have the more persistent problems still present in the fiscal outlook for the community.

Ms. KILGORE. It is certainly, Senator, in my opinion, management is what separates good governments from great governments, and being able to proactively plan for the future, and try and get ahead of anything that we can possibility get ahead of, that's the most important part.

Chairman WHITEHOUSE. Mr. Doe, you used the following phrase, if I wrote it down correctly. "Climate instability presents an unprecedented, systemic risk." That phrase, "systemic risk," keeps popping up in these hearings. It has a relatively technical meaning among economists. Could you please describe what a systemic risk is?

Mr. DOE. So a systemic risk would be not just an isolated specific stress for a specific issuance or state and local government, but across broadly, across the entire marketplace, so that all municipal bonds in this case would be impacted to some degree.

Chairman WHITEHOUSE. Understood. And Dr. Hartshorn, you have two companies that you founded that were bought by the Intercontinental Exchange. Can you explain a little bit first for the record of the Committee, what is the Intercontinental Exchange, and why were they interested in acquiring the expertise that those two entities provided?

Dr. HARTSHORN. Yeah. Thank you for the question. Intercontinental Exchange had a bunch of different businesses, I guess you would describe them. They are the owner of the New York Stock Exchange for one. They are one of leading data providers to the financial industry, in terms of pricing data, you know, data, the market, and they also operate a substantial mortgage data business.

The reason why I believe, Intercontinental Exchange acquired us, they had seen the momentum in the market for our data. There was a screaming need especially from the buy side, from ratings agencies, and even bond insurers to get comprehensive data for the entire municipal bond system in terms of the physical climate risk to that system, which was substantially unavailable, and certainly across the entire realm of what I've described as municipal bonds data.

Chairman WHITEHOUSE. Thank you. Dr. Kahn, do you agree that the emissions from the combustion of fossil fuel amount to an economic negative externality that ought to be priced into the underlying product?

Dr. KAHN. So in theory I do support a carbon tax, but I do worry that if only the United States adopts a carbon tax, that it has little effect because it's a global externality.

Chairman WHITEHOUSE. Yeah.

Dr. KAHN. And it lowers the purchasing power of poor people. But as an economist, of course I support people internalizing the social costs of their actions.

Chairman WHITEHOUSE. Thank you. Let me just put into the Record, or the proceedings, Dr. Kahn's article called The Green Economy and Foreign Policy, an interview entitled Economist Matthew Kahn says human ingenuity is key to living with climate change, and an Openforum.com article that the Doctor wrote on July 24th, 2022, called are there still "limits to growth". And with that I'll turn it over to my distinguished colleague.

[The information of Senator Whitehouse appears in the index.]

Senator GRASSLEY. Thanks to all the witnesses, and Dr. Kahn, I've got something that you could probably spend the full 5 minutes on answering, but I'd like to have a short answer, so I can get a lot of questions in. We hear Democrats argue for a cascade of expensive and expansive federal climate proposals that will saddle us and local governments with debt and red tape.

Democrats attempt to justify these proposals with apocalyptic hyperbole rooted in extreme Representative Concentration Pathways (RCP) 8.5 scenario. How can cities help themselves mitigate risk, and adapt to climate change without relying on more federal spending?

Dr. KAHN. Senator, thank you. So I am optimistic that the RCP8.5 projection model overstates where global greenhouse gas emissions are going. I believe the work of Roger Pielke and others

that the world's greenhouse gas emissions will grow, but at a less extreme rate, so we face less risk.

To directly answer your question of what cities can do, similar to me having a checkup with the doctor, it's to become aware of emerging risks. Every city has its own topography, history, demographics. Every city needs to do the sort of self-checkup of what risks it faces, and then with engineers to identify cost effective solutions to mitigate the challenges.

And then using its own funds. Senator, I think we agree of the importance of fiscal discipline of using the city's own funds to consider strategies that are cost-effective to adapt to the challenge, and to speak to insurers, and bond buyers of what risks are they worried about. So this set of actions can help a city be proactive to mitigate the physical risks, and to be attractive to insurers and bond buyers to be able to participate in municipal finance markets.

Senator GRASSLEY. And also to you when states and Local governments face budget challenges, they can restrain spending, and hopefully be able to tap rainy day funds. It's not appropriate for us to micromanage the state for the sake of climate change, or anything else for that matter. My state of Iowa is required to have a balanced budget.

We don't take fiscal responsibility for granted, unlike here in Washington, D.C. How does fiscal discipline help cities mitigate severe weather risk, and could federal intervention in the matter lead to bad outcomes?

Dr. KAHN. Thank you, Senator. Professor Leeper spoke about reputation in his remarks. If a city has a reputation for fiscal responsibility, firms and successful people will move with confidence to that city expecting good services and low taxes going forward. A city with a robust tax base can weather the storm.

New York City after Sandy, a city that has a resilient, industrial base, an economic base, has the resources to protect itself when surprising contingencies emerge.

Senator GRASSLEY. And for you Dr. Leeper in 2020 the share of federal aid to state and local governments reached an all-time high, as a share of GDP, well over 4 percent. And of course, as we don't have to mention too often, or can mention too often, we're broke here in Washington, D.C. Are there more immediate and bigger risks to the broader economy than climate change?

Dr. LEEPER. Well, I think that right now one of the most pressing questions really is getting the fiscal house in order. No matter what you want to spend your money on you need to have sound fiscal underpinnings. And I think those are increasingly under threat these days.

We celebrate when Congress manages to avoid shutting down the government. I think we can set the bar a little higher than that.

Senator GRASSLEY. And also for you we've heard a proposal to create an expensive new federal climate bureaucracy, doling out billions in green handouts to large corporations. This agency would be environmental, social, and corporate governance (ESG) police telling local governments across the country what to do. I've been trying to find out how the U.S. Environmental Protection Agency (EPA) has spent the billions of dollars in green grant programs that the democrats have already passed.

Guess what? The EPA and the grantees still haven't told us. Is spending hundreds of billions of dollars for the sake of climate change advisable when the federal debt is cascading out of control?

Dr. LEEPER. Well, here I go back to what I said in my testimony that we are thinking about a sustained increase in spending levels. You cannot finance that through borrowing, it's just infeasible to do that forever. And so, just as when I planned to put my children through college, I pre-financed that spending. So to, the government needs to be thinking about how do you finance the spending that is being planned for climate change, because that's going to be a sustained increase in spending, and it can't be done through borrowing.

Senator GRASSLEY. Thank you both. Thank you.

Chairman WHITEHOUSE. Thank you, Senator Grassley. Senator Kaine.

STATEMENT OF SENATOR KAINE

Senator KAINE. Thank you. Mr. Chairman, thanks to the witnesses for this first Budget Committee Hearing of 2024.

I spent a lot of time in the bond market as a former mayor and former governor. In fact, the first lesson that I learned as a public servant was a lesson from the bond market. In the time between my first election in Richmond City Council, and swearing in on July 1 of 1994.

We had a bad calendar of budget and elections. The elections run May 1. The City Council would finish the budget on June 1, and the new Council would be sworn in on July 1. I came in in a clean sweep crowd. We pushed about 6 of the 9 City Council members out, and so the Council voting on the budget were all lame ducks, and they were all mad.

And they just decided to kind of go wild. And they did a bunch of things, especially with the city's reserve fund that caused the bonding agencies to downgrade Richmond's bond rating right before we swore into office on July 1 of 1994. We were naive. We thought well, all we have to do is retract the action. The bond agency acted in the middle of June. We came in, we retracted the foolish budgetary moves made by our predecessors.

We went to New York, and we said guess what guys, there's a new group in town. We've cleaned it all up. And the lesson that I learned from the bonding agencies is yeah, we get it. We're glad you did that, but when you lose our confidence, it takes you a while to win it back. And it took us 6 years of really persistent effort to get the bond rating upgrade back to where we were.

I did that when I was Mayor, and then as Governor, I had the good fortunate to be Governor of Virginia, where we had been Triple A bond rated forever, and were able to maintain that, even during the recession of 2008–2009. I want to get at an underlying issue. For most cities, for most counties, the primary revenue source is property tax.

There's other taxes, visitor, lodging, sales tax. We have a particular challenge in Virginia with climate that I just want to talk about, and I think I'm going to direct this question of Ms. Kilgore, my City Auditor. The Hampton Roads area of Virginia is Norfolk,

Virginia Beach, Chesapeake, Suffolk, a number of communities that are very vulnerable to sea level rise.

The Hampton Roads Planning District has a low estimate of sea level rise indicating that approximately 59,000 residential homes in Hampton Roads will be permanently or regularly inundated by the end of the century, that's the low estimate. And the high estimate is 175,000 homes. Freddie Mac has estimated that the total losses to coastal real estate are "likely to be greater in total than those experienced during the housing crisis and Great Recession."

So, Ms. Kilgore, my understanding, my recollection from Mayor and Governor is our ability to get bonds to fund projects in Richmond were based on our ability to pay off the bonds, or based on our revenue base. That revenue base was primarily real estate property tax collection. Can you imagine a scenario where a metropolitan area of 1.6 million people would lose 59,000 to 175,000 homes?

Losing the real estate property tax attendant upon those dramatic numbers. How would that affect that region's ability to go into the bond market and get bonds to do projects necessary for quality of life in that metropolitan area?

Ms. KILGORE. Thank you, Senator, for the question. Anytime with a major government I look at it as a very complicated recipe. And one day you have a little bit of eggs, you have a little bit of flour, and in each of those categories for our world it is revenue streams. And so, when things are a little bit tight you have to have an offset in another area. And a lot of the communication that I have with peers around the country, in large governments, all the way down to places where I grew up, is the fact that revenue base often dictates what folks can do.

And so, for example, if you do have a tight, or even worse, downward trending revenue stream, revenue base, your capital plan is going to be very constrained. And so projects that are planning for several years out are going to fall victim to immediate, every single day needs, roads being repaved, things like that, which is why for me, it's so important that we have a menu of options, so that federal programs can come into play effectively to help get that last mile funding to keep things on track.

Infrastructure, as you know, is an incredible multiplier, and will help regrow that community over time.

Senator KAINE. And just using the example that I used about Hampton Roads, if even the low estimate occurs, and you see this shrinking of the residential real estate base and residential real estate values, the community will become more constrained on infrastructure investments at the very time where they might need more infrastructure investments to promote resilience against sea level rise.

And last question really quickly, there may be outliers to this. I can think of a couple, but am I basically correct that for most cities and counties in the United States the real estate property collection is the most sizable revenue source?

Ms. KILGORE. My suspicion is property taxes for most. For Ohio is the income tax, but yeah. There's certainly a number of ingredients across the country that support revenue streams.

Senator KAINE. Great. Thank you. Thank you, Mr. Chair.

Chairman WHITEHOUSE. So quick, logistical interruption. I have been called to a meeting with Chairman Wyden, and I'm going to go attend that for a while. Senator Padilla has been kind enough to agree to take over chairing this hearing until I can return. Senator Johnson will be next to be recognized.

Senator JOHNSON. Thank you, Mr. Chairman.

Chairman WHITEHOUSE. And I wish you all well until my return.

STATEMENT OF SENATOR JOHNSON

Senator JOHNSON. So, let me state at the outset I'm not a climate change denier. I'm just not a climate change alarmist. What I am is I'm a debt and deficit, U.S. federal government debt and deficit alarmist, and so I surely align myself with Dr. Leeper. Dr. Leeper, you're talking about the fact that the bond market has been weak for U.S. treasuries.

As the Federal Reserve has been going in to, you know, going into the bond market floating debt, what is the cost to that debt? What is the interest rate they've been paying? On recent debt? I mean is there again, we have a different material levels through the government. Last year on public debt, the cost of that goes about 2.5 percent, correct?

Dr. LEEPER. Yeah, it's gone up.

Senator JOHNSON. Did you know what the cost of our debt was in the last three decades of the last century? 70s, 80s and 90s?

Dr. LEEPER. It was substantially lower. Is that what you're saying?

Senator JOHNSON. I think it was substantially higher wasn't it?

Dr. LEEPER. I'm not sure what you mean by the cost?

Senator JOHNSON. So the interest cost, the interest rate. Again, I want you to describe what a debt crisis is going to look like. As we become less and less credit worthy, as creditors look at the United States and say they may not pay this money back. I'm still loaning the money, but I'm going to ask for a higher interest rate.

And I think that's—I don't think we've factored that into this discussion.

Dr. LEEPER. I think that's correct. And a debt crisis in the United States would first manifest as very high inflation. And the reason for that is because these bonds are denominated in dollars. And they're just a promise to repay in dollars. And if I think that when I get repaid in dollars, the dollars are going to buy fewer goods, then I want to get rid of those bonds today.

And the way I do that is I go out and buy stuff, it raises inflation. And so that would be the first instance, I think.

Senator JOHNSON. So again, we don't focus enough on the numbers here. Again, here we're talking about climate, we can do something about the bond market, which I think is not realistic. I agree with, you know, Dr. Kahn. Last fiscal year 2022 our interest expense was $476 billion. Last year it's $659 billion. A $183 billion increase, 30 percent increase.

According to CBO, in 10 years that expense will be $1.44 trillion. But again, that's an overall average interest rate of 3.1 percent compared to 2.5 percent for last year. I'm not so sure 3.1 percent is a realistic rate. I think that will be way too low.

In 10 years, according to CBO, I think they're low balling. This is rosy scenario. We're going to go from 600—we went from 476 to 659. In 10 years according to CBO, $1.44 trillion and that's a low ball estimate, assuming a 3.1 percent interest rate. What could it be? What's realistic?

And again, I'm looking at—I don't have the exact figures, but I saw one analysis that the last three decades of the last century as something with a 5.3 percent average interest expense on federal debt.

Dr. KAHN. Yeah. And I think that the interest rate will follow the inflation rate, so if we start to see—this is why I'm worried that you cannot rely on the federal reserve alone to get inflation under control. It's as much a fiscal phenomenon as it is a monetary phenomenon.

Senator JOHNSON. So again, if we were to go back, let's say the interest rate rolls to 5 percent, we would be looking at an interest expense of well over $2 trillion.

Dr. LEEPER. Exactly.

Senator JOHNSON. That's what this Budget Committee ought to be focusing on. That's what we ought to be alarmed about, not about how something that you know I've entered into the record that there is no climate emergency. This 1,600 scientists, led by two Nobel Prize winning physicists declared, there's no climate emergency.

We are spending, and by the way what will fuel that debt crisis is when we spend, according to Goldman Sachs, $1.2 trillion on these green energy boondoggles that were passed in the Inflation Reduction Act, that will fuel that deficit. That will increase interest rates. Isn't that a concern?

Dr. LEEPER. I think that's a very serious concern.

Senator JOHNSON. That's all I have. Thanks.

Senator PADILLA. Thank you. Senator Merkley is next.

STATEMENT OF SENATOR MERKLEY

Senator MERKLEY. Awe thank you, Mr. Chairman, and Dr. Hartshorn, we had in 2020 Labor Day fires that burned six of our towns to the ground, and did serious damage to six others. When other similarly situated towns look to issue a municipal bond, are they going to be having to essentially pay a lot higher interest rate as a result?

Dr. HARTSHORN. There is that possibility, depending on how the market perceives their risk relative to how the risk was for the given issuer and the given set of cities that you're actually talking about.

Senator MERKLEY. Yeah.

Dr. HARTSHORN. It's one of the reasons why that dataset that we put together was valuable. It provided a levelized benchmark for to compare risks across all issuers.

Senator MERKLEY. Well, it's just one example. If we look to California where there is much broader swaths of fire, or New Mexico, I cannot imagine the market does not look pretty carefully at the towns situated in those increased fire risk zones. We can pretend that nothing's changing, but the facts are otherwise.

I want to turn, Ms. Kilgore, to the fact that you had mentioned the idea of broadening the definition of municipal bond tax exemption for projects that reach certain climate metrics. Can you give a little example of what that might look like?

Ms. KILGORE. Certainly. Thank you for the question, Senator. My recommendation is when you're looking at governments across the country, I ask myself two questions. Are they motivated? And are they able? And, I have had a number of conversations with local governments who are very motivated to try and move projects forward, but they lack either technical capacity, you know, internal human capacity, or perhaps the opportunity because of constrained revenue sources, to be able to get projects funded in their respective capital plans.

So looking creatively to try and help them with the tools necessary to get those projects moving forward, and opening up some awareness, opportunities, incentivization, investor interest, et cetera, sir.

Senator MERKLEY. Okay. But let me be a little more specific. What type of metric are we talking about? For example, if a city says we want to take all of our municipal buildings and convert them to heat pumps, and can buy renewable energy to power those heat pumps, having a significant decrease in carbon dioxide, would that be something like an example of a metric, like reductions in carbon dioxide that would be used to create such a category?

Ms. KILGORE. Absolutely. And I think there is a good, perhaps bedrock of prior examples with water and sewer efforts across the country to mimic.

Senator MERKLEY. Okay. Mr. Doe, so in the City of Stillwater, Oklahoma, borrowed money to do water projects. And their low-cost provider of the lending was Bank of America. But it turned down Bank of America because Bank of America has an ESG policy. And the result is they are paying $1.2 million more to finance the loan with the next highest bidder.

What does such an ESG policy achieve for the town of Stillwater, other than paying more, delivering less?

Mr. DOE. Well, the ESG, thanks for the question, but the ESG policies and the whole issues around that certainly has become politically weaponized, and what is has is kind of obfuscated the responses of the kind of responsible responses to funding projects to mitigate climate risk, or adaptation risk.

So, to your point, is that yes, I mean that penalty that we are seeing in Oklahoma, we are seeing in Texas as well, is it that has been unfortunate. When the market though has responded in many cases, and again I can't remember the specifics about what the market conditions at the Stillwater issue, but that those bankers that have been—they eliminated from being able to underwrite a deal, have been replaced by other firms, and in some cases there has not been any negative impact at all.

Senator MERKLEY. Yeah. Sometimes there is though, as there was in that case, and if I was a citizen of that town I'd be kind of frustrated that we're paying more for less, especially because Bank of America is financing fossil projects. It is not like they are not willing to be in that space.

I want to turn—well no, I'm down to six seconds, so I will turn it back over to the Chair.

Senator PADILLA. Thank you Senator Merkley. Senator Kennedy is up next.

STATEMENT OF SENATOR KENNEDY

Senator KENNEDY. Thank you, Mr. Chairman. Mr. Doe, as I understand your testimony, you are saying that at some point climate change is going to cause municipal bonds to default. Is that right?

Mr. DOE. No. I would say that they will be under pressure just because of there being increased budgetary concerns.

Senator KENNEDY. Well, can they withstand that pressure?

Mr. DOE. I think so.

Senator KENNEDY. Then what is the problem?

Mr. DOE. The problem is that there might be a higher interest rate if there are issues that are not addressed by state and local governments. That if because of let us just say in anticipation of extreme weather events, that——

Senator KENNEDY. So, you are worried that the interest rates will go up?

Mr. DOE. Yes.

Senator KENNEDY. Okay. I looked on your website. You say, and I quote. I am quoting now, "contribution to the municipal industry has been extensive as an analyst, strategist, and visionary of the industry's future." So, I want to tap your visionary expertise. At what point do you think climate change is going to cause interest rates on municipal bonds to rise to the point that they will—the interest rates will be prohibitive? When will all this happen?

Mr. DOE. Well, I'll dust my crystal ball off, if I perhaps I think in 10 to 20 years.

Senator KENNEDY. 10 to 20 years. Okay. What do you think we ought to do about it?

Mr. DOE. I think we ought to be able to identify where infrastructure is most vulnerable to weather events, and that infrastructure is then—appropriate dollars are used to modernize infrastructure. For example, in the town of Marshfield——

Senator KENNEDY. I want to cut you off because I don't have too much time.

Mr. DOE. Sure.

Senator KENNEDY. Do you think we ought to spend money?

Mr. DOE. Wisely and appropriately.

Senator KENNEDY. Okay. Sure. Well, nobody around here ever stands up and says I have got a good idea, and I need to spend money unwisely and inappropriately.

Mr. DOE. Correct.

Senator KENNEDY. You understand that?

Mr. DOE. I do.

Senator KENNEDY. Okay. Do you support the world becoming carbon neutral by 2050? Would that solve? Do you support that?

Mr. DOE. I don't think that's a reasonable expectation.

Senator KENNEDY. Yeah. But if it were, do you support it?

Mr. DOE. It doesn't seem like it's a bad thing.

Senator KENNEDY. Okay. Do you support the United States becoming carbon neutral by 2050?

Mr. DOE. This may not be possible.

Senator KENNEDY. But do you support it?

Mr. DOE. If it were the right mix of power and energy in order to provide electricity that is needed for essential needs.

Senator KENNEDY. Well, you do understand that that is the goal of the most ardent proponents of climate change, do you not?

Mr. DOE. I do understand that.

Senator KENNEDY. Okay. How much will that cost?

Mr. DOE. I couldn't give a figure to that because it is outside my area of expertise.

Senator KENNEDY. Do you think we ought to just start spending money without an understanding of how much it is going to cost?

Mr. DOE. I don't think that's ever wise.

Senator KENNEDY. Okay. Well, don't you think we ought to look into how much it is going to cost?

Mr. DOE. Again, that's around that area, that's not an area of expertise. I am really focused on addressing the updating of infrastructure for our state and local governments.

Senator KENNEDY. You don't seem to have very many solutions, except what I take away from your testimony is that climate change is going to cause interest rates to rise on municipal bonds, so at some point the cost will become prohibitive, and we need to spend money on infrastructure to stop it. Where do you think this money will—should come from?

Mr. DOE. I think state and local governments have the capacity to borrow because the rates are significantly low, and there is an opportunity now to do so and be proactive.

Senator KENNEDY. So, you think state and local governments ought to borrow the money?

Mr. DOE. I do. I think they have the capacity to do so.

Senator KENNEDY. Just out of curiosity, what kind of car do you drive?

Mr. DOE. I drive a Jeep Wagoneer.

Senator KENNEDY. Is it gas or electric?

Mr. DOE. It's gas.

Senator KENNEDY. Okay. Do you have a gas stove?

Mr. DOE. I do not.

Senator KENNEDY. Okay. Do you have a heat pump?

Mr. DOE. I do not.

Senator KENNEDY. You don't?

Mr. DOE. I do not.

Senator KENNEDY. Oh. Okay. How big a house do you live in?

Mr. DOE. I live in a condominium 853 square feet.

Senator KENNEDY. Okay. I'm over. Thank you, Mr. Chairman.

STATEMENT OF SENATOR PADILLA

Senator PADILLA. Thank you, Senator Kennedy. It is actually my opportunity to ask questions, and I will be followed by Senator Braun. Good morning, and thank you to all the witnesses for your participation today. I am proud to represent California. I know you are familiar with the most populous and diverse state in the nation, and it has been a leader on climate policy across the board.

And in recent years, the urgency has been inspired by 2018, when the campfire devastated the town of Paradise, California,

burning 95 percent of its structures, and claiming 85 lives. I know Senator Whitehouse touched on some of this dynamic earlier in the hearing, but despite federal assistance in the aftermath of the fire, the town has struggled to rebuild, with only ⅓ of the residents that lived there prior to the disaster returning.

This has decimated the local economy, as you can imagine. If you go to the tax base, and a dynamic similar to what Senator Kaine was talking about in his questions, it has resulted in the inability of the Town of Paradise to meet its financial obligations on previously issued municipal bonds.

Right? The revenue is just not there at the moment. This type of systemic risk—financial risk, extends beyond wildfires, and has the potential to affect drought-stricken towns, heat-prone communities, or high-flood-risk areas across the country, all which have the potential to disproportionately impact both agricultural regions, as well as historically underserved communities.

My question is for Mr. Doe. How can the federal government improve support to communities like Paradise to ensure that bond obligations are met, while also ensuring they have the ability to issue future bonds in the process of rebuilding and economic recovery?

Mr. DOE. I think there are two ways. One is regarding the federal government. I think it is making it a priority for issuers of debt that are exposed to climate risk to disclose them appropriately. I think the second thing is that that way you are signaling to investors, and to the broader community of where there is area at risk, and that there are plans that are being made by those state and local governments to address those risks so that they are—when the federal government comes in after a disaster, the federal government is aware that those state and local governments have taken proactive action.

The second thing is that I think the federal government's big role here is to assure that issuers, the state and local governments, that the tax exemption is secure, and that that will continue onward and be an important part of the financing effort, so that state and local governments can plan with confidence and assurance that there will be low interest rates going forward.

Senator PADILLA. Thank you. I know earlier in the hearing there was a suggestion that part of addressing the longer term challenges ensuring that local jurisdictions are doing the appropriate planning, or thinking ahead if you will. Now, municipal bonds can play an important role in funding capital projects that mitigate climate related risks.

However, the up front costs of sustainable development projects are often substantial. This can leave "grain projects" out of reach for rural or underserved communities, limiting their ability to reduce their vulnerability to climate hazards, and it relies on federal dollars.

A question for Ms. Kilgore. Do you agree that the average cost differential for climate adaptation projects can at times be a significant burden for some communities? And how does the federal government help bridge the gap for underserved and vulnerable communities through the Infrastructure Bill or the Inflation Reduction Act?

Ms. KILGORE. Thank you, Senator. I think that sometimes we have to separate out infrastructure that is climate oriented from just the simple word "infrastructure." For us, oftentimes our infrastructure today is inclusive of the technologies, or the materials necessary to plan for the future.

For us, we do have a technical bench of experts to help us, and so when I'm talking to local communities, smaller communities, a lot of times it's that basic knowledge, awareness, education, in the tools to go about successfully employing those different loans.

That is the piece that in my head is the sweet spot where we, as a federal—asking for your support to lean on there.

Senator PADILLA. Is there any additional steps you would recommend that Congress take to incentivize some of the infrastructure spot projects that are specifically geared towards changing weather patterns, or changing climate, frankly?

Ms. KILGORE. I think you said earlier the most beautiful thing about our democracy is state sovereignty; one size fits all rarely works. And so, my sincere request would be to do a really good analysis, and have a data lake if you will, understand the governments across our country, where they are accessing funding. What their risks are at this time, and because until then I don't have an effective answer. I will just say from X percent you are going to be able to grow these types of projects because we don't have right now a holistic viewpoint as to where everyone is in the Nation.

Senator PADILLA. Thank you. Senator Braun.

STATEMENT OF SENATOR BRAUN

Senator BRAUN. Thank you. You know it has been an interesting discussion. We have heard systemic. We have heard I'd like to put an existential along with it, what the thread is currently. I want to give you a few givens. I come from the world of finance. This place, not hardly anyone has had finance 101, or understands the macroeconomics.

And I think the proof is in the pudding. Dr. Leeper has talked about a little bit of that. So, in 2000, that's when Bush took office, we were $5 trillion in debt. So, cumulative up to that point, $5 trillion. Put two R's on the credit card, we're at $10 trillion. Obama comes in.

So from there to 2016, we added $6 trillion more. We're at $16 trillion in 2016. You had the Coronavirus Aid, Relief, and Economic Security Act (CARES) and COVID and structural trillion dollar deficits annually, so we are about $26 to $27 at the end of the Trump years, but never now have we been at the level of where our deficits are close to 5 to 6 percent of our GDP, outside of a reason that would have driven it there.

World War II, savers, investors, we paid it off. Now we're consumers and spenders by nature, and this is the worst place of all that. Have not done a budget in over 20 years, okay. And we have tried to do it in fix and spurts where you had some discipline in there. We unravel it almost as soon as we do it.

Biden has put us out there with a budget. The only place it is publicly out there, $42 trillion in debt in 5 years, $52 trillion, in 10 years. Now, I want to go to Mr. Doe. What is more of an existential threat, 10 to 20 years where climate might drive up interest

rates, which you just told Senator Kennedy, or the behavior of this institution that I think you can extrapolate very easily what's going to be the driver of interest rates.

What do you fear more? Which is more inexorable? Which is more kind of hypothetical?

Mr. DOE. There is no question you have touched on a key issue in terms of the federal deficit and the borrowing that has placed a great deal of risk on the entire U.S. economy, if not the globe. I think one thing I will say about the municipal bond market is that it has been interesting over the last 20 years the average issuance has remained steady at $400 billion.

I think it is a real credit to state and local governments that even though they had the borrowing capability, that they have shown some restraint, but to come back to your point is I don't disagree with you.

Senator BRAUN. So, you feel more comfortable really, with state and localities to probably navigate through whatever we do invest in infrastructure, as opposed to this place that will be borrowed from our kids and grandkids.

Mr. DOE. I do.

Senator BRAUN. That's good to know. You know, the other thing when you look at the reality of this place, you go back over 50 years, we have never been able to tease out more than about 17.5 percent in federal revenues of our GDP. I said earlier that is now up to a deficit of 5 to 6 percent since we have had Bidenomics.

I want to ask Dr. Leeper this question. When it comes to the arithmetic we know that the climate issue is somewhat a bird in the bush in terms of what the financial cost is going to be. Mr. Doe has just said that. How quantifiable is it in terms of this current trajectory of borrowing and spending the modern monetary theory?

Where does that take our country, future generations, at this current pace?

Dr. LEEPER. Thank you very much for the question. One thing I would like to say is that these trajectories that say the Congressional Budget Office regularly produces with exponentially growing debt as a share of GDP, are things that can't happen.

And the reason they can't happen is because people are not going to be willing to absorb all of that debt. The price of that debt is going to get driven down, just as has been discussed about munis. Interest rates are going to take off. Inflation is going to take off.

Senator BRAUN. So, we will be saddled with almost an unbearable interest cost along the way driving by the behavior and actions of the federal government in a nutshell?

Dr. LEEPER. Exactly. Yes.

Senator BRAUN. And I think that is why it begs the question in this Committee, the Budget Committee. Shouldn't we be attending to that? And I can tell you in the 5 years I have been here, Chairman Enzi, who was a Certified Public Accountant (CPA) from Wyoming, attempted to do some of this discussion.

It was too uncomfortable. He didn't do it.

And I have just cited I think the last balanced budget was with the Clinton administration and Newt Gingrich, back in the late 90s. The easiest thing, the chip shot for this place, ought to be to just do a budget, quit borrowing from our kids and grandkids, and

all of this gets mitigated, whether you are dealing with climate, or any other issue that might confront the federal government.

And it sounds like everyone is more comfortable with actually more action being done by the states where there is responsibility, where there is budgeting, than there would be with this outfit. Everybody there, would you raise your hand if you think that makes sense? 3 out of 5 is not bad. Thank you.

Senator PADILLA. Thank you Senator Braun. Seeing no additional Senators here asking questions, we'll begin to bring this hearing to a close. I want to certainly thank the witnesses again for appearing before the Committee today. Their full, written statements will be included for the record.

And as information for all Senators, questions for the record will be due by 12:00 noon tomorrow, with the signed, hard copies delivered to the Committee Clerk in Dirksen in 624. Copies delivered via email will also be accepted. We ask that the witnesses respectfully respond to our questions within 7 days of receiving them. And with no further business before the Committee today, this hearing is adjourned.

[Whereupon, at 11:31 a.m., Wednesday, January 10, 2024 the hearing was adjourned.]

Opening Statement of Chairman Sheldon Whitehouse
Senate Committee on the Budget
Investing in the Future: Safeguarding Municipal Bonds from Climate Risk
January 10, 2024

Welcome to the first hearing of the Senate Budget Committee in 2024 and our twelfth hearing on the looming fiscal dangers of climate change. In the year since we started, climate economic warnings have just gotten worse. We are barreling past warning sign after warning sign.

The facts are bad: last year was the hottest year on record; it set a new record for billion-dollar disasters, including the deadliest wildfire in modern U.S. history, and a new worst for global fossil fuel emissions.

Climate change disrupted global food markets with flooding, persistent drought, and shipping bottlenecks that raised sugar, cocoa, and olive oil prices, as just a few examples, causing climate inflation around the world.

Shattered weather records battered insurance markets: Vermont and New York's once-in-a-thousand-year storms triggered deadly floods. California saw its first-ever Tropical Storm Warning. El Paso had 44 consecutive days at or above 100 degrees, topped by Phoenix's 55 days at or above 110 degrees. The Dallas Fed estimated that the summer heat wave cost Texas $24 billion. Insurance companies are already cutting their losses and exiting markets on the frontline of climate change in Louisiana, Florida, and California.

Follow the real estate economics here: without insurance, it's hard to get a mortgage; and if you can't get mortgages, property markets suffer, causing pain to families, communities, and ultimately the entire U.S. financial system. Look at when 2008's mortgage crisis cascaded into the Great Recession. As this current insurance crisis spirals into a mortgage crisis, and then spills over into housing markets, property values will suffer. The former chief economist at Freddie Mac warned this Committee that in this mortgage crisis, "unlike during the experience of 2007-2008, these homeowners will have no expectation that the values of their homes will ever recover." End quote.

I share my colleagues' debt-and-deficit concern about the "impending budgetary and fiscal crisis facing our nation." One front of that impending crisis is climate change's economic threat — a threat to families, neighborhoods, banks, federal housing lenders, real estate developers, insurers, investors, and to state and local tax bases.

Which brings us to the topic of today's hearing: the $4 trillion municipal bond market.

Municipal bonds—much like the 30-year mortgage—are a bedrock of our American economic system, enabling local governments to make investments that are essential for their communities: basic public services like water service, sewage treatment, electricity, and roads. Local government bonds finance more than 70 percent of U.S. infrastructure, including airports, bridges, railways, and seaports. Climate change now threatens that bond market.

Historically, municipal bonds have a sterling reputation among investors, with default rates of less than one percent. Investors lend their dollars to build a new school or highway and typically receive a tax-exempt stream of interest for the next fifteen or even thirty years. These bonds, secured by government revenues, are among our most stable investments.

Climate change undermines this stability in two ways. More intense storms, wildfires, droughts, heatwaves, and floods impose higher costs on state and local governments, putting pressure on the spending side. And on the revenue side, storm damage and insurance risk can undermine the municipal tax base. Already, climate change is making it harder for municipalities to service their bond payments and making it harder for governments to raise new capital for needed climate investments.

After a disaster, communities' local tax bases can be devastated. Five years after the Camp Wildfire, only a third of the population has returned to Paradise, California. Hurricane Matthew undermined tax bases across small towns in North Carolina. After a disaster, population declines mean revenues decline.

And bond markets are watching; fifteen- or thirty-year municipal bonds start to look less safe. Moody's has already given notice to coastal communities.

This risk comes home to roost in the federal budget. Over 40 percent of our national debt relates back to crises we did not prepare for, like the mortgage meltdown and the covid pandemic. Today, we'll hear more evidence that climate change is just such a crisis — an "impending budgetary and fiscal crisis facing our nation." It could well be the worst yet. We've heard warnings about a coastal property values crash, a similar collapse in wildfire-adjacent areas, a bursting of the "carbon bubble," of turmoil in insurance markets, climate inflation, and now danger to a pillar of American investment. Nothing says this all doesn't come to pass. Ignoring it is akin to financial negligence. If there's one thing we should be able to agree on, it's that we can't afford to be negligent.

UNITED STATES SENATE
BUDGET COMMITTEE
RANKING MEMBER CHUCK GRASSLEY

Opening Remarks by Senator Chuck Grassley of Iowa
Ranking Member, Senate Budget Committee
Hearing titled, "Investing in the Future: Safeguarding Municipal Bonds from Climate Risk"
Wednesday, January 10, 2024

VIDEO

Mr. Chairman,

I wish you, in turn, a happy new year, and to your family as well.

As you would expect, I'm going to say that I've enjoyed the first year we've had, even though we've had some disagreement on the agenda of the committee. And so, I'm going start out where you'd expect me to start out: on the purpose of the Budget Committee and the fiscal problems of our nation.

One of my hopes for the New Year is for this committee to turn its attention to the pressing fiscal challenges we face as a nation. Our unsustainable fiscal outlook is a bipartisan problem and it's going to require a bipartisan solution to resolve.

That was the crux of the letter that Senator [Rick] Scott and I, along with all Republican members of this committee, sent you in December. Your December 7th response suggests you agree that reducing the federal deficit and shrinking the national debt are good ideas. Yet, you rejected our request to hold bipartisan hearings focused on the matter.

Yes, we do disagree on the merits of many policies and proposals. But, for the good of our nation, we must begin to find common ground to address a national debt that recently topped $34 trillion and is growing at an historic pace.

Yesterday, the CBO warned that the federal budget deficit totaled $509 billion in just the first three months of fiscal year 2024. That's $87 billion more than this time last year, despite revenues coming in eight percent higher.

The Treasury Department recently reported that we ran a $1.7 trillion deficit in 2023, larger than all but six deficits recorded since 1946, as a share of GDP.

Now, we know that Fitch Ratings has downgraded our credit rating, and Moody's Investors Service recently placed a negative outlook on the U.S. sovereign credit rating.

This morning, the Budget Committee holds its 13th climate change hearing this Congress. This has prevented us from discussing ways to improve our immediate and dire economic position.

Climate discussion is always worthy of our time as legislators and must be considered, and debated and discussed. But climate change doomsday isn't around the corner. Reasoned adaptation is the key to coping with any climate change.

Today's hearing is about the role of climate change in the municipal bond market.

The $4 trillion municipal bond market is very resilient. According to Moody's, over 99 percent of municipal bonds, issued by cities, school districts, states and other local governments, are categorized as "investment grade."

The infrequency of general government defaults reflects a key feature of state and local governments – that is, they have the power to raise revenue through taxation, unlike their private sector counterparts.

States and local governments understand the risks their jurisdictions face and they are uniquely qualified to so adapt.

Where there've been defaults in municipal bonds, it's been in places that've been mismanaged for decades, such as the city of Detroit. And I haven't looked at Detroit lately, but I think they're making some progress coming out of the hole they dug for themselves.

In fact, according to Moody's, they've never seen a bond they rated default due to natural disasters. This includes the rated bonds of Paradise, California, which suffered near complete destruction in a 2018 California wildfire. Paradise has made every scheduled bond payment.

I agree that municipal bond issuers face challenges. A big one is the extent to which municipalities rely on the federal government for transfers – let's face it, we're broke.

I welcome all of today's witnesses. I look forward to hearing each of your testimonies.

-30-

Written Statement of Thomas G. Doe

President and Founder Municipal Market Analytics, Inc. (MMA)

Before the Senate Committee on the Budget

Wednesday, January 10, 2024

Municipal Bonds & Climate Hearing

Thank you, Chair Whitehouse, Ranking Member Grassley, and Members of the Committee, for inviting me here today. My discussions with state and local sustainability and resilience officers have revealed woeful ignorance regarding the capital market's essential role in financing their climate adaptation needs.

My name is Tom Doe. I founded and am president of Municipal Market Analytics, Inc. (**MMA**) the leading independent research firm in the municipal bond industry. For 30 years the firm's mission has been to assess market risks and opportunities.

Municipal bond issuance can serve as the initiative-taking financing tool to reduce the federal government's burden in responding to catastrophes via the Federal Emergency Management Agency (FEMA). To date, municipal investors have been able to downplay the climate issue because of FEMA's historical presence to backstop areas impacted by extreme weather events and rating agencies' limited credit outlook to a few years into the future. Investors' positive expectations have inhibited issuers' proactive action to reduce the consequences of future climate related risks.

ST	Political Orientation	Adpatation Plan Finalized	ST	Political Orientation	Adpatation Plan Finalized	ST	Political Orientation	Adpatation Plan Finalized
AL	Red	No	KY	Red	No	ND	Red	No
AK	Red	Yes	LA	Red	No	OH	Red	No
AZ	Red	No	ME	Blue	Yes	OK	Red	No
AR	Red	No	MD	Blue	Yes	OR	Blue	Yes
CA	Blue	Yes	MA	Blue	Yes	PA	Blue	Yes
CO	Blue	Yes	MI	Blue	No	RI	Blue	Yes
CT	Blue	Yes	MN	Blue	No	SC	Red	No
DE	Blue	Yes	MS	Red	No	SD	Red	No
DC	Blue	Yes	MO	Red	No	TN	Red	No
FL	Red	Yes	MT	Red	Yes	TX	Red	No
GA	Red	No	NE	Red	No	UT	Red	No
HI	Blue	No	NV	Blue	No	VT	Blue	No
ID	Red	No	NH	Red	Yes	VA	Red	Yes
IL	Blue	No	NJ	Blue	Yes	WA	Blue	Yes
IN	Red	No	NM	Blue	No	WV	Red	No
IA	Red	No	NY	Blue	Yes	WI	Blue	Yes
KS	Red	No	NC	Red	Yes	WY	Red	No
	Source: MMA and Georgetown University							

Figure 1: Adaptation efforts at the federal, state, and local have been slow to evolve. Only 19 states have finalized adaptation plans as of 3Q23 suggesting more effort is required to prompt proactive action.

Agree or disagree with the cause, the earth's warming has occurred just as Dr. Carl Sagan testified to the Senate in December 1985. The Administration and Congress' climate initiatives have been

laudable. However, the federal government has emphasized mitigation over adaptation. And still, as Chair Whitehouse knows, global mitigation efforts to date will not halt the breach of the earth's 1.5 degree warming barrier. As a result, US citizens will rely on state and local governments to execute needed adaptation and resilience measures.

It is fair to characterize the municipal market as the best form of partnership between state, local and federal governments. Municipal bonds have financed seventy-five percent of US public infrastructure. They provide low cost capital for state and local infrastructure needs – both large and small. Since 2004, the municipal market has raised an annual average of $400B for a variety of purposes. Its stability has created investor confidence. Steady regulation has improved the market's integrity. State revolving fund (SRF) programs have served as a shining example for financing future resilience needs.

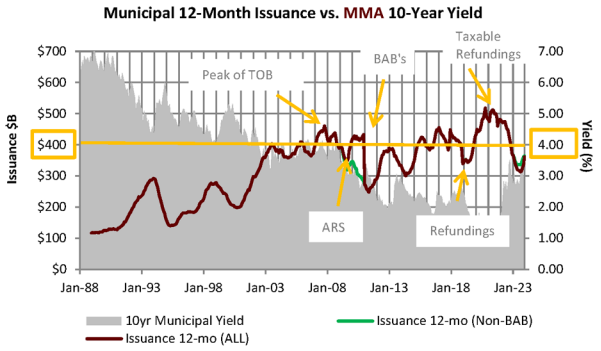

Figure 2: Municipal issuance has averaged nearly $400B annually since 2004. Spikes issuance over $400B (and above $500B) have occurred because of refunding opportunities or specialized demand or federal government programs. Climate needs could push annual municipal issuance above $600B.

With or without Congressional intervention, state and local governments are likely to expand medium– and long-term borrowing programs to address climate change mitigation and adaptation. Because spending needs may be immense (e.g., an unaffordable $1.8B for a temporary solution for the Florida Keys), financing will depend on new revenue creation, sweeping spending reallocations, tiers of intergovernmental participation, and very long bond maturities. A new federal SRF investment, to parallel existing clean water and drinking water programs, would be of great assistance. Regardless, trends are strongly bullish for long-term issuance and income projections, but less so for ratings and relative performance.

The pandemic reiterated that, in the US, the avoidance of taxes is a motivational force for investors. Over the past three years, states with population increases have an average state income tax of ~3%, while those who have lost population have a tax rate of ~7%. Ironically, the movement has been to states that have the greatest climate risks. These areas and elsewhere will need to finance adaptation projects to improve storm water management, provide clean water, cool educational

and healthcare facilities, secure the provision of electricity, and make transportation systems resilient, while also anticipating catastrophic events. Municipals' tax-exemption not only incentivizes high earners to invest in infrastructure but also allows states and localities to allocate capital to where it is most needed.

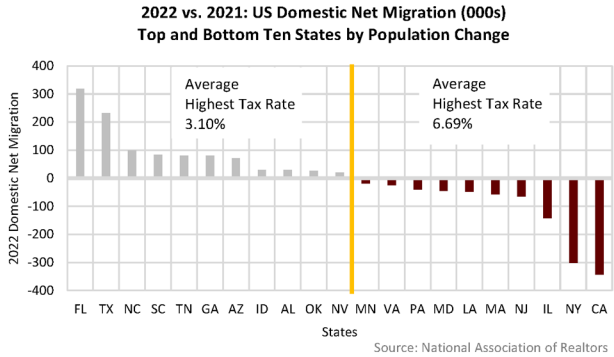

Figure 3: Low state personal income tax coincided with gains in population, while high state personal income tax rates correlated with population losses.

Once again, largely because of FEMA's historical backstop, investors and ratings agencies have not significantly penalized the most climate vulnerable state and local governments with lower prices or ratings. Hence, an absence of a penalty provides a current opportunity for issuers to invest now before a greater investor sensitivity evolves.

Climate change risks and preparedness may become the pension issue for the 2020s. As market participants increasingly integrate climate-risk assessment tools, **MMA** expects analytic outcomes will propel negative rating actions and, eventually, spread widening. Credits in areas most vulnerable to water, wind, and fire-related events are most at risk. An industry pivot could be hastened if FEMA changes its criteria and raises more hurdles between disasters and federal aid, undermining traditional views of FEMA as a credit stabilizer.

Some of the main factors driving climate change higher on the credit concern list include: 1) an uptick in the frequency and severity of climate-related events; 2) efforts by climate change groups to compel a more proactive and explicit assessment in investment decisions and ratings; 3) growth in climate-science technology firms focused on illuminating the impact on municipal governments; 4) more focus on climate risk disclosures by market regulators; 5) the growing federal deficit and how that will constrict federal aid disbursements; and 6) the signing of the Disaster Recovery Reform Act of 2018 (DDRA), which has FEMA working to update the factors considered for disaster declarations to better capture a jurisdiction's own capacity to respond and recover.

For the most part, excessive unfunded governmental pension obligations represent a financial burden and/or stress on future stakeholders in that government. Restructuring pension obligations, reducing other debts or expenditures, and/or raising revenues can be solutions to significantly underfunded pension. While these actions are typically credit negatives, post-restructuring

governments can continue to operate, work to further repair fiscal positions, and retain at least partial market access. Climate-related disasters, on the other hand, have the potential to cause a sustained, non-reversible, erosion of the tax base, or devastate it immediately. A year after the Camp Fire, Paradise, CA's population is ~10% of its pre-disaster size and building permits exist for only a portion of what was destroyed.

Before the Camp Fire, Paradise's heightened risk in terms of both probability and potential financial severity of a wildfire event was identifiable and could have been considered in an investment decision, according to work done by risQ, a leader in modeling and translating climate risk into metrics usable in credit and investment decisions.

The DDRA requires that FEMA initiate rulemaking within 2 years of enactment (October 2020) to update the factors considered when declaring a major disaster, including how it determines the cost to and fiscal capacity of the affected governments. The GAO reports that FEMA documentation indicates that the agency is working on rulemaking proposals that include adjusting the per capita factor for inflation, which would increase the threshold for FEMA assistance and undermines a supportive factor of municipal credit quality vis-à-vis natural disasters. Additionally, Moody's recent report on HUD's increasing role in providing disaster aid highlights further risks to local governments. Under HUD's Community Development Block Grants Disaster Relief program (CDBG-DR) funds for rebuilding and to facilitate recovery are provided via a supplemental appropriation outside of the federal budget process and are often used to augment FEMA funds for large or successive disasters. The increasing frequency and severity of climate-related disasters has led to greater reliance on CDBG-DR funds. But the complexity, inefficiency, and lengthy process required means that disbursements to affected governments often do not arrive in a timely manner, which can negatively impact economic activity, revenues, and credit quality.

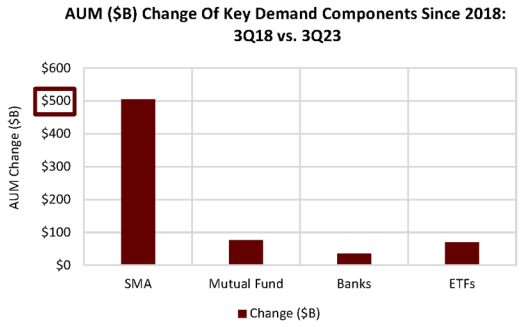

Figure 4: Since 2018, investors have increased their direct holdings of municipal bonds and placed their investments with separate managed account (SMA) managers.

Par (and #) of Outstanding Bonds With Uncured Impairments, Excl. PR Except Where Noted ($M)						Support Detail:
Sector	Last Wk	Impairments	DEFAULT	Support	Other	Bond Reserves
ALL (Inc'l Puerto Rico)	$1,381 (25)	$60,736 (685)	$26,676 (334)	$13,201 (146)	$20,858 (205)	$11,204 (28)
ALL (Exc'l Puerto Rico)	$1,381 (24)	$49,294 (681)	$15,505 (332)	$12,931 (144)	$20,858 (205)	$10,934 (26)
Retirement	$359 (6)	$8,094 (166)	$4,417 (90)	$548 (10)	$3,129 (66)	$431 (1)
IDB	none	$7,664 (56)	$2,734 (33)	$2,124 (9)	$2,806 (14)	$460 ()
Land Secured	$494 (7)	$4,102 (160)	$1,904 (88)	$1,720 (65)	$477 (7)	$1,666 (9)
Local Non-GO	none	$1,888 (16)	$1,560 (5)	$242 (6)	$86 (5)	$141 (1)
Student Housing	none	$1,795 (24)	$941 (11)	$422 (8)	$432 (5)	$422 ()
Hospital	$421 (2)	$12,523 (45)	$790 (8)	$37 (2)	$11,696 (35)	$37 (2)
All Risky Sectors	$1,321 (22)	$44,120 (633)	$13,332 (317)	$10,424 (130)	$20,364 (186)	$8,547 (24)
All Safe Sectors	$60 (2)	$5,175 (48)	$2,173 (15)	$2,507 (14)	$494 (19)	$2,386 (2)
Initially Non-Rated Bonds	$723 (13)	$22,558 (515)	$10,433 (289)	$6,553 (108)	$5,573 (118)	
Initially Rated & Insureds	$658 (12)	$26,736 (170)	$5,072 (45)	$6,378 (38)	$15,285 (87)	
Puerto Ricos	$ (1)	$11,441 (4)	$11,171 (2)	$270 (2)	none	

Figure 5: As of December 2023, there is ~$15B that is in default out of $4T municipal bonds outstanding. An overwhelming amount of defaults are in "risky" credit sectors.

State and local governments have an extremely low default rate, both on an absolute and relative basis. Ninety percent of the $4T public outstanding municipal bond debt is investment grade, suggesting that too great of an emphasis may have been placed on government officials' aspiration for the highest credit rating instead of efficient market utilization. In other words, state and local governments could assume a greater debt burden to address climate risks. Greater debt might result in a possible lower rating today but could put an issuer in a better position to stabilize or improve its future rating. This is admittedly a difficult needle to thread because climate instability poses an unprecedented systemic risk to municipal's hallmark credit quality.

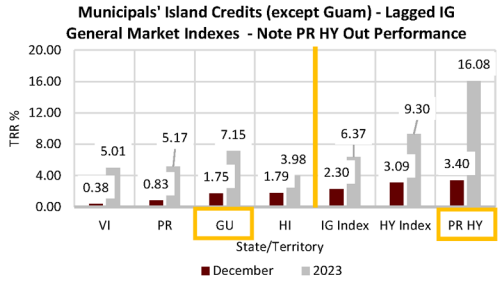

Figure 6: The performance of island credits may reflect some consideration of climate's negative impacts but note that Guam and PR high-yield indexes have outperformed the general market investment-grade and high-yield indexes. Source: Bloomberg

The Committee's prior hearings have revealed data sources to inform investors of climate risks in security offering documents. Fortunately, the Government Finance Officers Association (GFOA) in 2021, led in part by Florida's debt leadership, provided best practice guidance for climate disclosure. Also, the SEC is continually reviewing state and local borrowers' disclosure practices, which have been disappointingly inconsistent or silent regarding climate change's specific risks and the plans to address them. It is egregious that state and local governments' easily quantified

climate risks are not clear to investors who deliver capital and to the federal government who provides the critical subsidy.

Ratings agencies, while investing considerable resources on ESG practices and climate data, have not communicated climate risk as clearly, nimbly, and concisely as needed. The new era will require new practices to better inform investors of climate risks and steps taken by issuers to mitigate those risks. Under Dodd Frank there is a section that addresses "Information from sources other than the issuer" which requires that a rating agency shall consider information from credible sources that are potentially significant to the determination of a rating.

Therefore, the SEC could improve the communication of climate risk to investors, under Dodd-Frank by:

- Require that rating agencies provide in annual disclosures and/or answer questions in annual reviews regarding how the agency systematically considers publicly and privately available climate-related data in its determination of ratings;
- Require the rating agencies to have policies that ensure that rating committees are constructed so that there is sufficient expertise to adequately assess publicly and privately available climate information and determine the level of incremental default risk that should be incorporated in the rating; and
- Require the rating agencies disclose in rating reports the specific climate related risks that were assessed, the climate scenarios used in assessing the risk, the time horizon considered, the impact (positive, negative, neutral) on the rating, and if the time horizon is less than the maturity of the bonds and elongating such would have an impact on the assigned rating, requiring that such be acknowledged in the rating report.

These requirements would reasonably lead the rating agencies to level up their expertise (and focus) in assessing climate risks in the ratings process, highlight risks in the analysis (e.g., time horizon, climate scenarios utilized), and generally improve transparency on the topic.

Environmental risks and costs of adaptation are part of the disclosure gap that exists in available information related to issuers' infrastructure obligations. A lack of information regarding an issuer's unfunded current and future infrastructure adaptation costs means that investors could be underestimating their investment's exposure to future financial and political consequences of a major infrastructure failure or climate change effects. The Municipal Securities Rulemaking Board (MSRB) has issued a request for information (RFI) to better understand the current state of disclosure of risks related to ESG factors and ESG-bond labeling. This inquiry is not terribly surprising as it follows market participants' growing thirst for information on these risks, particularly climate risks.

State or local government's physical asset liability (PAL) is a combination of past funding choices and future funding needs, meaning: 1) historical underinvestment in routine maintenance that jeopardizes future asset use or economic capacity, or its deferred maintenance obligation (DMO); and 2) the estimated prospective costs related to climate adaptation necessary to maintain critical infrastructure and viability of the tax-base, or its climate adaptation obligation (CAO). The CAO is similar to an unfunded pension or OPEB liabilities because those costs will reasonably need to

be incurred, although the range of potential and/or estimated costs are obviously subject to greater variability.

The amount of the nation's ASCE-estimated $2.59T 10-year funding gap for deferred maintenance (DMO) is not allocated to and recognized as a liability on states and local governments' financial statements. Nor is it uniformly disclosed. There is some debate on whether the obligation is a debt (owed to anyone) and therefore relevant to be measured in financial statements; but we'd argue the debt is owed by the governmental entity to the taxpayer to maintain the health, safety, and welfare of those living and operating within its jurisdiction. Information on infrastructure liabilities, both the current DMO and the future CAO, should be part of the disclosure package in bond offering documents and updated through commitments made via continuing disclosure agreements.

To do this successfully, efforts to measure individual governments' PAL related obligations and future costs should be more robust. For the DMO, this should start with an audit of a government's physical infrastructure, condition, and cost to bring it to and maintain it at a reasonable state of repair, similar to the requirements of GASB's modified approach available as an alternative to depreciating capital assets. And, all governments—either on their own or with the guidance of their respective state government—will reasonably need to assess the costs required to preserve their infrastructure and tax-base, the CAO, or the economic implications of not doing so. Once again, the growing research and resources available to assess climate related risks and adaptation costs will reasonably make not knowing this information unacceptable.

I appreciate your invitation to join you today and look forward to your questions and discussion.

APPENDIX

The following is **MMA**'s 2023 analysis of climate disclosure practices in two areas of the country – AZ and TX. Climate disclosure in security offering documents is inconsistent or absent in most cases.

Maricopa Co. AZ

PHOENIX AZ AREA ILLUSTRATES THE INCONSISTENCY OF CLIMATE DISCLOSURE FOR ISSUERS EXPOSED TO SIMILAR RISKS: In May 2023, the Phoenix Civic Improvement Corporation issued bonds for its airport. In the offering statement "climate change impacts" were disclosed. The document outlined the risks not only to the physical infrastructure but also its operation and related economic impact of disruptions caused by severe weather conditions. The paragraph from the offering statement is below:

"The Airport's ability to generate Airport Revenues is at risk from climate change impacts and other force majeure events, such as extreme weather events, wildfires, and other natural occurrences, although the Airport's geographic location reduces some of these risks compared to other large commercial airports. Furthermore, the long-term effects of climate change, combined with the increasing passenger awareness of the climate change impacts of aviation, could reduce demand for travel globally or locally. Increased frequency and intensity of weather patterns, including droughts and fires, may have an adverse impact on the Airport's operations and infrastructure."

Date	Issuer Description	Type	Climate Disclosure	Security Type
01/02/2023	Higley Unified School District No. 60 of Maricopa Co., AZ	Negotiated	None	Certificates of Participation
01/09/2023	Deer Valley Unified School District No. 97 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
01/09/2023	Estrella Mountain Ranch Community Facilities District (City of Goodyear, AZ)	Negotiated	None (Environmental Matters page 28)	Special Assessment
01/10/2023	City of Scottsdale, AZ	Competitive	None	G.O. Unlimited Bonds
01/16/2023	Roosevelt Elementary School District No. 66 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
01/30/2023	Cadence Community Facilities District (City of Mesa, AZ)	Negotiated	None (Environmental Matters page 24)	G.O. Unlimited Bonds
01/30/2023	Eastmark Community Facilities District No. 1 (City of Mesa, AZ)	Negotiated	None (Environmental Matters page 26)	G.O. Unlimited Bonds
02/06/2023	Pendergast Elementary School District No. 92 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
02/13/2023	Salt River Project Agricultural Improvement and Power District, AZ	Negotiated	Substantative	Revenue Bonds
03/06/2023	Cartwright Elementary School District No. 83 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
03/28/2023	Tempe Union High School District No. 213 of Maricopa Co., AZ	Competitive	None	G.O. Unlimited Bonds
04/17/2023	Arizona Board of Regents Arizona State University	Negotiated	None	Revenue Bonds
04/24/2023	Mystic at Lake Pleasant Heights Community Facilities District (Peoria, AZ)	Negotiated	None (Environmental Section pages 30 & 31)	G.O. Unlimited Bonds
05/01/2023	Glendale Union High School District No. 205 of Maricopa Co., AZ	Negotiated	None	G.O. Limited Bonds
05/08/2023	Gilbert Unified School District No. 41 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
05/08/2023	Phoenix Elementary School District No. 1 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
05/15/2023	Phoenix Civic Improvement Corporation, AZ	Negotiated	Substantative	Revenue Bonds
05/22/2023	City of Tempe, AZ	Negotiated	Extensive Drought Disclosure—Appendix - pages A-24 & A-25	G.O. Unlimited Bonds
06/05/2023	City of Litchfield Park, AZ	Negotiated	None	Revenue Bonds
06/05/2023	Madison Elementary School District No. 38 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
06/05/2023	Washington Elementary School District No. 6 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
06/19/2023	Alamar Community Facilities District (Avondale, AZ)	Negotiated	None (Environmental Matters Page 26-27, Water Availability)	G.O. Unlimited Bonds
06/19/2023	City of Maricopa, AZ	Negotiated	None	G.O. Unlimited Bonds
07/24/2023	Fowler Elementary School District No. 45 of Maricopa Co., AZ	Negotiated	None	G.O. Unlimited Bonds
08/07/2023	Verrado District 1 Community Facilities District (City of Buckeye, AZ)	Negotiated	None (Environmental Matters Page 29)	G.O. Unlimited Bonds

Date	Issuer Description	Bond Counsel	Municipal Advisor	Underwriter Counsel
01/02/2023	Higley Unified School District No. 60 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
01/09/2023	Deer Valley Unified School District No. 97 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
01/09/2023	Estrella Mountain Ranch Community Facilities District (City of Goodyear, AZ)	Gust Rosenfeld P.L.C.	Hilltop Securities Inc	Greenberg Traurig LLP
01/10/2023	City of Scottsdale, AZ	Greenberg Traurig LLP	Piper Sandler & Co	None
01/16/2023	Roosevelt Elementary School District No. 66 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
01/30/2023	Cadence Community Facilities District (City of Mesa, AZ)	Greenberg Traurig LLP	Hilltop Securities Inc	Squire Patton Boggs LLP
01/30/2023	Eastmark Community Facilities District No. 1 (City of Mesa, AZ)	Greenberg Traurig LLP	Hilltop Securities Inc	Squire Patton Boggs LLP
02/06/2023	Pendergast Elementary School District No. 92 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Squire Patton Boggs LLP
02/13/2023	Salt River Project Agricultural Improvement and Power District, AZ	Chiesa Shahinian & Giantomas	PFM Financial Advisors LLC	Katten Muchin Rosenbaum LLP
03/06/2023	Cartwright Elementary School District No. 83 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
03/28/2023	Tempe Union High School District No. 213 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	Hilltop Securities Inc	None
04/17/2023	Arizona Board of Regents Arizona State University	Ballard Spahr LLP	RBC Capital Markets	Squire Patton Boggs LLP
04/24/2023	Mystic at Lake Pleasant Heights Community Facilities District (Peoria, AZ)	Greenberg Traurig LLP	PFM Financial Advisors LLC	Snell & Wilmer L.L.P.
05/01/2023	Glendale Union High School District No. 205 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
05/08/2023	Gilbert Unified School District No. 41 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	Piper Sandler & Co	Greenberg Traurig LLP
05/08/2023	Phoenix Elementary School District No. 1 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Greenberg Traurig LLP
05/15/2023	Phoenix Civic Improvement Corpotation, AZ	Greenberg Traurig LLP	Frasca & Associates, LLC	Squire Patton Boggs LLP
05/22/2023	City of Tempe, AZ	Greenberg Traurig LLP	None	Squire Patton Boggs LLP
06/05/2023	City of Litchfield Park, AZ	Greenberg Traurig LLP	None	Snell & Wilmer L.L.P.
06/05/2023	Madison Elementary School District No. 38 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Squire Patton Boggs LLP
06/05/2023	Washington Elementary School District No. 6 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	None	Squire Patton Boggs LLP
06/19/2023	Alamar Community Facilities District (Avondale, AZ)	Greenberg Traurig LLP	Stifel, Nicolaus & Company, Inc.	Squire Patton Boggs LLP
06/19/2023	City of Maricopa, AZ	Greenberg Traurig LLP	Lewis Young Robertson & Burningham, Inc.	Gust Rosenfeld P.L.C.
07/24/2023	Fowler Elementary School District No. 45 of Maricopa Co., AZ	Gust Rosenfeld P.L.C.	Hilltop Securities Inc	Squire Patton Boggs LLP
08/07/2023	Verrado District 1 Community Facilities District (City of Buckeye, AZ)	Gust Rosenfeld P.L.C.	Hilltop Securities Inc	Greenberg Traurig LLP

This data was assembled from publicaly available sources and was compiled with best efforts, but may not be definitive.

Phoenix's climate disclosure prompted **MMA** to examine the offering documents of other Phoenix issuers that raised capital via the municipal market in 2023. The **table above** presents the issuers, issuance manner, whether or not there is climate disclosure, bond counsel, municipal advisor, and underwriter's counsel. The data revealed that issuers with the same climate risks have varied in how the exposure has been articulated, if at all. Historically such variance could be attributed to security type. Perhaps the most interesting is that the two issuers with distinctively complete climate disclosure utilized advisors and counsels that were not often providers of their services to most Phoenix AZ area issuers. Of further curiosity was that Phoenix's bond counsel was also associated with area issuers with similar climate risks that did not provide similar climate disclosure as did the airport deal—an inconsistency. The data suggests a deeper review of procedures, policies and disclosures is merited that could prompt more proactive comment or action by ratings agencies and evaluation services. As the tax-exempt industry has demonstrated over its 100+ year history, it has preferred to respond to crisis rather than to anticipate negative events and adequately inform investors of risks. Such practice is no longer good enough for this new era.

The recent events in HI were preceded by adequate disclosure but were followed by ratings downgrades and sharp security evaluation declines. The question from HI, and as it relates to the Phoenix area issuers (and the industry more broadly), is at what point do ratings agencies and evaluation services shift from reflecting the current conditions and become more proactive in communicating risks and assessing the value associated with potential catastrophes? Because after all, even current conditions at the surface can obfuscate the long-term problems. Is it enough to maintain the status quo or should entities who access the capital markets be held more accountable and responsible for their efforts to (or not to) address quantifiable and known climate risks of the future? Rather than reflecting the comparable transactions to determine the value of a municipal bond in an investor portfolio, should evaluation services factor in the potential and degree of future loss so that holders know the risks they own? HI municipal indexes have suffered significant losses in the wake of the wildfire damage, but should evaluation processes adjust to a potentially more frequent and vulnerable environment? Should investors demand greater accountability from their service providers to incorporate such risks into their valuations? In the case of residential real estate, such risks as wildfire, floods, hurricanes, and environmental waste negatively impact prices of homes assessments so why not for municipal bonds? The industry has a rare opportunity to lead in how to address the complexities associated with climate risk. In fact, it could be argued it has a legal and regulatory responsibility to do so. Such actions could reverberate positively across the financial industry, as well as the regulatory and political landscape.

Harris Co. TX

TX TRUE TO FORM CHOOSES "EXTREME WEATHER" RATHER THAN "CLIMATE CHANGE": **MMA**'s Outlook of August 21, 2023, examined the climate disclosure for this year's issuers from Maricopa Co. AZ. The study revealed an inconsistency at best and absence at worst of the disclosure of risks associated with climate change. In AZ's example, the conditions of greatest concern were extreme heat and sustained drought.

As a next step, **MMA** delved into issues from Harris Co. TX, which included the City of Houston, as well as several state deals. There was not an intention to make a direct comparison to the Maricopa Co. AZ study simply because of the difference in the magnitude and frequency of municipal issuance. Therefore, **MMA** focused on issues that were $100 million or larger, and that came to market in 2023. Of note, both Harris and Maricopa counties are in states that are "red" in their political orientation and have not finalized a state climate adaptation plan. The review of the issues captured the challenge that TX issuers and their counsels have regarding the terminology of "climate change." Most of the issuers chose to provide a laundry list of extreme weather events as a means to disclose risks associated with natural catastrophes. However, this strategy comprises the communication of systemic risks posed by the faster than anticipated changes in the severity of climate change and the persistence of the stresses caused by global warming.

The inevitability of warming temperatures has only exacerbated the risks posed to US infrastructure and particularly TX where in 2023 heat was sustained at higher temperatures and storms demonstrated greater volatility and severity than historically experienced. As winter begins, TX's ERCOT has already issued warnings of potential energy grid failure should temperatures fall below freezing for the 4th consecutive winter. TX's weather extremes and unsatiable demand for electricity have and will continue to test the state's vulnerable infrastructure.

TX has demonstrated a defensive posture in its approach toward the climate issue in order to protect the state's critical economic relationship with the oil and gas industry. Sadly, the perspective that an acknowledgement of climate risks necessitates an obfuscation strategy with regards to the fossil fuel industry is a disservice to the protection of the state's citizens and development of stabilizing strategies for modernizing infrastructure in order to adapt to a new era of "extreme weather." There were two issuers that did mention "climate change" and three issuers which chose to avoid the broader issue of weather completely. The TX and AZ issues' review highlighted the regional, societal, and political dynamics that investors must consider when purchasing a municipal security and a want for regulatory intervention to improve processes.

Date	Issuer Description	Type	Moody's	S&P	Climate Disclosure	Security Type
01/09/2023	Tomball Independent School District, TX	NEGT	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
01/23/2023	Spring Independent School District, TX	NEGT	Aa2	AA-	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
02/13/2023	Houston Independent School District, TX	NEGT	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Limited Bonds
02/13/2023	Lower Colorado River Authority, TX	NEGT		A	Extreme Weather Events Disclosure	Revenue Bonds
02/27/2023	TX Department of Housing & Community Affairs	NEGT	Aaa	AA+	None	Revenue Bonds
03/06/2023	TX Natural Gas Securitization Finance Corporation	NEGT	Aaa		Mentions Climate Change	Revenue Bonds
03/06/2023	Board of Regents of the Univ. of TX System	NEGT	Aaa	AAA	Mentions Potential Natural Disasters	Revenue Bonds
04/24/2023	Katy Independent School District, TX	NEGT	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
05/15/2023	Harris Co.TX Industrial Development Corporation	NEGT	Baa3	APPLIED	Mentions Potential Natural Disasters	Revenue Bonds
06/05/2023	Harris Co., TX Toll Road First Lien Rev	NEGT	Aa2		Extreme Weather Events Disclosure	Revenue Bonds
06/19/2023	Harris Co. Flood Control District, TX	NEGT	Aaa		Extreme Weather Events Disclosure	G.O. Limited Bonds
06/26/2023	Houston, TX Airport System Subordinate Lien Rev Ref	NEGT	A1		Extreme Weather Events Disclosure	Revenue Bonds
06/27/2023	Klein Independent School District, TX	COMP	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
06/28/2023	State of TX	COMP	Aaa	APPLIED	None	G.O. Unlimited Bonds
07/31/2023	Grand Parkway Transportation Corporation, TX	NEGT	Aa1		Extreme Weather Events Disclosure	Revenue Bonds
07/31/2023	TX Private Activity Bond Surface Corporation	NEGT	Baa1		Extreme Weather Events Disclosure	Revenue Bonds
08/07/2023	Harris Co., TX Perm Impt Ref & Unltd Tax Road Ref	NEGT	Aaa		Extreme Weather Events Disclosure	G.O. Limited Bonds
08/07/2023	Port of Houston Authority of Harris Co., TX	NEGT	Aa3	AA+	Mentions Climate Change	Revenue Bonds
09/04/2023	Pasadena Independent School District, TX	NEGT	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
09/25/2023	TX Water Development Board	NEGT		AAA	Extreme Weather Events Disclosure	Revenue Bonds
10/09/2023	Houston, TX Public Impt & Ref	NEGT	Aa3		Extreme Weather Events Disclosure	G.O. Limited Bonds
10/16/2023	North TX Tollway Authority	NEGT	Aa3	AA-	Mention Air Quality Control Requirements	Revenue Bonds
10/23/2023	Cypress-Fairbanks Independent School District, TX	NEGT	Aaa	AAA	Extreme Weather Events Disclosure	G.O. Unlimited Bonds
10/23/2023	TX Public Finance Authority	NEGT		AAA	None	G.O. Unlimited Bonds

Date	Issuer Description	Bond Counsel	Municipal Advisor	Underwriter Counsel
01/09/2023	Tomball Independent School District, TX	Orrick, Herrington & Sutcliffe LLP	BOK Financial Securities, Inc.	Bracewell LLP
01/23/2023	Spring Independent School District, TX	Bracewell LLP	Post Oak Municipal Advisors LLC	Orrick, Herrington & Sutcliffe LLP, and The Bates Law Firm PLLC
02/13/2023	Houston Independent School District, TX	Orrick, Herrington & Sutcliffe LLP	Estrada Hinojosa & Company, Inc.	Cantu Harden Montoya LLP, and Kassahn & Ortiz PC
02/13/2023	Lower Colorado River Authority, TX	McCall, Parkhurst & Horton LLP	Specialized Public Finance Inc.	Bracewell LLP
02/27/2023	TX Department of Housing & Community Affairs	Bracewell LLP	Stifel, Nicolaus & Co., Inc.	Chapman and Cutler LLP
03/06/2023	TX Natural Gas Securitization Finance Corporation	Norton Rose Fullbright US LLP	Estrada Hinojosa & Company, Inc.	Orrick, Herrington & Sutcliffe LLP
03/06/2023	Board of Regents of the Univ. of TX System	Bracewell LLP	N/A	Orrick, Herrington & Sutcliffe LLP and Kassahn & Ortiz, PC
04/24/2023	Katy Independent School District, TX	Orrick, Herrington & Sutcliffe LLP	Hilltop Securities Inc.	Bracewell LLP
05/15/2023	Harris Co.TX Industrial Development Corporation	Bracewell LLP	N/A	Hunton Andrews Kurth LLP
06/05/2023	Harris Co., TX Toll Road First Lien Rev	Greenberg Traurig LLP	Masterson Advisors LLC, and TKG & Associates LLC	McCall, Parkhurst & Horton LLP and Baker Williams Matthelsen LLP
06/19/2023	Harris Co. Flood Control District, TX	Holland & Knight LLP and The Bates Law Firm, PLLC	Masterson Advisors LLC, and TKG & Associates LLC	McCall, Parkhurst & Horton LLP and Levi Benton & Associates PLLC
06/26/2023	Houston, TX Airport System Subordinate Lien Rev Re	Bracewell LLP and West & Associates, LLP	Masterson Advisors LLC and The RSI Group LLC	McCall, Parkhurst & Horton LLP and Levi Benton & Associates PLLC
06/27/2023	Klein Independent School District, TX	Bracewell LLP, The Bates Law Firm PLLC, and Spalding, Nichols, Lamp, Langlois LLP	RBC Capital Markets, LLC	N/A
06/28/2023	State of TX	McCall, Parkhurst & Horton LLP	Hilltop Securities Inc.	N/A
07/31/2023	Grand Parkway Transportation Corporation, TX	McCall, Parkhurst & Horton LLP	Estrada Hinojosa & Company, Inc.	Locke Lord LLP, and Cantu Harden Montoya LLP
07/31/2023	TX Private Activity Bond Surface Corporation	McCall, Parkhurst & Horton LLP	Sperry Capital Inc.	McGuireWoods LLP
08/07/2023	Harris Co., TX Perm Impt Ref & Unltd Tax Road Ref	Bracewell LLP, and West & Associates, LLP	Masterson Advisors LLC and TKG & Associates LLC	Haynes and Boone, LLP and Bratton & Associates, PLLC
08/07/2023	Port of Houston Authority of Harris Co., TX	Greenberg Traurig LLP, and Baker Williams Matthiesen LLP	PFM Financial Advisors LLC and TKG & Associates LLC	Orrick, Herrington & Sutcliffe LLP and Hardwick Law Firm, LLC
09/04/2023	Pasadena Independent School District, TX	Jackson Walker LLP	BOK Financial Securities, Inc.	Bracewell LLP
09/25/2023	TX Water Development Board	McCall, Parkhurst & Horton LLP	Hilltop Securities Inc.	Orrick, Herrington & Sutcliffe LLP
10/09/2023	Houston, TX Public Impt & Ref	Bracewell LLP and Burney & Foreman	Masterson Advisors LLC and The RSI Group LLC	Holland & Knight LLP
10/16/2023	North TX Tollway Authority	McCall, Parkhurst & Horton LLP, and Locke Lord LLP	Hilltop Securities Inc., Estrada Hinojosa & Co., Inc, and RSI Group LLC	Bracewell LLP, and West & Associates
10/23/2023	Cypress-Fairbanks Independent School District, TX	Bracewell LLP	Post Oak Municipal Advisors LLC	Jackson Walker LLP
10/23/2023	TX Public Finance Authority	McCall, Parkhurst & Horton LLP	RBC Capital Markets, LLC	Greenberg Traurig LLP

Prepared Testimony of Megan Kilgore
City Auditor
City of Columbus, Ohio

Municipal Bonds & Climate Hearing
United States Senate Committee on the Budget
January 10, 2024

Chairman Whitehouse, Ranking Member Grassley, and distinguished Members of the Committee: Thank you for inviting me here today.

My name is Megan Kilgore. This year marks my twentieth year in the public finance industry. For the last six years, I have had the privilege of serving as the elected City Auditor of the City of Columbus, Ohio. My office is responsible for debt issuance, capital planning and rating agency strategy, and investor relations. I am proud to say that we are the largest city in America to maintain the highest ratings possible — AAA/Aaa/AAA from S&P Global, Moody's Ratings, and Fitch Ratings, respectively.

Prior to my elected service, I worked as a municipal financial advisor, helping clients such as cities, counties, school districts, and community colleges determine how best to finance their infrastructure.

Any time we have a major initiative in our industry, local governments ask a number of good questions: why, how, what, when, and who will pay for it. In my conversations, the "why" has been fairly evident and local governments are becoming increasingly aware of the economic and societal risks of climate change.

The remaining questions are where I'd like to focus my time today, as my objective is to leave this Committee with solutions for increasing climate-oriented project financing and implementation — both mitigation and adaptation.

To date, of the hundreds and hundreds of bond issues I've worked on, I have not issued, nor have I advised that a client issue, bonds that are designated as "green", even if the projects could earn that designation. The primary reason for that is lack of definitive financial benefit.

I have also not found there to be any incentive from a rating agency standpoint — "green" debt is still considered debt, and carries no credit quality advantage. In other words, municipal debt that is financing a renewable energy project with sizable long-term economic benefit is on parity with a community pool. Our objectives are to get the best deal possible and maintain affordability for our residents, so in addition to traditional municipal debt, we also consider available federal funding.

The good news is that there are incredible levels of federal programs available today. The IRA, programs like WIFIA[1], TIFIA[2], rural-specific programs, and numbers of other acronyms exist, but we lack a user-friendly resource that wholly connects the dots. I can attest that even a large Triple-A like Columbus, with a deep bench of experts, has difficulty working through this complexity, let alone many of my former clients who lack financial and technical resources.

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[1] The United States Environmental Protection Agency's Water Infrastructure Finance and Innovation Act (WIFIA)
[2] The United States Department of Transportation's Transportation Infrastructure Finance and Innovation Act (TIFIA)

So, how do we get these necessary projects underway? I'd like to share opportunities I see that could eliminate barriers to local governments' participation in more climate-oriented projects.

1) **Provide clear financial incentives for both local governments and investors.** For instance, consider broadening the definition of municipal bond tax-exemption for projects that reach certain climate metrics and growing climate-related opportunities with Private Activity Bonds (PABs).

2) **Help local governments overcome human capacity barriers by creating a federal office to serve as the single point of knowledge.** There are over 50,000 local governments that issue debt, making it incredibly difficult to generate transformational change using a one-size-fits-all approach. I am inspired by how the websites *America is All In* and *Rewiring America* have done this by using technology to create highly personalized tools that estimate, for instance, how much money homeowners can save by employing clean technologies, which types of tax credits the homeowner is eligible for, and how to go about applying.

   Similar to President Eisenhower's Public Roads Administration, we need a one-stop-shop to help local governments with project analyses, regional design, implementation, as well as a place to collect, analyze, and communicate information regarding grant, loan, and financing sources and uses.

   Just imagine if such a single source of information was available to my small hometown on the Ohio River; a site where users could see their location-specific estimates of physical climate risk exposure, alongside potential economic loss, types of projects that would best benefit that area, and corresponding funding opportunities.

3) **Help smaller and lower-credit communities achieve total funding needs.** I saw a lot of success with the Super-BAB-type structure (the Recovery Zone Economic Development Bonds created by the American Recovery and Reinvestment Act of 2009). Such a reinvented program could help these local governments — especially those seeking last mile funding — use bonds to spread the costs of projects over a reasonable number of years, while keeping affordability in check.

The solutions I see are big, transformative, and require our federal government to take action at a scale commensurate with the opportunities before us. Please know that I stand ready to do what I can to support this effort. Thank you again for the opportunity to testify and I look forward to continued conversation.

Prepared Testimony of Chris Hartshorn
Advisor
Zeus AI (among others)

Municipal Bonds & Climate Hearing
United States Senate Committee on the Budget
January 10, 2024

Good morning, Chairman Whitehouse, Ranking Member Grassley, and Members of the Committee. Thank you for inviting me to testify at this hearing to explore the implications of climate risk on the municipal bond market. It is an honor to do so, and to represent the hard work of many colleagues and collaborators.

My name is Chris Hartshorn, and currently I serve as an advisor to numerous environmental data science-enabled starts-ups focusing on nature and biodiversity, carbon credits and markets, and a NASA spin-out focused on next generation weathering modeling and forecasting. I also advise a venture capital firm that has most recently closed a fund focused on decarbonization of hard to abate industries, wherein the limited partners are comprised of corporations from those very industries, as well as a start-up developing a new carbon capture material.

More relevant for this hearing were my many years fully dedicated to building two start-ups focused on climate risk to US fixed income debt instruments, risQ and Level 11 Analytics, both now acquired by Intercontinental Exchange. risQ, in particular, became the leading provider of physical climate risk data for the municipal bond market and a large number of its participants.

I'd note at the outset how much of the discussion at this committee's July 26th, 2023 hearing on The Fiscal Consequences of Climate Change on Infrastructure is pertinent here, given how much infrastructure is provided as a part of municipal services. The insights of that hearing don't need my regurgitation. It is important to note, however, that the municipals as defined by the *municipal bond market*, rather than "just" cities or the infrastructure discussed that day, is a vast diaspora of overlapping debt issuers covering states, counties, utilities, school districts, transit systems, airports, hospital systems, charter schools, retirement communities, cities and many more. The implications of climate-mitigative, -adaptive and -resilient actions to the population are even broader and starker under this financial market municipal definition.

With respect to climate risk, it is easiest to conceptualize property-destroying, evacuation-invoking perils - hurricanes, wildfires, floods, and the like - as these "acute" events happen quickly, catalyze local and often federal emergency responses, have quantifiable economic consequences and replacement costs, and leave single name scars – Katrina, Sandy, Paradise – to name just three. The National Oceanic and Atmospheric Administration (NOAA) documented 25 such acute events in the US each with at least $1 billion in costs in 2023 – a CPI-adjusted record for any year.[1]

Climate risks are clearly material to municipal finance. Taking wildfires as one example, in the five years after a fire the net fiscal effect of wildfires on a municipality is a decline in excess revenues of $97 per capita – equivalent to 10.7% the per capita budget size – and a 25% increase in the probability of a budget deficit.[2] For hurricanes, local governments experience significant declines in revenues, expenditures, and debt in the 10 years after a hurricane strike. These declines are initially offset by intergovernmental transfers in the immediate aftermath of a hurricane but ramp up significantly after 6–10 years post hurricane.[3] The impacts of past floods – inland and coastal – also litter the Official Statements of the bond issuing community. In our own analysis over multiple years of each week's bond offerings to the market and the Preliminary Official Statements from issuers that accompany them, we saw case after case where the financial remnants of floods and hurricanes could be seen, and where impacts on population size and property – two of the critical indicators for revenues for the bond issuers – where apparent.

Across the key acute perils, rebuilding costs have been underpinned by FEMA DRF funding that has been on an admittedly bumpy but nonetheless upward trajectory over recent decades.[4] Another key constituent has been property insurers that help reestablish the property value; the taxes thereon are a key revenue stream from which debt servicing of municipal general obligation bonds occurs. It is noteworthy, therefore, that in many higher climate risk states – Florida, Louisiana, California – that major insurers are withdrawing from those markets,[5] and those that remain are ramping up policy premiums, an outcome that will inevitably lead to a decrease in coverage, and anecdotally already has. The diminishing of this historically critical pillar of past disaster recovery will only heighten the post-disaster financial pressure on the municipal (and federal) system. Relatedly, the impact of insurance coverage and costs flows through to mortgages and even further into the financial system via mortgage-backed securities (MBS). risQ and Level 11 Analytics were also providing climate risk data to the US fixed income investor community for agency and non-agency residential MBS debt instruments.

Other perils must also be accounted for which the impacts are more "chronic" in nature: heat, drought and even sea level rise on water supply in many coastal areas. Heat is a good example to focus on given we just experienced the hottest year on record globally, with July 2023 the hottest month ever recorded,[6] and cities such as El Paso and Phoenix shattered records for consecutive days above 100 ºF and 110 ºF, respectively.[7]

This is a critical issue across much of the municipal US, for the health and safety of their served populations and the municipal workforce, and for municipal infrastructure. Mitigating the impacts of urban heat islanding is an active effort for many cities including my own hometown of Boston, and no doubt top of mind for the Chief Heat Officers in the likes of Phoenix, Los Angeles and Miami Dade county. Municipal sectors beyond just cities and counties also feel this heat. At extreme temperatures, not only are airport personnel at greater risk but aircraft aerodynamics can be negatively impacted.[8] At least one credit rating agency I am aware of has expressed interest in heat projections for airports over time.

School districts' exposure to heat risk may be a greater systemic risk, noting that September, the start of the typical US school year, also set new records in 2023 according to the NOAA.[9] My former colleagues at risQ have published a comprehensive study focused on this very topic.[10] Temperature has been shown to have a direct impact on educational performance.[11] In schools without functioning air-conditioning, a 1 ºF hotter school year reduces test scores by 1% of the expected learning gain for that year, and notably on a given day once daytime heat indexes exceed only 80 ºF. By some estimates, around $40 billion of new air conditioning installation is required across US K-12 schools to address this.[12] As an example of the gap that exists, when the Department of Energy awarded the first tranche of grants through its Renew America's Schools program in 2023, over 1,000 concept papers, totaling nearly $5.5 billion in requests were received.[13] Close to 90% of selected proposals included HVAC upgrades. In one such case, a $2 million grant to Natick School District augmented $627K of its own funding.[14]

As always, funding represents a bottleneck and catalyst. Improved access to debt is one critical path to explore. As of January 1, 2024, K-12 public school districts represent around 15% of the total municipal bond market.[15] Access to debt has been shown to improve K-12 educational outcomes in general,[11] but there is now potentially a climate-driven educational performance imperative to add to this funding vs outcome mix.

There are already proven mechanisms for lowering the cost of such debt: school districts in states without credit enhancement programs could have saved between $383 million and $1 billion in debt service payments from 2009 to 2019 if their states had enhancement programs.[16] It is noteworthy that states with such enhancement programs very rarely experience negative fiscal side-effects of doing so. Such credit enhancement mechanisms also have current precedent at the federal level for charter schools, another sector within the municipal bond issuer universe.

In reality, any combination of a given climate peril and a given sector within the municipal universe can be explored for underlying materiality, but the themes of climate risk, trajectory of risk and cost implications would remain. More broadly, and critically, mitigation funding can save the nation $6 in future disaster costs, for every $1 spent on hazard mitigation.[17] That 6x multiple needs to be seen in the context the American Society of Civil Engineers (ASCE) estimate that the infrastructure deficit in the US is around $2.59 trillion over the next 10 years, or about $259 billion per year.[18] The question is how to maximize those upfront dollars for an adaptive and resilient municipal sector versus continuing to spend a multitude more on post-event recovery and where dollars for doing so are increasingly stretched.

This, of course, sets aside a still broader question of how the different sectors and jurisdictions within the municipal bond issuing community – with all their regiospecific idiosyncrasies – prepare for and participate in a transition away from fossil fuels, the need for which was unanimously agreed to at COP28 in December 2023.[19] Commercial buildings are responsible for approximately 17% of the total energy consumed in the US.[20] Local government alone represents more than 10% of total commercial building ownership across the country, and state government adds a further 1/3 to this number.[21] These amounts exclude significant building

occupying sectors also operating within the municipal bond issuing universe. Transportation represents 37% of the total energy consumed in the US,[22] a number in which municipal bond issuing influence is clear via mass transit availability and fleets, road infrastructure and investment, zoning decisions (that influence urban density vs sprawl), and broader issues of urban design and use. In this regard, high resolution geospatial data is now available to city planning and project siting decision makers to optimize any given decarbonization strategy.[23] There is also obvious interaction to be found between physical climate risk, carbon transition, housing affordability in decisions within municipal purview.[24] It is also important to remember that utilities themselves represent a non-trivial sector of debt issuance within the municipal bond market.[25] Finally, local governments also need to consider the potential impacts of any given carbon transition path on their own revenue streams and local economies, a topic we initially explored at risQ and put in the context of potential financial risk.[26]

This does not need to be a monolithic draw on the federal purse. The municipal bond market has held steady at $3.8-$4.1 trillion over the last 15 years,[27] but that apparent stasis is misleading. There is willing capital just sitting on the sidelines. In the multitude of municipal bond conferences I – and colleagues - have attended, and conversations with many more clients also show, there is more demand for municipal bonds than there is supply. Prospective municipal debt issuers are often reluctant to take on more debt to address these infrastructure needs, often driven by the perception that they might get penalized by credit rating agencies for being over leveraged – but so many, almost all, large metros in good standing could still borrow money at a AAA interest rate and meet the investment grade requirements of a large swath of the municipal bond investor market. This is without the extra fuel of aforementioned enhancement programs or relevant support mechanisms such as the The Clean Water State Revolving Fund or the Building Resilient Infrastructure and Communities grant program.

Again, thank you for the opportunity to address the critical issue of climate and municipals. I look forward to addressing any questions the committee may have.

1 https://www.ncei.noaa.gov/access/billions/time-series
2 Liao, Yanjun and Kousky, Carolyn, The Fiscal Impacts of Wildfires on California Municipalities (September 24, 2021). Liao, Y., & Kousky, C. (2022). The fiscal impacts of wildfires on california municipalities. Journal of the Association of Environmental and Resource Economists, 9(3), 455-493.
3 Rhiannon Jerch, Matthew E. Kahn, Gary C. Lin. (2023). "Local public finance dynamics and hurricane shocks", Journal of Urban Economics, 134
4 https://www.cbo.gov/publication/58840#:~:text=(In%20this%20section%20of%20the,roughly%20%2412%20billion%20a%20year.
5 https://www.nytimes.com/2023/11/01/climate/climate-insurance-disasters-senate.html
6 NOAA data
7 https://abcnews.go.com/US/2023-year-record-heat-temperatures/story?id=105555594
8 https://news.climate.columbia.edu/2017/07/13/surging-heat-may-limit-aircraft-takeoffs-globally/
9 https://www.noaa.gov/news/topping-charts-september-2023-was-earths-warmest-september-in-174-year-record
10 https://www.ice.com/publicdocs/Insights-_The_link_between_access_to_U.S._municipal_debt_and_socioeconomic_outcomes.pdf
11 Park, R. Jisung, Joshua Goodman, Michael Hurwitz, and Jonathan Smith. 2020. "Heat and Learning." American Economic Journal: Economic Policy, 12 (2): 306-39.
12 https://coolingcrisis.org/findings
13 https://www.energy.gov/scep/renew-americas-schools-grant
14 https://www.scientificamerican.com/article/extreme-heat-threatens-student-health-in-schools-without-air-conditioning/
15 ICE Data Services data
16 Yang, L. (2022). School District Borrowing and Capital Spending: The Effectiveness of State Credit Enhancement. Annenberg Institute at Brown University, EdWorkingPaper: 22-663.
17 Per the United Nations: https://press.un.org/en/2019/sgsm19807.doc.htm
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19 https://www.un.org/sg/en/content/sg/statement/2023-12-13/secretary-generals-statement-the-closing-of-the-un-climate-change-conference-cop28?_gl=1*1htprug*_ga*MTM3MDEzOTE0NC4xNzA0Mzk4Nzcx*_ga_S5EKZKSB78*MTcwNDY0MTI4NC4xLjEuMTcwNDY0MTQ0OC42MC4wLjA.*_ga_TK9BQL5X7Z*MTcwNDY0MTI4NC4yLjAuMTcwNDY0MTI4NC4wLjAuMA..
20 Per the U.S. Energy Information Administration in https://www.eia.gov/tools/faqs/faq.php?id=86&t=1
21 Per the U.S. Energy Information Administration in https://www.eia.gov/todayinenergy/detail.php?id=27972
22 Per the U.S. Energy Information Administration in https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy_2022.pdf
23 https://www.crosswalk.io/use-cases
24 https://risq-inc.medium.com/wildfires-housing-affordability-and-climate-change-virtuous-cycle-or-death-spiral-ca53758965c9
25 Per the American Public Power Association in https://www.publicpower.org/policy/municipal-bonds-and-public-power
26 https://risq-inc.medium.com/us-carbon-transition-risk-the-highwire-act-of-municipal-credit-impairment-and-climate-justice-c42717faff2e
27 Per SIFMA: https://www.sifma.org/resources/research/fixed-income-chart/

STATEMENT OF
DR. MATTHEW E. KAHN
to the COMMITTEE ON the BUDGET
of the UNITED STATES SENATE

HEARING on
Investing in the Future: Safeguarding Municipal Bonds from Climate Risks
10 January 2024

Does climate change pose a major risk for America's municipal bond sector? My short answer is "no". My optimism is based on two points. First, global greenhouse gas emissions are likely to rise but the pessimistic RCP8.5 model scenario over-states likely future global emissions growth.[1] Second, our economy's capacity to adapt to emerging climate risks will vastly expand in the coming decades.[2]

Bond buyers have an incentive to do their "due diligence". If a municipality faces rising climate impacts that imperil its ability to repay debt, bond buyers will recognize this and they will offer lower prices for bonds. Places that fail to adapt to new risks will thus pay higher interest rates and insurance rates. While bond defaults are rare, there have been high profile cases such as Detroit's default in 2013.[3]

To see why climate risk does not imperil the financial system via municipal bond defaults, let's play out a hypothetical Doomsday Scenario. What does it take for a "climate event" to cause a financial crisis?

A Doomsday Scenario

The year is 2034. Over the last decade, the climate has gotten worse, storms are more frequent. The city of Chicago issues new bonds each year. A new batch of bonds are rated at Baa3/BAA- (i.e., the lowest notch in the investment grade category) and the majority of the bonds are purchased by a hedge fund. While well below the median bond rating for a municipal bond of

[1] Kahn, Matthew E., and Somik Lall. *Will the Developing World's Growing Middle Class Support Low Carbon Policies?*. No. w30238. National Bureau of Economic Research, 2022.
https://www.budget.senate.gov/imo/media/doc/Dr.%20Roger%20Pielke%20-%20Testimony%20-%20Senate%20Budget%20Committee.pdf
https://www.aei.org/wp-content/uploads/2022/06/Zycher-comment-SEC-climate-risk-disclosures-file-S7-10-22-RIN-3235-AM87-6-17-2022.pdf
[2] Anderson, Sarah E., Terry L. Anderson, Alice C. Hill, Matthew E. Kahn, Howard Kunreuther, Gary D. Libecap, Hari Mantripragada, Pierre Mérel, Andrew J. Plantinga, and V. Kerry Smith. "The critical role of markets in climate change adaptation." *Climate Change Economics* 10, no. 01 (2019): 1950003.
[3] Holian, Matthew J., and Marc D. Joffe. "Assessing municipal bond default probabilities." *Available at SSRN 2258801* (2013).

around Aa3/AA-, the hedge fund is familiar with the financial woes of Chicago. It thinks these bonds are a good opportunity to earn high returns.[4] This hedge fund uses the City of Chicago bonds as collateral to borrow at a short term low interest rate from banks.

Suppose that an unprecedented storm strikes the City of Chicago in mid-2034. This storm floods the city and tax revenue plummets as this becomes the straw that breaks the camel's back, following years of financial mismanagement and crime waves and warnings from credit rating agencies. Tourists do not visit the city and work dinners and office hotels are vacant. Sports teams relocate to safer jurisdictions. Major firms depart for other locations. Suppose that the storm also severely impacts other areas in the Midwest and the local service economy stalls out. Local infrastructure is overwhelmed such that the power supply and water treatment systems and roads are left heavily damaged.

As the short run damage from the shocks materialize, the governor of Illinois and the federal government chooses not to offer disaster relief to the city. Further, Chicago's feature powerful public sector unions refuse to take a short term earnings reduction to help balance the city's short run budget. Rating agencies see the federal government's refusal to step in and bail out the people of Chicago as a sign the city will be unable to repay its debts and the raters embark on a series of bond grade downgrades. This once mighty city comes to a decision point.

Chicago chooses to default on repaying all of its municipal debt. This causes downstream consequences. The hedge funds who own the bonds go under. Banks who lent them money now own worthless collateral and they fail. Still, only a few banks have failed. Suppose depositors at other banks, worried about hidden risks, run. For some reason, the federal government does not bail out the banks or depositors. Finally, we have a crisis.

An Economic Critique of the Doomsday Scenario

Based on my ongoing research in urban and environmental economics, I reject this Doomsday Scenario. Starting with my 2010 book Climatopolis: How Our Cities will Thrive in Our Hotter World and my 2021 book; Adapting to Climate Change: Markets and the Management of an Uncertain Future. I have argued that free market competition protects our economy from place-based extreme weather risks.

My critique has six sections.

[4] Longstaff, Francis A. "Municipal debt and marginal tax rates: Is there a tax premium in asset prices?." *The Journal of Finance* 66, no. 3 (2011): 721-751.

First, local property owners seek to enhance the value of their assets. They have an incentive to lobby local leaders to invest in resilience to reduce default risk. Property owners recognize that a municipal default leads to lower local quality of life and higher property taxes.

Second, if local property owners, insurers and municipal bond investors prioritize addressing local resilience challenges, then this provides mayors with an incentive to invest in resilience.

Third, in recent years the Federal Government has provided generous disaster relief. This aid reduced municipal default risk.

Fourth, portfolio theory warns against "putting all your eggs in one basket". Municipal bond investors do not hold concentrated risks in one city, such that a default will cause them to fail. They invest in spatially diversified asset portfolios. Banks do not make concentrated loans to hedge funds.

Fifth, a recent empirical research literature documents that the fiscal impacts of storms have been relatively small.

Sixth, as we grow richer, we are willing to pay more for products that enhance our safety such as anti-flood equipment, and stronger windows. Firms have a profit motive to design these climate resilient products. Competition in adaptation product markets leads to lower prices.

I predict that over time that the investments made by people, firms and local governments in building up their local resilience will translate into less damage and less municipal bond default risk being caused by future natural disasters. This is the core climate change adaptation hypothesis.

Critique #1: Local property owners form a powerful adaptation coalition

A central lesson in real estate valuation is the importance of "location, location, location". Those properties in areas with a booming local economy and objectively better quality of life sell for a price premium. Past economic studies have examined the relationship between local risk factors such as crime on home prices.[5] Real estate prices are higher in places with more pleasant weather.[6]

The owner of a property is entitled to its rental stream for the duration of the asset's life. Real estate scholars are now exploring how place based forecasts of future weather conditions are capitalized into current real estate prices. Such research finds evidence that areas expected to

[5] Bishop, Kelly C., and Alvin D. Murphy. "Estimating the willingness to pay to avoid violent crime: A dynamic approach." *American Economic Review* 101, no. 3 (2011): 625-629.
[6] Cragg, Michael I., and Matthew E. Kahn. "Climate consumption and climate pricing from 1940 to 1990." *Regional Science and Urban Economics* 29, no. 4 (1999): 519-539.

face more severe weather conditions feature lower current real estate prices.[7] This capitalization effect is not a "law of physics". Suppose that a given area is expected to face more severe weather over the next decade but that offsetting technological advances such as stronger windows protects local homes from such risks. In this case, basic real estate economics predicts that we will not observe large real estate price discounts in such areas. Investment in effective market products that offset local weather risk helps to boost real estate prices in areas facing more volatile weather.

Millions of Americans live near the coasts.[8] There are trillions of dollars of real estate invested in high quality of life areas that do face natural disaster risk.[9] Owners of these assets have an incentive to invest in private market precautions and to push for local public policies to protect their assets against anticipated risks. Their asset's value will decline if local insurance rates increase.

The American West features many growing cities that face extreme heat and drought risk. Some posit that Phoenix will soon face a "day of reckoning" as Phoenix will become too hot in summer and run out of water.[10] If quality of life declines in Phoenix, then firms and people will be less likely to locate there and the city's municipal default risk would rise. If property owners anticipate that water is becoming more scarce in Phoenix, then they may vote for a municipal bond to be issued to pay for an aqueduct to transport water they buy from nearby farmers. If Phoenix heat is rising, then new local initiatives will be explored such as tree planting to offset

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[7] Bernstein, Asaf, Matthew T. Gustafson, and Ryan Lewis. "Disaster on the horizon: The price effect of sea level rise." *Journal of financial economics* 134, no. 2 (2019): 253-272.

Gibson, Matthew, and Jamie T. Mullins. "Climate risk and beliefs in new york floodplains." *Journal of the Association of Environmental and Resource Economists* 7, no. 6 (2020): 1069-1111.

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Ortega, Francesc, and Süleyman Taşpınar. "Rising sea levels and sinking property values: Hurricane Sandy and New York's housing market." *Journal of Urban Economics* 106 (2018): 81-100.

Severen, Christopher, Christopher Costello, and Olivier Deschenes. "A Forward-Looking Ricardian Approach: Do land markets capitalize climate change forecasts?." *Journal of Environmental Economics and Management* 89 (2018): 235-254.

[8] Rappaport, Jordan, and Jeffrey D. Sachs. "The United States as a coastal nation." *Journal of Economic growth* 8 (2003): 5-46.

[9] Pielke Jr, Roger A., Joel Gratz, Christopher W. Landsea, Douglas Collins, Mark A. Saunders, and Rade Musulin. "Normalized hurricane damage in the United States: 1900–2005." *Natural hazards review* 9, no. 1 (2008): 29-42.

[10] https://www.theguardian.com/us-news/2023/jul/14/phoenix-heatwave-summer-extreme-weather-arizona

the summer heat. Such investments in creative solutions to local climate risks helps to reduce default risk.

Critique #2 Mayors Have a Growing Incentive to Invest in Climate Resilience

In the doomsday scenario, Chicago was not prepared for the intensity of the major storm. Those mayors that fail to invest in local resilience will lead cities that borrow at a higher interest rate, and pay more for city insurance. Such cities risk losing people and firms who will migrate away to higher quality of life areas featuring lower taxes and higher quality of services.[11] No mayor seeks to lead a declining city.

Mayors from Red states and Blue states have incentives to invest in local resilience. If their city's quality of life suffers, they face rising interest rate costs and rising insurance costs. The current mayor of Miami is a Republican. The city has implemented a bond selling program to invest in flood protection.[12] The open question here is how effective will this investment be in reducing flood risk? The answer depends on how the city oversees the construction work that seeks to reduce the flood risk. The cost of construction projects is lower in Red States because local public sector unions are less powerful.[13] Public sector wages are higher in places with more powerful local public sector unions and this reduces the real purchasing power of a given amount of capital invested in enhancing resilience.

Many cities seek to buy insurance for their municipal debt.[14] If insurers charge more such insurance in cities that face more objective climate risk, then this provides cities with an incentive to offset such risk through investments in natural capital and infrastructure projects because if these risk mitigation projects are successful then they will face lower insurance prices. Insurance markets and bond markets are the "adults in the room" whose pricing of insurance and bonds sends price signals that facilitate climate risk adaptation.

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[11] Gyourko, Joseph, and Joseph Tracy. "The structure of local public finance and the quality of life." *Journal of political economy* 99, no. 4 (1991): 774-806.

[12] https://www.miami.gov/My-Government/ClimateChange/Coastal-and-Stormwater-Infrastructure

[13] Jerch, Rhiannon, Matthew E. Kahn, and Shanjun Li. "The efficiency of local government: The role of privatization and public sector unions." *Journal of Public Economics* 154 (2017): 95-121.

[14] https://www.brookings.edu/articles/the-price-of-safety-the-evolution-of-municipal-bond-insurance-value/

Critique #3 The Federal Government's Disaster Relief Reduces Default Risk

In the midst of a Doomsday-like Shock, consider two different scenarios that can arise concerning the responses by the Governors and the Federal Government. In case #1, the governors and the Federal Government respond to the shock by sending in billions of dollars to rebuild the afflicted areas. In this case, bond default risk will be unlikely. This case does have fiscal implications for the state and the Federal Government as their respective deficits will increase.

The influx of disaster relief causes two unintended consequences. In the short run, the shocked place is awash in disaster relief funds. This raises the risk of corruption as accountability and oversight are less likely to be in place as new construction takes place.[15] A second unintended consequence of expected Federal Government bailouts of shocked places is to induce a moral hazard or "too big to fail" effect. Cities that anticipate that they will be rebuilt using "other people's money" will invest less of their own funds in protecting themselves.

In providing such disaster relief, the Federal Government must balance being compassionate with unintentionally encouraging excessive municipal risk taking. A Federal Government seeking to decentralize responsibility for paying for local defenses to municipalities might commit to offering no disaster relief to shocked places. If such a promise is credible, then this "tough" approach would cause localities to invest more of their own money in protecting the place.[16] This strategy poses major political risks for national leaders and they are unlikely to choose this path unless the Federal government faces extreme budget challenges.

Critique #4 Municipal Bond Investors Seek to Diversify Their Risk

The Doomsday Scenario becomes less likely if municipal bond investors hold a more spatially diversified portfolio. The first idea in portfolio theory is to avoid "putting all of your eggs in one basket". Investors have strong incentives to consider how a specific investment affects their overall portfolio's risk and return. If more investors fear emerging climate risks, then they will demand bond index funds that are spatially diversified. Wall Street's financial engineers will design these products. The profit motive helps to mitigate the risk of the Doomsday Scenario.

[15] https://www.npr.org/2014/02/12/275989820/face-of-katrina-recovery-found-guilty-of-corruption-charges
[16] Kydland, Finn E., and Edward C. Prescott. "Rules rather than discretion: The inconsistency of optimal plans." *Journal of political economy* 85, no. 3 (1977): 473-491.

The Doomsday Scenario is more likely to occur if bond investors naively trust the credit rating agency's ratings.[17] If the agencies give a city a "AAA" bond rating, is it really risk free? Humble investors are more likely to recognize that they know "that they do not know" all of the risks that may be materializing. They will seek out experts. For profit and non-profit climate risk firms are popping up offering risk maps that alert people and firms about local climate risks. Of course, these predictive maps feature unknowns but they do inform decision making under uncertainty. Climate science is making objective progress and this science forms the foundation for this new generation of climate risk models.

Cities differ with respect to their credit ratings because some cities such as Baltimore face large public pension obligations while simultaneously experiencing a shrinking population. Those cities facing a rising expenditure stream and declining revenues are at greater risk of default. Information about these pension obligations is known and market prices for bonds and insurance reflect these risks.[18] Those cities with the worst credit ratings are the most likely to default in the aftermath of a major local disaster. Bond buyers have strong incentives to consider how much to invest in these high risk/high returns assets in forming their optimal portfolios.

Municipal bonds have different maturity structures. If investors anticipate that a given city faces rising risks over the next 20 years, then this city will pay a lower interest rate for its short term bonds and will pay a higher interest rate for its 30 year bonds. This long term interest rate risk premium provides the city's Mayor with an incentive to work with the Army Corps of Engineers to upgrade local infrastructure. The financial sector's forward looking price signals provide an incentive for mayors today to invest more effort to adapt to medium term risks. These efforts defuse the "doomsday bomb".[19]

Critique #5 Past Disaster Shocks Have Not Caused Large Municipal Default Risk Increases

Environmental economists study how people and places are affected by natural disasters. In recent years, major weather related disasters have struck California, Florida, Louisiana and others states, and none have resulted in defaults of investment grade municipal bonds.

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[17] Kahn, Matthew E. "Climate change adaptation will offer a sharp test of the claims of behavioral economics." *The Economists' Voice* 12, no. 1 (2015): 25-30.

[18] Giesecke, Oliver, and Joshua Rauh. "Trends in state and local pension funds." *Annual Review of Financial Economics* 15 (2023): 221-238.

[19] Painter, Marcus. "An inconvenient cost: The effects of climate change on municipal bonds." *Journal of Financial Economics* 135, no. 2 (2020): 468-482.
Goldsmith-Pinkham, Paul, Matthew T. Gustafson, Ryan C. Lewis, and Michael Schwert. "Sea-level rise exposure and municipal bond yields." *The Review of Financial Studies* 36, no. 11 (2023): 4588-4635.

Several recent papers have examined the association between hurricane strikes and local public finance dynamics.[20] On average, these shocks have small quantitative effects on a city's fiscal health. Municipal bonds that are insured are more insulated from disaster risk. Measured municipal bond price declines are attenuated as Federal disaster aid inflows occur.[21]

In addition to studying the effects of hurricanes on municipal finance, new research is exploring the impacts of wildfires on places in the American West. Such wildfires tend to occur in ex-urban areas where relatively few people live. Recent research has documented that such wildfires increase the affected municipality's deficit but the magnitude per person is small.[22]

Critique #6 The Adaptation Menu of Market Products Keeps Growing

As we grow richer, we are willing to pay more to be safe. Those who live in hurricane prone areas will demand better anti-flood equipment, and stronger windows and roofs that can withstand extreme wind. This demand creates incentives for firms to innovate. This dynamic process increases our adaptation menu and reduces prices.[23]

Future innovation will help us to adapt to extreme heat, wind and flood risk. Think of the cell-phone and the personal computer. Over time, these products have featured quality improvements and price declines.[24] As municipal residents adopt improved safety products, more of them are protected from extreme weather shocks and the overall economy becomes more resilient.

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[20] Deryugina, Tatyana. "The fiscal cost of hurricanes: Disaster aid versus social insurance." *American Economic Journal: Economic Policy* 9, no. 3 (2017): 168-198.
Jerch, Rhiannon, Matthew E. Kahn, and Gary C. Lin. "Local public finance dynamics and hurricane shocks." *Journal of Urban Economics* 134 (2023): 103516.

[21] Auh, Jun Kyung, Jaewon Choi, Tatyana Deryugina, and Tim Park. *Natural disasters and municipal bonds*. No. w30280. National Bureau of Economic Research, 2022.

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[23] Barreca, Alan, Karen Clay, Olivier Deschenes, Michael Greenstone, and Joseph S. Shapiro. "Adapting to climate change: The remarkable decline in the US temperature-mortality relationship over the twentieth century." *Journal of Political Economy* 124, no. 1 (2016): 105-159.

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A Final Thought

Going forward, big city municipal bond risk will mainly be determined by public pension obligations and day to day quality of life concerns leading to suburban flight, not by a change in the frequency of bad weather events beyond that which cities and bond investors are already planning for.

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Written Statement of Eric M. Leeper*
to the Committee on the Budget
of the United States Senate
Hearing on

"Investing in the Future: Safeguarding Municipal Bonds from Climate Risks"
10 January 2024

Chairman Whitehouse, Ranking Member Grassley, committee members, thank you for inviting me to talk with you.

My testimony aims to broaden the perspective on the subject of this hearing by focusing on federal budget policy and its implications for financing expenditures associated with climate change. I draw on consensus economic theory about optimal public finance at the macroeconomic level and review recent developments in the market for Treasury securities.

1 Government Bond Valuation

Treasury securities and municipal bonds, like any assets, derive their value from expected future payoffs, discounted to the present. For government-issued bonds, those payoffs are budget surpluses, excluding interest payments, called "primary surpluses." Higher expected payoffs raise demand for and the value of bonds, so governments can borrow on more favorable terms.

This is not a controversial view, as it derives from the fact that government policies—fiscal and monetary—must "add up" to satisfy an accounting identity each period. A little

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notation helps to make the concepts concrete.[1]

I adopt the accounting convention that gathers all government liabilities into a single object called "total privately-held government debt." Two government entities lie behind the budget condition—the Treasury and the Federal Reserve. Each entity has its own budget. Because the entities are part of the same government, economic analyses often consolidate the two budgets into a single "government" budget. Total government liabilities to the private sector include Treasury bills and bonds, currency, and bank reserves. Fed purchases of Treasury securities in the open market do not reduce total government indebtedness. They merely alter the maturity structure, ownership, and labeling of privately-held debt.[2]

The consolidated government budget identity may be written as[3]

$$\frac{Q_t^P B_t^P}{P_t} + T_t = G_t + \frac{Q_t^P B_{t-1}^P}{P_t}$$

where

Q_t^P = market price of total privately-held government—Treasury plus Federal Reserve —debt portfolio at t

B_t^P = total nominal privately-held government debt at t

P_t = aggregate price level at t

T_t = real value of tax receipts at t

G_t = real government outlays, excluding interest payments, at t

The left side of the budget identity reflects total sources of revenue broadly construed: tax revenues, T_t and new borrowing from the public, B_t^P, at the portfolio price of Q_t^P. Those

[1] This draws on the exposition in Anderson and Leeper (2023).

[2] In a series of important papers, Hall and Sargent (2011, 2022b, 2023) adopt a different convention that focuses on privately-held government bills and bonds, treating Fed holdings of Treasury securities as seigniorage.

[3] Anderson and Leeper (2023) describe how to arrive at this form of the consolidated budget identity.

revenues must equal total outlays: government spending plus redemptions of outstanding debt.

It is natural to measure government debt relative to the size of the economy by scaling everything in the budget identity by real GDP at time t, Y_t. Imposing this and manipulating the right side of the identity leads to useful interpretations of the spending side of the budget.

$$\frac{Q_t^P B_t^P}{P_t Y_t} + \frac{T_t}{Y_t} = \frac{G_t}{Y_t} + i_{t-1,t}^P \frac{Q_{t-1}^P B_{t-1}^P}{(1+\pi_t)(1+g_t)P_{t-1}Y_{t-1}} + \frac{Q_{t-1}^P B_{t-1}^P}{(1+\pi_t)(1+g_t)P_{t-1}Y_{t-1}}$$

where the new notation is

$$\begin{aligned} 1 + i_{t-1,t}^P &= \text{gross one-period nominal weighted holding period return on the total} \\ &\qquad \text{government portfolio between } t-1 \text{ and } t \\ 1 + \pi_t &= \text{gross rate of inflation} = P_t/P_{t-1} \\ 1 + g_t &= \text{gross growth rate of real GDP} = Y_t/Y_{t-1} \end{aligned}$$

On the right are three types of spending as shares of GDP—expenditures on goods, services, and transfers, interest on outstanding borrowing, and reduction in debt-GDP due to inflation and economic growth.

A final simplification of the budget identity defines the primary surplus, S_t, as total revenues less total spending—excluding interest payments on the debt—to give us

$$\frac{Q_t^P B_t^P}{P_t Y_t} + \frac{S_t}{Y_t} = \left(\frac{1 + i_{t-1,t}^P}{(1+\pi_t)(1+g_t)} \right) \frac{Q_{t-1}^P B_{t-1}^P}{P_{t-1} Y_{t-1}} \tag{1}$$

This budget identity lays out precisely how policy can meet its obligations. Start with the obvious ways: government can raise revenues or cut spending to increase the primary surplus or it can borrow more by selling new debt instruments at the price Q_t^P. These obvious ways receive most of the attention in policy discussions.

But the terms on the right side of the identity embody three other sources of financing.

First, the holding period return, $i^P_{t-1,t}$, is negative when debt prices at t fall below those in the previous period. By reducing returns on debt, debt-service costs and the debt-GDP ratio fall. Second, higher inflation—P_t and π_t—has two effects: it reduces the real return on existing debt and it reduces the real value of new debt. Most government debt instruments are a promise to repay in dollars. By eroding the purchasing power of those dollars, higher inflation makes repayment cheaper in terms of goods and services. Finally, because the identity expresses debt relative to total goods and services the economy produces, higher real GDP—Y_t and g_t—reduces both the (growth-adjusted) return and debt's share of the economy.

Real primary surpluses represent the government's command over resources that can be used to pay off debt while maintaining debt's purchasing power. If the government sells new bonds today that increase the debt-GDP ratio 1 percent, then investors expect the government will raise future surpluses (in present value) by 1 percent of current GDP. If instead investors believe the present value of surpluses will not change, then with no increased backing, the value of debt cannot increase. Even if the government sells more nominal bonds, their real value and share of GDP cannot change. Prices of debt and of goods and services must adjust to realign the value of debt with its backing.

We summarize how debt instruments are valued with an expression, derived from the government budget identity and some behavioral assumptions, that links the current value of the total government debt-GDP ratio to the present value of future surplus-GDP ratios[4]

$$\frac{Q^P_t B^P_t}{P_t Y_t} = \text{Expected discounted stream of } \frac{S_{t+1}}{Y_{t+1}}, \frac{S_{t+2}}{Y_{t+2}}, \frac{S_{t+3}}{Y_{t+3}}, \ldots \tag{2}$$

Expression (2) is an asset-pricing relation for government debt that lurks in most macroeconomic models. It says that the value of debt relative to the size of the economy can rise or fall only if the current value of expected backing—in the form of future real surpluses

[4]We assume investors make choices that eliminate all arbitrage opportunities across assets and that they do not over-accumulate saving.

relative to GDP—rises or falls. If legislation were to be enacted that raises the future path of primary surpluses relative to the economy, the right side of expression (2) would increase. By increasing expected real payoffs to debt, the legislation raises the demand for government bonds. To keep the reasoning simple, assume the fiscal news has no effect on nominal GDP (P_tY_t) initially. Then higher bond demand, with no change in bond supply, bids up bond prices today, so Q_t^P rises. Higher bond prices correspond with lower interest rates, so the government can borrow on more favorable terms.

2 Optimal Public Finance

Virtually all taxes that governments levy directly affect rates of return and, therefore, alter the margins that decision makers face. Payroll taxes, for example, reduce take-home pay and lower the after-tax return on labor. Big swings in payroll tax rates would induce correspondingly big swings in labor supply choices and after-tax income for workers. Because households generally seek to avoid big swings in their consumption—this is why people save to provide for lean days in the future—large fluctuations in tax rates reduce social welfare.[5]

This logic underpins the decision of whether to financing fluctuating government expenditures with taxes or borrowing. If a large temporary increase in spending—like that associated with Covid-relief—were to be financed contemporaneously with tax revenues, tax rates would need to jump up with the emergency spending and then decline sharply when the emergency ends. Tax distortions tend to rise at an increasing rate with the level of tax rates: the distortion in moving from a 10-percent to a 15-percent tax rate is less than in moving from a 20-percent to a 25-percent tax rate.

To make these ideas concrete, I examine three examples of spending patterns and how theory says the spending should be optimally financed. The examples are stylized—not

[5] Analogous arguments apply to fluctuations in various components of government expenditures. If infrastructure funding expires before a new bridge is completed, for example, society is worse off because resources have been wasted on an unusable bridge. For simplicity, the optimal financing literature that follows Barro (1979) and Lucas and Stokey (1983) treats government expenditures as given to focus on the optimal choice of tax vs. debt financing.

intended to be realistic—but they can be readily extended to more plausible cases.[6]

2.1 An Anticipated War of Known Duration

Government receives information at date 0 that in five periods spending will rise and remain elevated for three periods before returning to its initial level [see figure 1]. Optimal policy raises revenue immediately and permanently keeps it at that level. Until spending increases, positive primary surpluses retire debt. During the war, spending and borrowing rise. With constant revenue, policy runs primary deficits during the war. After the war ends, spending falls and the government returns to running positive primary surpluses to service the permanently higher level of debt.

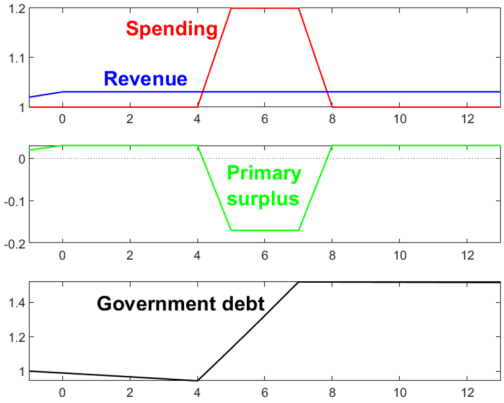

Figure 1: At date 0, government knows spending will rise in period 5 for 3 periods, then return to initial levels.

By raising revenue once and for all, the policy minimizes tax distortions. Importantly, policy must generate primary surpluses after the spending burst subsides in order to maintain

[6] I derive the figures below from a formal model with an infinitely-lived representative household and a constant equilibrium real interest rate. All variables are real, abstracting from inflation.

the value of outstanding government debt. As expression (2) implies, a higher level of debt requires a higher expected present value of primary surpluses.

2.2 One-Time Surprise Spending Increase

The second example resembles the Covid episode. Spending is expected to remain constant, but in period 2 there is a surprise increase in spending that lasts one period. Policy reacts to higher spending with a combination of somewhat higher revenue and new borrowing. Notice that the increase in revenue is only a tiny fraction of the increase in spending. The bulk of the financing is through borrowing. Elevated spending increases the primary deficit for one period.

As before, once the crisis passes, policy returns to running steady positive primary surpluses to sustain the higher level of debt.

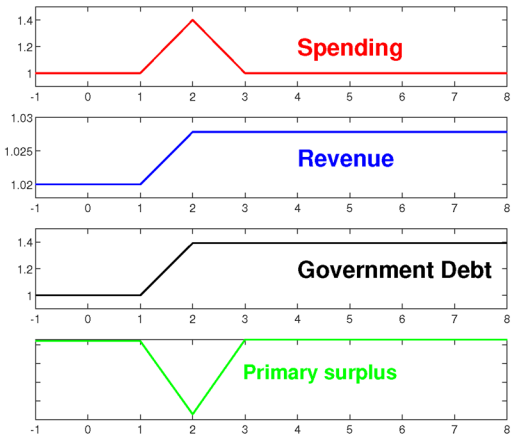

Figure 2: At date 0, spending is expected to be constant. It rises surprisingly for a single period at time 2.

2.3 Permanent Increase in Spending

The final example bears some resemblance to increased spending to deal with the consequences of climate change. At date 0, it is known that spending will rise permanently beginning in period 2. Figure 3 shows that optimal policy raises revenue before spending rises and then maintains revenue above the new level of spending. In the initial periods policy runs a substantial surplus, which reduces the level of debt.

Notice that permanent spending requires permanent revenue. This is because it is not feasible to finance the spending by borrowing. Doing so would make government debt explode, which cannot be sustained indefinitely.

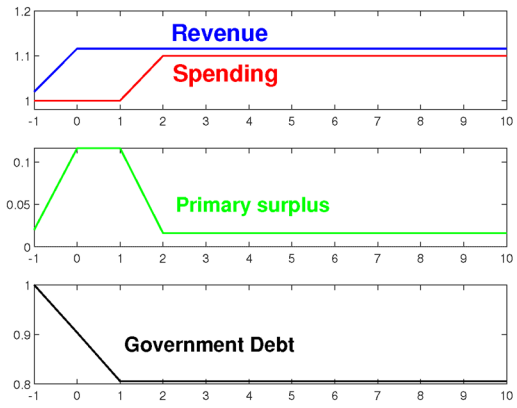

Figure 3: At date 0, government knows spending will rise permanently beginning in period 1.

These examples treat spending as beyond the control of policy. An alternative specification would permit some other component of spending to adjust to compensate for the component that rises.[7] That analysis, while feasible, requires far more detailed modeling.

[7]If spending components involve government investment, rather than consumption—as is true of some

2.4 Hall and Sargent's Three Wars

In a series of papers, Hall and Sargent (2022a,b, 2023) examine the financing of spending during World Wars I and II and the Covid period to ask how closely actual behavior aligns with the theory just explained. Figure 4 plots federal spending and receipts since 1900, including Congressional Budget Office projections for 2022–2031.[8]

Outlays in the blue line exhibit three spikes associated with World War I, World War II, and Covid-19. During the world wars, receipts in the orange line rose but by only a fraction of the increases in spending: most of the war expenditures were financed by borrowing. The pattern resembles the war of known duration in the example in section 2.1. Actual outcomes, unlike the example, do not contain the anticipatory "pre-financing" in figure 1, where revenue exceeds spending before the war. But as in the optimal financing example, government ran primary surpluses for several years after the wars ended.

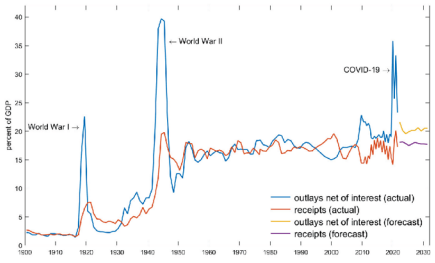

Figure 4: U.S. federal government expenditures and receipts: 1900–2031 from figure 2 in Hall and Sargent (2022a).

How things will play out after the fight against Covid remains to be seen. Most of the increase in Covid-related spending was financed by borrowing. CBO does not project post-

types of infrastructure spending—optimal financing becomes more complex because the rate of return on the spending must be taken into account. Leeper, Walker, and Yang (2010) examine fiscal multipliers for infrastructure investments.

[8] Outlays are net of official interest payments. 1900–2010 annual by fiscal year; 2011-present monthly data aggregated to 6-month periods. Outlays and receipts from 2022–2031 are computed using CBO projections.

Covid primary surpluses. Instead, primary deficits are expected to persist over the projection period.

Optimal public finance theory provides a useful benchmark for policy makers. The theory reports how to finance bursts in government expenditures in the least-distorting manner, with the goal of maximizing social welfare.

3 Treasury Market Developments

Optimal public finance *presumes* there is a robust market for government debt instruments in which the government never defaults or reduces its liabilities through inflation. The actual U.S. Treasury market has often functioned close to that theoretical ideal. Since the Covid period, some troubling signs of weakness have emerged from that market.

3.1 The Value of Treasurys

Return to the expression for the market value of debt as a share of GDP in expressions (1) and (2). B_t^P is the face (or par) value of the total U.S. government bond portfolio and Q_t^P is the price of that portfolio.[9] Figure 5 plots the par value (blue line) and market value (red line) of debt as a percentage of GDP from the 2020-Q1 to 2023-Q3. The par value ratio rose 14 percentage points, while the market value share *fell* 2 percentage points.

The difference between the two measures is accounted for entirely by the price of the bond portfolio, Q_t^P. Figure 6 tells the story. Since the beginning of Covid the price of the Treasury bond portfolio has declined 18 percent. The figure places this decline in historical context: the price is currently at levels not seen since the late 1970s. The recent drop in price is the sharpest and fastest in the post-war period.

[9]In what follows, I use the marketable debt definition and the face value and market values of that definition, as computed by the Federal Reserve Bank of Dallas, available at https://www.dallasfed.org/research/econdata/govdebt. I compute the price of the portfolio by dividing the market value by the face value. Marketable debt includes debt held by the public and by the Federal Reserve.

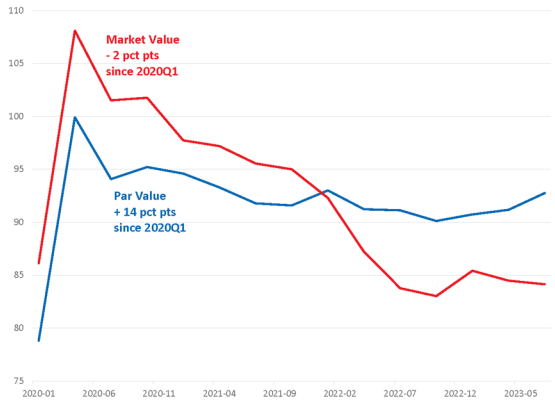

Figure 5: Face value—blue line—and market value—red line—of marketable Treasury debt as a share of nominal GDP from 2020-Q1 to 2023-Q3.

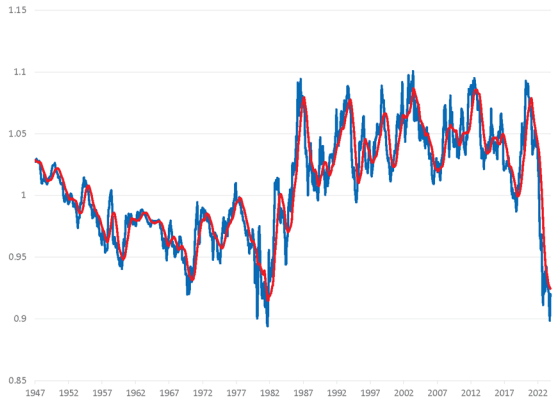

Figure 6: Price of the bond portfolio, Q_t^P, from January 1947 to November 2023. Blue line is actual data and red line is a smoothed, one-year moving average.

3.2 Recent Treasury Auctions

Treasury auctions in the last quarter of 2023 showed marked weakness compared to normal. Wallerstein (2023) describes the difficulties the Treasury has had selling new bonds,

particularly at longer maturities. Two direct signs of auction weakness have emerged: primary dealers, who are required to place bids, end up buying more bonds; the government ends up selling bonds at lower prices than the market expected (called "tailing auctions"). November's auction had "a massive tail by historical standards," according to Wallerstein, and primary dealers bought more than twice as much as they usually do.

The secondary market for Treasurys has shown unusual volatility. The 10-year yield peaked at 5 percent in October and has since fallen to below 4 percent. And in 2022 the Bloomberg aggregate bond index lost 13 percent, before rebounding in 2023 with the prospect of interest rate cuts by the Fed [Wallerstein (2024)]. Large movements in long yields over short periods may reflect increased uncertainty about fiscal financing.

3.3 Interest Payments of the Debt

Interest payments on outstanding debt is one of the first places in which monetary policy actions have fiscal consequences.[10] When the Fed cuts the federal funds rate and the rate on reserves, both short-term rates, it reduces incentives for the banking industry to sit on its liquidity and collect interest. The lower the rate, the stronger the incentives for households and businesses to borrow to finance their consumption and investment choices. This is the conventional channel for monetary stimulus, which the Fed pursued for two years starting in March 2020.

The short-term policy interest rate is woven into the fabric of financial markets. Current and expected future rates cascade to affect decisions that banks, firms, and households make. All interest rates tend to rise or fall with the path of short rates. Easier monetary policy in 2020 raised bond prices and reduced interest payments from the Treasury to debt holders. Fed tightening triggered opposite movements. Figure 7 plots interest payments as a share of non-interest federal expenditures. Payments rose slowly in 2021 as borrowing expanded but interest rates remained low. Since the Fed started to tighten in 2022, interest payments

[10] This section draws on Anderson and Leeper (2023).

have risen rapidly. With those interest payments, marketable Treasury debt has grown over $2 trillion in the first 11 months of 2023.

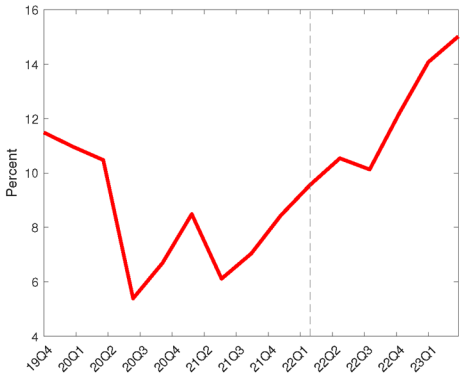

Figure 7: Interest payments on Treasury bonds as percentage of federal expenditures less interest payments. Vertical line marks beginning of Fed tightening.

It matters how the government chooses to finance rising interest payments. Will primary surpluses rise or will government borrow to meet interest needs? If Congress chooses to roll interest payments into more rapid growth in nominal debt, we can expect more inflation in the future. A higher expected path of interest rates reduces bond prices, so the market value of debt declines with no change in face value. The immediate impact on inflation is beneficial because the price level can fall along with bond prices to maintain the debt-GDP ratio in valuation equation (2). But this is only the immediate impact.

Fed tightening raises real rates in the short run and future interest payments over longer horizons. The shorter the maturity structure of government debt, the sooner the interest-rate impacts on interest payments show up. As monetary policy's impacts on real rates diminish, we are left only with higher interest payments on the debt. Eventually a higher average funds rate manifests as a higher inflation rate. Fed efforts to combat fiscal inflation are ephemeral: tighter monetary policy pushes inflation into the future, but it cannot eliminate the inflation

that Covid spending triggered.

4 The Hamilton Norm

Over many years, stable democracies have developed certain norms for policy behavior.[11] In the United States and elsewhere, monetary norms have emerged largely from the legislative process. Central banks' responsibilities and powers have adjusted, sometimes rapidly, to prevailing economic conditions. But they are lodged in law.

American fiscal norms, in contrast, are not codified. They have evolved informally over the country's history and owe much to Hamilton's understanding of dynamic economic behavior.[12,13] For example, the United States has earned a reputation for repaying, rather than inflating away or defaulting on its public debt. This reputation is sustained without formal commitments of a gold standard, collateral or other recourse, specific streams of revenues tied to repayment, or other devices common through history.

Despite their informal nature, fiscal norms have imposed constraints on fiscal institutions in the sense that North (1990) describes. Today Hamilton's monetary vision has been realized: U.S. treasurys possess the unique status as the world's go-to safe asset and perform a central role in global financial markets. Treasurys serve many of the functions of money throughout the world.

There are troubling signs that American fiscal norms may be eroding. Recurring nibbling away at fiscal norms is bound eventually to affect what people expect of fiscal policy. Those expectations feed directly into bond prices, inflation, and real economic activity. They can also undermine the desired impacts of monetary policy.

In light of economic and policy developments since the global financial crisis, it is useful to step back to ask what policy norms now exist. If we can agree on today's norms, we can

[11] This section draws heavily on Leeper (2022b).

[12] A large number of countries have adopted formal and informal, frequently explicit, rules to govern fiscal behavior. The IMF maintains a dataset on fiscal rules [International Monetary Fund (2017)].

[13] Sargent (2012) makes closely related points, but in more detail and with greater eloquence.

then ask if the norms will serve us well going forward.

What is a "norm?" It is *not* a policy objective. Monetary policy objectives have not changed recently. They remain full employment, stable prices, and well-functioning financial markets. But central bank behavior has changed markedly.

Fiscal policy objectives in the United States have always been anyone's guess. Fiscal priorities vary with the party in power, as they should in a democracy. But it's not clear what, if any, macroeconomic objectives have remained constant across time.

In the absence of consistent macroeconomic fiscal objectives, norms take on greater importance. Norms are patterns of behavior that are relatively stable or change in predictable ways over time.

4.1 American Fiscal Norms

I emphasize three norms that have guided fiscal decisions in the United States.

Alexander Hamilton's (1790) *Report on Public Credit* established America's primary fiscal norm:

> **Fiscal Norm #1:** Deficits beget surpluses to repay debt in full.

Hamilton's *Report* lists several benefits that flow from this norm; for our purposes I highlight two. The first is that "proper provision for the public debt" arises when it is "well funded" and "has acquired an *adequate* and *stable* value" (p. 3, emphasis in original). This ensures that a government that borrows will be able to borrow again, should the need arise. The norm anchors fiscal expectations, a point that Sargent (2012) emphasizes.[14]

A second benefit, particularly relevant today, was to establish a robust market for government debt to grow the financial system. Hamilton foresaw the advantages of public debt as a "*substitute* for money" (p. 3, emphasis in original). Because money then was commodity money, it was fully backed. Any substitute for money would have to be similarly backed,

[14] See also Gordon (1997) for further discussion of the *Report*.

requiring confidence that new debt issuances would ultimately bring forth higher taxes.[15]

The history of government debt in the United States is one of run ups, usually due to wars, and retirements [Hall and Sargent (2021)]. This is even true in the past 75 years under a fiat currency regime [Hall and Sargent (2011)]. Since 2008, government debt in advanced economies looks more like a step function, as table 1 shows. And in the United States there seem to be no plans for returning government debt to pre-2008 levels.

Is Hamilton's norm on shaky ground? Do doubts that the norm will be maintained affect the moneyness of public debt?

	2006	**2016**	**2021**
Canada	69.4	91.7	116.3
France	63.6	98.0	115.2
Germany	67.6	69.3	70.3
Japan	191.3	232.5	256.5
United Kingdom	43.1	86.8	107.1
United States	61.1	106.6	132.8
Advanced countries	73.8	105.5	122.5

Table 1: General government gross debt as a percentage of GDP. Source: IMF, *Fiscal Monitor*, various issues.

A second norm, supported by modern macroeconomic theory, has been applied off and on in the United States:

> **Fiscal Norm #2:** Ordinary and emergency spending may be differently financed.

Emergency spending usually applies to wars, but the argument can be extended to any emergency that calls for substantial, but temporary, deficit spending. Hall and Sargent (2021) examine 10 historical episodes of emergency spending to understand how it was financed, contrasting the prescriptions of Barro (1979) and Lucas and Stokey (1983). Barro's

[15] This point about fiscal backing for "money" is implicit in, but frequently ignored by modern monetary theory discussions. See Leeper (2022a) for further analysis of MMT.

policy leaves *ex-post* returns on government bonds unchanged, while Lucas and Stokey's policy adjusts *ex-post* returns to bond holders.[16]

One interpretation of the norm is that ordinary spending—what would occur without the emergency—should be financed by taxes, while emergency spending may be financed in part by surprise changes in inflation and bond prices, which reduce *ex post* real returns on the debt. Franklin D. Roosevelt adopted this norm when he took office in 1933. Roosevelt's treasury maintained a dual budget, which differentiated between ordinary spending and the emergency spending that aimed to fight the Great Depression. Roosevelt balanced the ordinary budget, but pledged to run debt-financed deficits on the emergency budget until the economy recovered. Jacobson, Leeper, and Preston (2023) argue that differently financed emergency spending raised the price level and output by more than would tax-financed spending. Bianchi, Faccini, and Melosi (2023) and Barro and Bianchi (2023) apply this reasoning to Covid spending.

The U.S. federal government has spent $4.3 trillion in Covid-19 related programs and appropriated $4.6 trillion [see usaspending.gov]. This is not unlike fighting a temporary war. Although there has been extensive political debate about how to pay for proposed infrastructure spending, little discussion of financing accompanied the Covid-19 bills.

This is a missed opportunity. Covid bonds could have been issued to support the spending, along with a clear statement from policy makers that taxes will not rise to finance the debt until the crisis is well passed and the economy has recovered. With FDR's experiment as a guide, this approach would have delivered larger stimulus to demand. Should we assume the norm is operative?

A third fiscal norm comes from an observation based on American fiscal behavior since World War II:

Fiscal Norm #3: Fiscal consolidation occurs when interest payments on

[16]Recent work in models with nominal rigidities finds that jointly optimal monetary and fiscal policies finance fiscal needs with a combination of taxes and surprise inflation and bond prices that create capital gains and losses to bond holders [Sims (2013), Leeper, Leith, and Liu (2021), Leeper and Zhou (2021)]. In that work, optimal fiscal finance depends explicitly on the maturity structure of government debt.

outstanding debt become a sufficiently large fraction of federal expenditures.

Three major consolidations—late 1940s, second half of 1980s, mid-1990s—were prompted by high debt service. Political dynamics behind the reforms are easy to understand. Elected officials don't feel the bite of debt service until it crowds out spending programs that observably benefit their constituents.[17]

Secretary of the Treasury Janet Yellen sought to tamp down inflation concerns by reassuring people that "The Federal Reserve has the tools to address inflation, should it arise."[18] To be sure, Paul Volcker showed a doubting world that a central bank with sufficient resolve can wring inflation out of the economy.[19] But today's fiscal setting is very different. In 1980, the debt-GDP ratio was about 25 percent; now it is 100 percent. Today a five percentage point increase in interest rates raises debt service about $1 trillion. The prevailing level of debt amplifies the fiscal consequences of monetary policy.

Fiscal consequences of these magnitudes require large consolidations that will put the third fiscal norm to the test.

4.2 Fragility of Fiscal Norms

For better or worse, fiscal policy decisions are inherently political. Broad acceptance of norms limits the range of possible fiscal outcomes. Norms arise from clear consensus about how to conduct policy. As consensus erodes, so too do the norms. Legislation to raise the American debt ceiling or even to keep the federal government running have become political footballs, battled over for reasons unrelated to fiscal policy. The "fiscal cliff" in 2013 grew from a confluence of fiscal choices based on political expediency, rather than sound policy. In 2016 one presidential candidate floated a muddled idea that some observers interpreted as renegotiating Treasury securities contracts. Some elected officials at the other end of the political spectrum have embraced Modern Monetary Theory's key prescription to print

[17] See Leeper (2023) for more discussion.

[18] On "Meet the Press," 2 May 2021.

[19] Although Silber's (2012) biography of Volcker, with which I wholly agree, emphasizes the central role of fiscal reforms in the success of Volcker's disinflation efforts.

money to pay for government spending. Viewed as a pattern, these factors cast doubt on the durability of America's most venerable fiscal norm.

If centuries-old norms like Hamilton's can be wantonly tossed aside, they are powerless to prevent fiscal policy from being a source of instability in the economy. Perhaps the time has come to institutionalize the norms through rules and procedures that bite.

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To: Ranking Member Chuck Grassley
From: Eric M. Leeper

"Investing in the Future: Safeguarding Municipal Bonds from Climate Risks"
10 January 2024
Senate Budget Committee

Question #1

In both Dr. Hartshorn's oral and written testimonies, he asserted his belief that climate risk "mitigation funding can save the nation $6 in future disaster costs, for every $1 spent on hazard mitigation."

Rather than using peer-reviewed academic research to justify this assertion, which was used as a basis to justify climate change-related spending, he cited a 2018 message from an international politician.[1] Is it true that the federal government spending additional money on climate change will have a six times return (i.e., 6x multiple) on investment and ultimately save money?

Answer #1

Senator Grassley, Based on the information provided in the citation, it is impossible to rigorously assess the plausibility of this claim. It is not even clear how to interpret it.

One interpretation is that for every dollar spent on climate change mitigation, spending on recovery from weather-related events declines by $6 dollars. Drawing on the vast fiscal multiplier literature, which addresses a different question, the number $6 is exceptionally large, well outside the range reported for the impacts of government spending on real GDP, the "output multiplier."

I am naturally suspicious anytime someone reports a single number for the impacts of government spending. At a minimum, serious research acknowledges the uncertainty inherent in any empirical estimates, so good research reports a range of possible impacts. A consistent finding in the multiplier literature is that the strength of the multiplier varies across time and countries. The United Nations appears to treat $6 as *the* effect at all times and in all places.

Estimates of output multipliers are based on long samples of data, across many countries. After all, government have been spending for many years. Despite plentiful evidence, results remain unclear and no broad consensus exists among macroeconomists. Climate change mitigation must suffer from a paucity of data, which produces very uncertain estimates. What empirical analysis underlies the $6 figure?

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[1] United Nations, *For Every Dollar Invested in Climate-Resilient Infrastructure Six Dollars Are Saved, Secretary-General Says in Message for Disaster Risk Reduction Day*, Oct. 10, 2019, https://press.un.org/en/2019/sgsm19807.doc.htm.

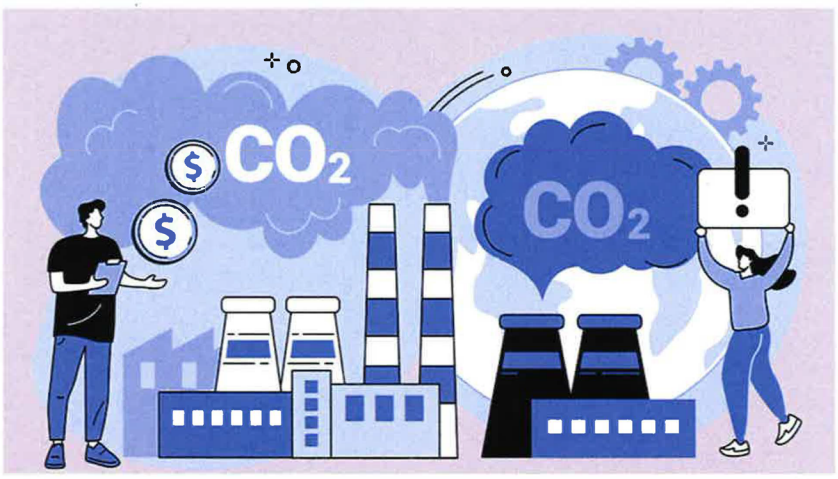
Over what time horizon does the $6 in benefits accrue? A sensible guess is that the benefits accrue over many decades. How is the mitigation spending financed in the short run? Output multipliers are highly sensitive to the assumed source of financing. In fact, if taxes on capital rise to pay for the spending, multipliers can even be *negative*.

Finally, the UN number smacks of "free lunch" logic. (In this case, the lunch is not only free, it buys five additional lunches!) Arguing you can get something for nothing or, in the fiscal context, that spending increases or tax cuts pay for themselves, is a common technique to generate popular support for a policy proposal. Modern Monetary Theory is a recent example of that logic: government can provide goods and services that never have to be paid for with taxes, and nothing bad will happen to the economy. We are living through the inflationary consequences of paying for Covid-related expenditures by printing "money" (bonds and reserves).

The $6 claim raises more questions than it answers. I am skeptical of the $6 figure, but with no research cited to support it, it isn't possible to provide a thorough assessment.

Having said this, I do think it is plausible that certain kinds of climate change mitigation could generate a positive return over some time horizon. But that return must be highly dependent on the details—what is the spending on? where is the spending taking place? how much spending has already been undertaken in that location? The marginal return on an additional dollar spent on mitigation surely declines as spending levels rise. This economic reality applies to climate change, just as it does to other forms of government investment.

USC Dornsife
College of Letters, Arts and Sciences



A carbon tax could spur changes that lower greenhouse gas production. (Image Source: iStock.)

Economist Matthew Kahn says human ingenuity is key to living with climate change

The USC Dornsife professor explains how market capitalism will help us adapt to the growing challenges unleashed by a warming planet. **[5¼ min read]**

By **Lance Ignon** February 7, 2022

Matthew Kahn is anything but sanguine when it comes to climate change. As Provost Professor of Economics and Spatial Sciences in the Department of Economics at the USC Dornsife College of Letters, Arts and Sciences, he knows it's bad news. But as he argues in his recently published book, *Adapting to Climate Change: Markets and the Management of an Uncertain Future* (Yale University Press, 2021), human ingenuity, driven by free markets, will help us adapt to climate

change more effectively than we might think. (*Publishers Weekly* named it one of its Top 10 books in business and economics for spring 2021.)

Am I right in concluding that you are an optimist by nature?

I am an optimist. When I teach my USC Dornsife students economics, I speak to them about the "Time Machine" thought experiment. If each of us lives for 80 years, when would you like to live your life? Few of us would pay to take the time machine back to 1500, but would you prefer to be born in 1950 or in 2030? We differ, and this means that people will give different answers to this question.

In a recent discussion with my students, two students said that they wish they had been born in 1980 because this cohort had access to cheaper housing when they were young adults. I wish I was born in 2022. Despite the pandemic, climate change and the myriad challenges we face both domestically and in international affairs, I continue to be optimistic about quality-of-life progress. At the same time, I must acknowledge that my mother (a New York City lawyer) strongly cautions me to avoid "magical thinking"!

Is there a limit to our ability to adapt to climate change?

Back in the early 1980s, Julian Simon, an economist, and Paul Ehrlich, a biologist, debated whether there are "limits to growth." Simon, the optimist, argued that on a planet featuring almost 8 billion people with rising human capital and access to venture finance, human ingenuity will play a central role in devising solutions to any emerging challenge that materializes. The rise of the COVID-19 vaccine is just one example.

Of course, there are limits to adaptation, and this is why I strongly support the introduction of a carbon tax that rises over time. While I support this prudent public policy, the global collective action problem is so severe that I do not believe that a credible binding treaty will be signed. Global GHG (greenhouse gas) emissions will continue to rise, and thus we must adapt. My work explores the microeconomics of the adaptation challenge. The anticipation of mass misery caused by climate change creates new opportunities for entrepreneurs and leaders who devise private sector and public sector solutions that improve our quality of life.

How do we accelerate adaptation to climate change?

Leading universities play a key role here in expanding our knowledge about the actual risks we face, about how people perceive these risks and creating new knowledge that expands our coping strategies. Breakthroughs by Viterbi (USC Viterbi School of Engineering) engineers regarding enhancing our water supply represent just one example.

As young people train in new fields such as climate resilience, we will build up the skills to reduce the impacts of shocks such as the next Hurricane Ida. We are not "passive victims" here. We have strong incentives to build up our resilience in the face of Mother Nature's stronger punches.

At USC Dornsife, an important dialogue is starting between economists and psychologists concerning climate risk perception. We will be better able to adapt to the new risks if all of us perceive them. We face greater danger if we naively underestimate the new emerging risks we face.

For those who underestimate the new climate risks related to heat, drought and fire threats, prices play a fundamental role in signaling scarcity, and rising prices induce behavioral change. We can accelerate our adaptation progress by allowing the prices of scarce water, electricity and insurance to reflect place-based risk. If California is facing greater drought, then water prices need to rise. If a geographic area such as Miami faces greater flood risk, then insurance prices there need to rise.

Can you tell us about the role of local versus federal government in spurring adaptation?

We need to change our housing zoning codes so that developers can build multi-family buildings on a given plot of land. Much of the United States is zoned for single family homes. The emerging climate science risk rating industry is now generating more geographically refined risk predictions to identify areas within cities that face less heat and flood and fire risk. In these "safe zones," we need to change zoning codes to allow taller buildings to be built there. This will allow more people to face less climate risk in the future.

The poor face the greatest risks posed by climate change. This creates a social imperative for the federal, state and local governments to create a set of rules that

helps adults and children to achieve their full potential. Reducing America's poverty rate and strengthening our middle class will help us to adapt to climate change because richer people can afford higher quality food, shelter and products to protect themselves from emerging risks.

Recent empirical research in economics has documented the risks that climate change poses for the poor. Children learn less on hot days when they attend public schools that do not have air conditioning. Outdoor work health and productivity is directly impacted by extreme heat. Many of the victims of Hurricane Ida were poor people who lived in basements of buildings that flooded.

Is there a closing thought you'd like to convey?

Free market environmentalism is not an oxymoron! When I teach undergraduate urban economics and environmental economics, my students are surprised to encounter a passionate environmentalist who firmly believes that market competition helps to improve all of our quality of life. We respectfully debate my ideas that I present in my free textbook, *Fundamentals of Environmental and Urban Economics.* USC Dornsife features great undergraduates who I hire as research assistants, and several are my co-authors, including on a piece that was published in the *Harvard Business Review.* Everyone who knows me knows that I love to debate and that I can be convinced when I am wrong!

THINK AGAIN

By Matthew E. Kahn

THE GREEN ECONOMY

Going green has finally gone mainstream, and politicians from London to Seoul are spending billions on clean technologies they say will create jobs. But unless we are all willing to risk a little more pain, the green revolution could founder before it ever really starts.

"Going Green Will End the Recession."

No way. Vowing to pump $150 billion into green technology over the next decade, U.S. President Barack Obama has made big promises about his environmental agenda. "It will also help us transform our industries and steer our country out of this economic crisis by generating 5 million new green jobs that pay well and can't be outsourced," he said in November.

British Prime Minister Gordon Brown has similarly called for an international "Green New Deal" to create a "low-carbon recovery." The United Nations wants a full 1 percent of global GDP to go to environmental initiatives. Rich countries such as Canada, Japan, and South Korea are obliging, spending billions to promote ecofriendly projects and green businesses.

Even the U.S. Congress is considering a range of measures to reduce greenhouse gases—from regulatory mandates, such as raising vehicle fuel economy or requiring electric utilities to produce more of their power from renewable sources, to carbon taxes and a cap-and-trade system for electric utilities.

Many of these ideas are very much worth pursuing for environmental reasons. But it's doubtful they offer a double dividend of helping to jump-start the economy. For one thing, the global financial crisis is fundamentally about different issues: the popping of housing and credit bubbles from St. Petersburg to San Francisco, the associated implosion of a highly leveraged international banking sector, and the resulting fallout on real economies. These pressing problems won't be solved by switching to hydrogen-powered cars or installing solar panels on every roof.

Second, let's be honest: Anti-carbon regulations will simultaneously create and destroy jobs. Take the United States: Given the country's current reliance on cheap, coal-fired power plants, carbon caps will translate into higher electricity prices. (How much higher remains an open question.) Older manufacturing firms—especially in energy-intensive industries such as petroleum and coal products, paper, cement, and primary metals—will face higher costs of doing business, and this may lead them to shut down or seek international locations where electricity prices are lower and carbon regulation is less stringent.

In the long run, a little creative destruction will likely be a good thing. The same regulations that might kill jobs in smokestack industries will act to stimulate a host of new manufacturing opportunities, ranging from energy-efficient household appliances to solar panels to energy-efficient vehicles. Even former U.S. Vice President Dick Cheney might consider buying a fuel-efficient vehicle if gas prices rose enough.

But don't count on clean technology to pull us out of the doldrums. The green revolution won't happen overnight.

Matthew E. Kahn is professor of economics at the University of California, Los Angeles, and author of Green Cities: Urban Growth and the Environment.

Windfall. Air is power, but is the price right?

HOWARD KINGSNORTH/ZEFA/CORBIS

"Governments Should Promote Alternative Energy."

It depends how. Governments have a dreadful record when it comes to picking winners. Consider the U.S. Energy Policy Act of 2005, which required that gasoline sold in the United States be mixed with increasing amounts of renewable fuel. As intended, this regulatory mandate created large demand for ethanol made from corn (which was already heavily subsidized). Corn Belt senators were thrilled, but it made environmentalists and economists queasy—because corn-based ethanol may actually create more carbon over its life cycle than conventional gasoline. Now that oil prices have collapsed, subsidizing this fuel source makes little economic sense. With newly built ethanol plants already rusting across the Midwest, U.S. taxpayers are left propping up an industry that could never survive on its own.

Ethanol is hardly a special case. Take the historical track record of Japan's powerful Ministry of Economy, Trade, and Industry, which was set up to aid particular economic sectors. Economists Richard Beason and David Weinstein found that this supposed engine of Japanese success had actually been financing losers and that government aid did nothing to increase productivity between 1955 and 1990.

Why are governments so bad at this game? Because the future is hard to predict. Better to avoid top-down mandates (i.e., Soviet five-year plans) and instead encourage individual experimentation. A decentralized approach would let firms and households identify the most efficient ways to reduce their carbon footprints. Instead of handing out subsidies for technologies that may or may not succeed, governments should level the playing field by forcing polluters to pay the true social costs of their consumption of dirty fuels. When my local power plant fires up its boilers, it should pay for the greenhouse gases it emits as well as the cost of the coal. A carbon tax or a cap-and-trade program would do the trick.

"China's Out-Greening the United States."

Not on your life. Some pundits, such as *New York Times* columnist Nicholas Kristof, have suggested that China, with its foray into hydrogen fuel cells and tough new fuel-economy standards, threatens to leapfrog the United States in going green.

We should be so lucky. The unfortunate reality is that China has extremely high air and water pollution levels. Yes, the average Chinese person's greenhouse gas emissions are much lower than the average American's, but this gap is closing fast, as private vehicle ownership and electricity consumption are rising sharply in China. In 2001, there were 1.5 million vehicles in Beijing. By August 2008, the city's vehicle count had grown to 3.3 million. If the Chinese began consuming like Americans, resource pressures would go up dramatically. Geographer and historian Jared Diamond of the University of California, Los Angeles, warns: "Oil consumption would increase by 106 percent, for instance, and world metal consumption by 94 percent. If India as well as China were to catch up, world consumption rates would triple."

When it comes to producing clean, renewable power, the Middle Kingdom is falling ever further behind. With its ample coal supplies, China can meet its soaring electricity demand only by opening more coal-fired power plants—approximately three or four per month. Even with the best available technology, each megawatt-hour of power created by a coal-fired power plant creates a minimum of 1,600 pounds of carbon dioxide. In total, China is now pumping more than 6 billion tons of carbon dioxide into the Earth's atmosphere each year, to say nothing of the sulfur dioxide and particulates that pose a major public health threat. It's not too great an exaggeration to say that convincing the Chinese government to change this equation ranks among the greatest challenges facing humanity.

Indeed, it would be a mistake to view the global competition to master green technology as a zero-sum game. Perhaps the best hope for taming China's belching coal plants is for rich countries, including the United States, to master a specific carbon sequestration technology—such as injecting carbon dioxide safely underground or beneath the ocean floor—and then give the blueprints to the Chinese. If China grows greener, the world will benefit.

"Europe Has Shown That Green Is a Job Creator."

Not yet, though an optimist can certainly find success stories. Denmark, for example, has gotten a PR windfall from its status as the world's leading exporter of wind-turbine technology. Spain has offered generous subsidies to renewable electricity producers. Germany has poured billions of euros into solar power (though critics of the subsidies point out that the price of silicon has skyrocketed as a result, pushing up the cost of solar power in sunnier parts of the world).

Setting aside the inherent problems with governments picking winners, the world recession may tell us whether these "successes" are here to stay. Last year, amid soaring energy costs, Germany and Spain cut back on their solar subsidies; now, many producers are struggling to survive on their own. An optimist would argue that such infant industries need special protection from government while they are young but will learn by doing and develop into more competitive businesses that become cost effective in the global marketplace. But with credit for capital-intensive projects increasingly hard to come by, this theory is being painfully tested.

No matter what, such government subsidies are costly. Denmark may be a clear success, but how many green failures have there been in Europe? Repackaging an old-fashioned industrial subsidy as a "green jobs" stimulus may be not so much an environmental plan as a politically correct way for governments to transfer resources to a favored sector. European carmakers have been asking for such a handout, ostensibly to help them build more fuel-efficient vehicles. Cynics question their sincerity.

Let's also not forget that governments face a budget constraint. To pay for large strategic subsidies, someone's taxes will eventually have to be increased. Higher taxes distort consumption and investment decisions. Households respond to lower after-tax wages by working less, and companies respond to higher corporate income taxes by investing in fewer new projects. The net effect is a less robust economy.

"Green Cities Are Overhyped."

Actually, no. By the year 2030, 60 percent of the world's population will be living in cities. These urbanites will be more productive, healthier, and happier if they are living in clean, livable cities. This is where the jobs of the future will be.

In the 19th century, Karl Marx and Friedrich Engels bemoaned that capitalism gave us such nasty places as Manchester, England. Today, it's green cities—with their clean air, parks and trails, and transit-oriented development—that are winning the capitalist game. Attracting and retaining skilled workers is the key to long-run growth—just ask the chamber of commerce in gritty Detroit, where there are homes for sale today for just $13,000. Meanwhile, once sooty Pittsburgh, New York, and London have reinvented themselves as high-end places where the footloose and educated want to live and work.

Today, all over the world, cities with high quality of life and high environmental quality feature higher housing prices and less out-migration of skilled workers than nearby cities with a lower quality of life. Stockholm is a good example. The Swedish capital enjoys physical beauty and perhaps as no accident has established itself with a synergistic combination of universities, cultural centers, and financial headquarters. Across Europe, high gasoline taxes and the absence of urban fringe land for development have encouraged compact development around historical city centers and the reliance on high-quality, fast public transit.

In China, home to some of the most polluted cities in the world, market forces are revealing the demand for clean air. Beijing's ambient air pollution levels, for instance, are more than four times worse than in Los Angeles. But within the sprawling city, there are areas with high air pollution levels and other areas with much cleaner air. My own research has documented that home prices for standardized housing units are significantly lower in areas of the city with polluted air and little green space. So, even in a country where economic growth seems to trump all, the skilled are voicing a preference for green.

"'Green-Collar Jobs' Is Just a Marketing Slogan."

Yes. But what is being sold? Take this multiple-choice test: Who is a green-collar worker?

A. A trucker who delivers gas to a gas station without ever suffering a spill
B. A scientist doing research on improving hybrid battery technology
C. A home weatherizer who makes house calls helping families increase their energy efficiency

No wonder estimates of the employment impact of Obama's energy plan vary so widely. Defining a "green" job is tricky. The trucker could have caused a disaster by making a careless mistake. His extra effort will not be written up in the newspaper, but such little decisions help to protect us from fires and pollution. The scientist has a shot at devising a great new technology that could both foster economic growth and decarbonize the economy. Finally, many households and firms are unaware of how much money they are wasting on electricity and heating bills. A team of home weatherizers could cost-effectively plug these holes, creating jobs, lowering energy bills, and reducing greenhouse gas production in the process.

But what if these three workers approached the government for a subsidy and the president could only choose one? Which is the greenest job of the three? The president would be forced to take a stand. Does he prioritize a) protecting public health, b) betting on the next generation of green technology, or c) minimizing wasteful energy consumption?

DAVID MCNEW/GETTY IMAGES

"Stopping Climate Change Will Boost Economic Growth."

Unproven. An optimist would hope that the carbon tax incentives or cap-and-trade policies needed to stop climate change would accelerate the development of the hydrogen economy, offering the win-win of cheap, green power. And, of course, we have our children to worry about. Nicholas Stern of the London School of Economics, who has forcefully argued that the benefits of devoting significant resources to stopping climate change exceed the costs, is asking us to sacrifice now (perhaps up to 15 percent of current consumption) so that future generations will suffer less.

This may well be a good trade-off. But it is unlikely to stimulate growth. Carbon mitigation investments will not be costless, and other valuable investments will be displaced by the resources we devote to stopping climate change.

Meanwhile, the arithmetic of global warming is only getting more daunting. Imagine if the American Dream went global, if 8 billion people each owned a vehicle of average fuel efficiency and drove it 10,000 miles a year, a typical amount. This driving alone would create more than 44 billion tons of carbon dioxide annually. But leading scientists say we must reduce annual carbon dioxide emissions to around 7 billion tons annually to protect ourselves against climate change.

How can we get there from here? Today, politicians can point to specific efforts such as questionable subsidies or a "green jobs" program and claim they are taking action. And though most economists and environmentalists agree on the incentives—such as carbon taxes—needed to truly green the economy, politicians, especially those hailing from carbon-intensive areas, are slow to embrace them, as are voters increasingly concerned with pocketbook issues.

With the right policies, we can build a green economy and stabilize the climate. A good first step might be to stop telling ourselves that half measures will work and that the transition will be easy and painless: just a few subsidies here, some technological wizardry there, and presto, green jobs. This may be the most inconvenient truth of all. FP

WANT TO KNOW MORE?

■ In ***Green Cities: Urban Growth and the Environment*** (Washington: Brookings Institution Press, 2006), Matthew E. Kahn examines how evolving preferences about the environment are reshaping the way cities grow and shrink. The Brookings Institution's Web site offers a wealth of information on urban development and environmental policy.

■ U.S. President Barack Obama's energy plan calls for the creation of "5 million new jobs" over the next decade through a combination of subsidies, the promotion of plug-in hybrid vehicles, renewable portfolio standards for electric utilities, and a cap-and-trade program for greenhouse gases.

■ In ***Natural Capitalism: Creating the Next Industrial Revolution*** (New York: Little, Brown and Co., 1999), environmental entrepreneur Paul Hawken and energy experts Amory and L. Hunter Lovins argue that environmentalism and economic growth aren't incompatible. ***New York Times*** columnist Thomas Friedman takes up the cause in ***Hot, Flat, and Crowded: Why We Need a Green Revolution—and How It Can Renew America*** (New York: Farrar, Straus and Giroux, 2008). In ***The Green Collar Economy: How One Solution Can Fix Our Two Biggest Problems*** (New York: HarperCollins, 2008), activist Van Jones argues that a new wave of environmentalism can create jobs and address economic inequality in the United States.

■ In **"Think Again: Climate Change"** (FOREIGN POLICY, January/February 2009), Bill McKibben warns that it may already be too late to stop global warming. Philip J. Deutch cautions in **"Think Again: Energy Independence"** (FOREIGN POLICY, November/December 2005) that efforts to wean the West off foreign oil are hopeless and counterproductive.

MARK NOLAN/GETTY IMAGES

Are there still “limits to growth”?

Matthew Kahn | July 24, 2022

The 1970s launched an environmental reckoning across the U.S. Spurred by rising public concern, corporations and national leaders pledged to protect resources, and created new laws and agencies to lead that effort.

Amid these discussions, a group of researchers at MIT tackled a far-reaching question: How long can humanity keep growing and consuming at its current rate?

Using computer modeling, they came up with an ominous answer:

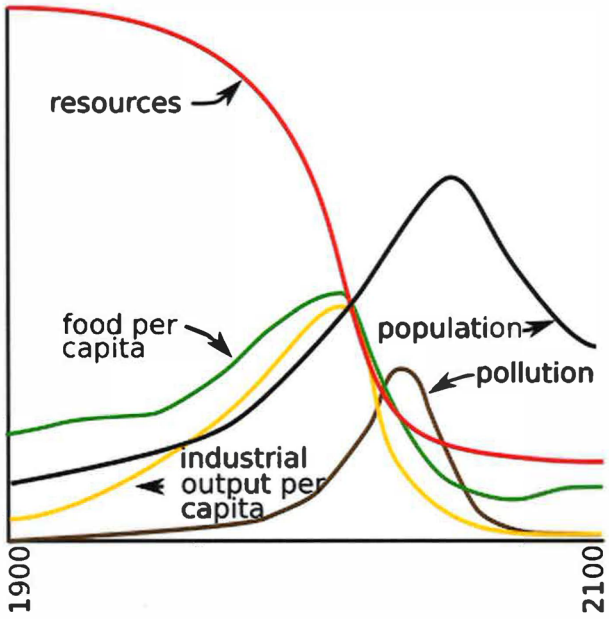
> *“If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most*

probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."

Their report, "The Limits to Growth," generated widespread controversy when it was published in 1972. It was an intellectual extension of biologist Paul Ehrlich's thesis in his 1968 bestseller "The Population Bomb," which predicted that aggregate world demand for resources, driven by population growth, would lead to future starvation. Some predictions in "The Limits to Growth" were impressively accurate, while others proved to be way off.

As an environmental economist, I tend to be skeptical that any one model can explain how the global economy operates at a single point in time, let alone predict global conditions in 2100.

Nonetheless, I believe "The Limits to Growth" got a larger point right: Humans must limit and soon reduce their aggregate production of greenhouse gas emissions. The authors anticipated the potential for the world's economy to shift to cleaner sources of energy, noting that "If man's energy needs are someday supplied by nuclear power instead of fossil fuels, this increase in atmospheric carbon dioxide will eventually cease, one hopes before it has had any measurable ecological or climatological effect."



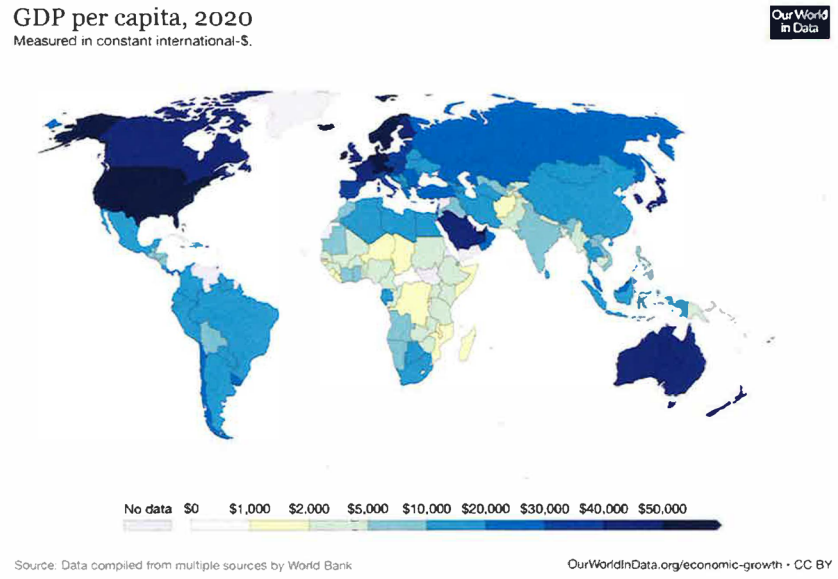
A figure from 'The Limits to Growth,' with consumption continuing at the 1970 rate. It predicted that the depletion of nonrenewable resources would lead to a collapse of industrial production, with growth stopping before 2100.

Extrapolating resource use

The MIT research team that produced "The Limits to Growth" focused on five basic factors that they claimed determined, and therefore ultimately limited, growth on Earth: population, agricultural production, natural resources, industrial production and pollution.

They hypothesized that a growing economy eventually devours its finite supplies of natural resources. If aggregate demand for resources such as wood, oil, rubber, copper and zinc increases as the world's population grows and per capita income rises, they forecast that the world will eventually run out of these precious resources.

At its heart, this is an extrapolation exercise. If developing nations such as India catch up by the year 2035 to the U.S level of average income in the year 2000, the argument goes, then the average person in India in 2035 will consume the same quantity of natural resources as the average American did in 2000. This approach assumes that we can foresee a developing nation's future consumption patterns by looking at consumption patterns in a rich country today.



Wealth per capita varies widely around the world. Richer nations have much higher per capita resource consumption. Our World in Data.

Economists respond

Economists have tended to be more optimistic that ongoing economic growth can slow population growth, accelerate technological progress and bring about new goods that offer consumers the services they desire without the negative environmental consequences associated with past consumption.

The Limits to Growth mindset implicitly assumes that our menu of consumption choices does not really change over time. Consider the vehicle market: In the year 2000, one could not buy a Tesla or Chevy Volt to get around without consuming fossil fuel.

A typical economist would argue that Elon Musk invested in Tesla because he anticipated rising demand for high-quality electric vehicles. In this sense, the belief that we could run out of oil helps us to adapt to expected scarcity by accelerating innovation.

Why? If the Limits to Growth hypothesis is correct, then future gas prices will soar as aggregate demand devours our finite supply of resources. And as gas prices rise, so will future demand for electric vehicles.

This point applies to more than cars. In a 1992 reassessment of "The Limits to Growth," Nobel laureate William Nordhaus argued that rising aggregate demand for natural resources traded in markets, such as oil, wood and copper, will lead to rising prices. This scarcity signal will encourage buyers to substitute other products for increasingly expensive resources.

Economists tend to be optimistic that we can always find substitutes for resources that are becoming increasingly scarce. "The Limits to Growth" implicitly assumed that such possibilities were limited.

For-profit firms constantly design new products to attract consumers. Some goods, such as smartphones, may deplete natural resources. But others have smaller environmental footprints than the products they replace, and those eco-benefits can help attract customers.

For example, affluent people today are choosing to eat less red meat to improve their health. Innovative firms are designing "fake meat" to cater to those consumers. If more consumers substitute fake meat for meat, then the perverse environmental impacts of global caloric intake decline.

"The Limits to Growth" emphasized population and income growth as key determinants of resource collapse. But worldwide, as people move to cities and their earnings rise, they tend to marry later and have fewer children. Nobel laureate Gary Becker argues that choosing to have fewer children represents prioritizing quality over quantity of children. Such household choices help to reduce aggregate population growth and defuse the "population bomb."

Copenhagen offers a model for sustainable urban development, with a goal of carbon neutrality by 2025.

The limits that matter today

Today, scientists and policymakers widely agree that climate change is an overriding challenge worldwide. But the risk isn't running out of resources. Rather, it is warming Earth drastically enough to produce heat waves, wildfires, floods and other impacts on catastrophic scales.

The standard economic policy prescription for cutting greenhouse gas emissions that drive climate change is adopting a carbon tax. This gives consumers an incentive to use less fossil fuel and businesses an incentive to produce better low-carbon technologies, such as electric vehicles and green power.

If every nation enacted a carbon tax that rises over time, then economists would be confident that we could avoid the most severe negative effects of global economic growth. Why? A great race would unfold, with carbon emissions per dollar of global gross domestic product declining faster than economic growth would rise and global emissions declining.

The vast majority of economists believe that economic growth is essential for improving the lives of billions in the developing world. As people invest in their education and urbanize, economic logic predicts that population growth will slow. And energy efficiency will increase if energy prices are rising over time, due to induced innovation.

Children stand in line to receive water distributed by the Kenyan government in Nairobi on April 7, 2020.

Climate scientists are analyzing how much nations must reduce their aggregate emissions to avoid climate change on a catastrophic scale. Ideally, climate mitigation policies can be fine-tuned to balance ongoing global per capita income growth while staying within the aggregate emissions constraints prescribed by climate science research.

Since the full costs of runaway climate change aren't known, many economists have embraced the idea of reducing carbon emissions as insurance against extreme climate risks. Call it a "limit to carbon growth." Ongoing efforts to invest in climate change adaptation, and nascent efforts to explore the potential of geoengineering, provide humanity with additional strategies for coping with the consequences of our past carbon growth.