

Scenarios for Fiscal Space

Adapting to the Long-Term Challenges of Climate Change

Peter S Heller

January 2020

ABSTRACT

Climate change poses significant challenges for governments seeking to assess their long-run financial condition. Looking forward, climate change is likely to threaten multiple aspects of a country's economy. Governments will necessarily be required to provide support in adapting to these challenges. While considerable uncertainty exists as to the nature and magnitude of the adaptation burdens that will be faced, many countries are likely to confront serious limits in their fiscal capacity to address them. With this in mind, this paper argues that governments need to urgently expand their understanding of the long-term fiscal impact of climate change adaptation and outlines pathways to complement current assessments of fiscal space accordingly – with a particular emphasis on scenario analysis. It also calls for the IMF to play an increasingly supportive role in helping countries to anticipate and prepare for the fiscal challenge of adaptation.

ACKNOWLEDGEMENTS

This paper is a chapter in a forthcoming volume on the Business and Investment Case for Sustainability (edited by Alexander Preker and Diane-Charlotte Simon). The author appreciates the helpful comments by both Alexander Barkawi of CEP and Alexander Preker at Columbia University.

ABOUT THE AUTHOR

Peter S. Heller is a Visiting Professor of Economics at Williams College in Williamstown Massachusetts and an Advisor to the Council on Economic Policies. For almost thirty years he worked at the International Monetary Fund (IMF), and was ultimately the Deputy Director of the IMF's Fiscal Affairs Department. He has written extensively on issues of public finance, public health, and development economics. He is the author of *Who Will Pay? Confronting Aging Societies, Climate Change and Other Long-Term Fiscal Challenges*, a book published by the IMF in 2003 on the challenges of addressing long-term policy issues in public finance. He holds a Ph.D. from Harvard University, MA, USA.

CEP DISCUSSION NOTES

CEP Discussion Notes are published by the Council on Economic Policies (CEP), an international economic policy think tank for sustainability focused on fiscal, monetary and trade policy. The views expressed in these publications are those of the authors and do not necessarily represent those of CEP or its board. Discussion notes describe policy-related analysis and research. They are published to elicit comments and further debate.

CONTENTS

1	Introduction	1
2	Integrating Climate Change into the Fiscal Policy Regime	3
2.1	Prevailing approaches to introduce the long run into fiscal policy	3
2.2	Integrating climate change into long-term fiscal planning.....	5
2.3	Recent IMF efforts to integrate the effects of large climate-related natural disasters into a country’s fiscal policy strategy.....	8
3	Grappling with the Uncertainties and Challenges Posed by Climate Change.....	12
4	Why Climate Change Requires a Broader Approach for Assessing “Fiscal Sustainability” and “Fiscal Space”	17
4.1	The role that scenario analysis can play in facilitating analysis of long-term fiscal space in the context of climate change	18
4.2	How to introduce a quantitative dimension to the effects of long-term climate risks on fiscal space?.....	19
5	A Strengthened Approach to Addressing the Fiscal Risks of Climate Change Adaptation	22
6	Final Thoughts	29
7	Bibliography.....	31

1 INTRODUCTION

In the last year, a number of central banks have moved toward testing the financial sector for the implications of climate change. Prudential regulators increasingly seek to assess the risks posed by climate change, both from the impact of climate hazards as well as from the transitional risks to sectors particularly affected by climate change mitigation efforts. In 2018, the Dutch central bank, DNB, has conducted a stress test to account for transition risks for the financial sector in the Netherlands. The Bank of England has included climate change scenarios into its 2019 stress tests for UK insurance companies and announced analogous steps for the entire financial sector, including banks in 2020. The European Central Bank, the Bank of Canada as well as the French financial regulator have signaled similar steps. Members of the US Federal Reserve Board have added further voices of support.¹

Such initiatives provoke the obvious question as to whether the balance sheet of governments should be subject to comparable stress tests. It is now widely recognized that climate change will cause social and economic harm in coming decades to most countries of the world and that the financial position of some governments may be adversely affected. Such harms are already in the pipeline from the climate change already built in from past emissions. The success or failure of current global efforts at mitigation will determine how much more harm will arise from future emissions.

The role of government in both mitigation and adaptation efforts has recently been the focus of several reports by the International Monetary Fund (IMF). In particular, in its recent *Fiscal Monitor*, the IMF has examined the role that fiscal policy and government regulation can play in supporting aggressive mitigation efforts. Recent IMF Board papers have also noted the vulnerabilities that will arise from the effects of large natural disasters arising from climate change and the challenge that countries will face in seeking to address these risks. A recent World Bank research paper (Feyen et al, 2020) also highlights the macro-financial aspects of climate change.

This paper will argue that climate change will pose overwhelmingly large fiscal risks for many countries. Compared to many other contingent liabilities (e.g., for public sector pensions) which are recognized as negatively affecting a country's "fiscal space" or its fiscal

¹ The Bank of England's 2021 Biennial Exploratory Scenario (BES) (2019) highlights that the largest banks and insurers will need to test the resilience of their current business models to the physical and transition risks from their exposure to climate-related risks and to assess the "scale of adjustment that will need to be taken in coming decades for the [financial] system to remain resilient." The BES will require multiple scenarios that embody the risks that might arise *over a 30-year* modelling horizon from less successful mitigation initiatives than had been envisaged in the Paris Accord, including the least desirable "business as usual," no policy action scenario where "the Paris Agreement target is not met and more severe physical risks crystallize as a result. Also see Vermeulen (2018), Howcroft and Jones (2019), Molico (2019), Reuters (2019), Federal Reserve Bank of San Francisco (2019) and Flavelle (2019a).

sustainability,² climate change poses unusually difficult and complex challenges for any assessment of a country's fiscal position. Indeed, this paper will argue that the existing approaches to analyze fiscal space need to be supplemented to assess fiscal policy in the context of climate change and that one must seek methodologies that broaden the concept's insights for long-term policy analysis.

Indeed, most countries should *already* be focused on how to grapple with the enormous complexity of the issues that will be posed by climate change over the next several decades. This includes: the uncertainty of what climate change trajectory can be anticipated, both as a consequence of what global mitigation efforts eventuate looking forward and the numerous geological, biological and meteorological interaction effects that will also influence the trajectory; what hazards are likely in the context of different potential trajectories, given the specifics of a country's location, its physical characteristics and its social and economic dimensions; and what are the vulnerabilities of a country's population in the context of its current social and economic development path.

The challenge for a government will not only be to estimate the extent and magnitude of the risks affecting its balance sheet under different scenarios, but also to grapple with the multiple dimensions of the challenges that climate change may pose. What economic and social policies can be pursued to manage the risks that are entailed? What budgetary and fiscal tools can be used to achieve maximum leverage to support the efforts of the private sector agents who will undoubtedly bear much of the burden from the effects of climate change.

In what follows, section II will describe the methodologies that fiscal economists have used to take account of the impact of long-term risk factors, in particular from that of climate change. It notes that most of the focus has appropriately been on what would be needed to limit further climate change. The section also examines how the IMF has proposed integrating the climate change risks associated with large natural disasters into its assessment of a country's fiscal policy. The section argues that the IMF's approach insufficiently addresses the adaptation challenges that climate change will pose and the instrumental role that IMF surveillance could play in supporting adaptation efforts. Section III will suggest that the inadequate response is not surprising. Policymakers confront significant uncertainties in trying to assess the nature of the economic and social risks posed by climate change and in the formulation of policies to support adaptation to these risks. The discussion in Section III highlights the challenges that arise in trying to estimate the contingent financial burden that might be borne by a government. But nevertheless, most

² Assessments of fiscal sustainability take account of whether, looking into the future, a government will be able to finance its explicit public debt obligations as well as other implicit liabilities (e.g., associated with pensions and other social insurance promises). Fiscal space captures whether a government has the financial room to undertake new policy initiatives—such room may be created by increased taxation, cutbacks in expenditures or additional borrowing. The latter option is typically constrained by whether capital markets are willing to increase lending to a government without concerns for its ability to repay at the prevailing sovereign interest rate.

governments will still be faced with a dilemma: how to reconcile their fiscal space constraints while still addressing the long-term risks and harms posed by climate change.

Section IV offers some thoughts on what kinds of methodologies could illuminate the fiscal space impact of adaptation to climate change. It will emphasize the role that scenario analysis can play, particularly if such scenarios can also draw on the increasingly rich experience of the insurance and reinsurance industries in addressing climate change risks and the growing body of research by central banks and financial regulators on the topic. Section V will suggest a number of initiatives that countries and the international community should urgently undertake to respond to the adaptation challenge. These ideas build on the significant work and insights of the Global Commission on Adaptation (2019) (GCA), the Intergovernmental Panel on Climate Change (IPCC) and various elements of the insurance and reinsurance industry. Section VI will offer some final thoughts on the issues raised in this paper.

In proceeding, the focus of the paper is largely on the challenge of assessing the fiscal risks associated with adaptation. **This is not meant to downplay the importance of global mitigation efforts.** Indeed, the paper fully supports the aggressive mitigation efforts discussed by the IMF and by the IPCC and other international bodies. Such efforts will be critical to minimize the risks and damages that this paper cautions about. But equally, in managing public policy, particularly for the many countries whose emissions are relatively small as a share of total emissions, one cannot bank on the success of even the Paris Accord, let alone more ambitious mitigation targets.

2 INTEGRATING CLIMATE CHANGE INTO THE FISCAL POLICY REGIME

2.1 PREVAILING APPROACHES TO INTRODUCE THE LONG RUN INTO FISCAL POLICY

Climate change epitomizes the issue of a long-run policy challenge. The roots of the phenomenon derive from the beginning of the Industrial Revolution. Its evolution has been driven by the slow buildup of greenhouse gases in the atmosphere over the last 200 years. Its consequences have only begun to manifest themselves in the last several decades with their full force accumulating over time and with their most substantial effects going to be felt in coming decades and, if not mitigated, centuries.

The treatment of long-run issues by macroeconomists has been fairly limited (see Heller (2003)). In a policy context, such as practiced by IMF economists, fiscal policy issues have dominated the discussion with a focus largely on debt and fiscal sustainability. Debt

sustainability became a concern as mounting ratios of debt to GDP raised issues of whether governments could service their debts, and whether the resulting burden could imply a tax ratio that would prove excessive politically. Enshrined by their Maastricht criteria, the fiscal policy of EU countries is constrained in terms of how large a budget deficit can be as a share of GDP without raising the risk of pushing debt levels to unsustainable levels (at assumed rates of interest and real growth).

Managing for sustainability was also recognized as challenged by other factors independent of fiscal policy—e.g., a depreciating exchange rate, changes in commodity prices for a country's principal exports, *inter alia*. The well-recognized myopia of politicians further complicates the issue, as policy commitments were made that initially had only short-term budgetary consequences but with a longer-term tail of anticipated budgetary costs (e.g., with regard to pensions and medical insurance). The change in the demographic picture, with the unanticipated drop in fertility in many countries, only aggravated the likely long-run fiscal consequences of social insurance promises. The awareness that not only explicit debt but implicit debt associated with policy promises gave rise to a broader concern for the *fiscal* sustainability of a government's finances.

In the last few decades, the challenge of rising public debt levels, particularly in many developing and emerging market economies, provoked concern both by multilateral lending institutions and capital markets as to whether governments are constrained in their capacity to finance new investments. Rising debt shares could provoke an increase in the sovereign debt premium, further tightening the debt sustainability noose. The question was posed as to how much "fiscal space" a government had in order to finance expanded budgetary investments and policy initiatives. For countries already burdened by high levels of public debt, challenged in issuing domestic debt by monetary financing, and facing difficulties in floating new debt on international capital markets, the creation of additional fiscal space required either increasing taxes or cutbacks in existing public expenditure programs. For countries with access to capital markets, the amount of available fiscal space was seen as constrained by whatever debt ratio was seen to precipitate a significant adverse change in the sovereign debt premium.

Based on the incorporation of the fiscal space concept into IMF surveillance, a recent IMF (2018) study suggested that there are many industrial and emerging market countries that do have fiscal space, with levels of public debt significantly below the threshold that markets would deem as too high. One could argue that these measures of fiscal space are overestimated in that they do not capture the contingent risk from known off-balance sheet liabilities (notably from pension and other social insurance risks, e.g., particularly medical insurance).³ But less controversial is the recognition that a very substantial number of

³ We would argue that the concept of fiscal space continues to be relevant when thinking about the short-to-medium-term, even when one seeks to embed some types of long-term implicit or explicit obligations of the government such as those associated with potential

countries, certainly among many low-income countries but also for some emerging market countries, possess little or no traditional fiscal space. For these countries, expanded public sector budgets principally depend on the support that might be obtained from foreign assistance or from significant subsidies from multilateral lenders. Recent developments in the conjunctural environment for fiscal policy have perhaps changed perspectives on the availability of fiscal space. In particular, the extremely low interest rate environment has led some fiscal economists to argue that more expansionary fiscal policy initiatives are possible without jeopardizing fiscal sustainability (see Furman and Summers, (2019)). Proponents of modern monetary theory would be even more supportive of expansionary initiatives.

In sum, the concepts of fiscal sustainability and fiscal space both recognized that long-run fiscal challenges could further limit the possible financing for policy initiatives, whether of a short- or long-run nature. Climate change considerations have been seen as affecting this picture in a number of ways. First, the insurance and reinsurance sectors, by offering private sector resources to address the consequences of natural disasters, may now be providing an additional way to expand future fiscal space (the Caribbean regional initiative is illustrative of this approach), though at the cost of insurance premia in the short run.⁴ Second, some mitigation initiatives, in particular, the levying of a carbon tax, could actually create fiscal space by the revenues mobilized (though most proposals involve offsetting reductions in other types of taxation or increased expenditure for other purposes). Third, while both mitigation initiatives and the burdens of adaptation to climate change involve behavioral changes by private sector agents, it is recognized that governments would likely be involved in financing some of these efforts. Adaptation efforts, particularly disaster relief and the rebuilding of infrastructure damaged by climate events could result in future fiscal costs that would add implicit charges on available fiscal space. However, in what follows, we will argue that incorporation of climate change risks, particularly as relates to adaptation, will involve much more substantial charges on a country's economy, raising questions as to the role that governments will be able to play in supporting adaptation efforts.

2.2 INTEGRATING CLIMATE CHANGE INTO LONG-TERM FISCAL PLANNING

In the context of global efforts to address the risks of climate change over the last thirty years, economists have disproportionately and appropriately addressed their attention to understanding what policy initiatives would be required to contain the rise in the average global temperature to no more than 1.5° C during this century. Policymakers confronted scientific uncertainty as to what amount of climate change has already been built into the

social insurance liabilities. Actuarial estimates of potential shortfalls in pension funding can be made, reflecting reasonably solid demographic projections.

⁴ The key challenge that parametric insurance and other reinsurance policies will confront in a climate afflicted role is the extent to which many risks may prove more frequent or more correlated than heretofore.

environment, not to mention the challenge of differentiating and understanding the relative impact of alternative possible policies. Given the expected political and economic costs of such initiatives, economists were initially hesitant to urge aggressive policies in the face of much uncertainty on the magnitude of the threat posed by climate change (see the early work of the recent Nobel Prize recipient William Nordhaus (1994)). Over time, however, economists have increasingly recognized that the threat is indeed large and that substantial mitigation efforts are warranted (e.g. Nordhaus, (2019)). In this context, a key initiative was the advocacy of Lord Nicholas Stern of zero interest rates in policy formulation in order to limit the bias produced by positive interest rates from discounting techniques on climate-related investments that yielded benefits only over the very long term.

Economists have thus put much effort into exploring the policies required for mitigation (see the IMF's 2019 *Fiscal Monitor*). Policy efforts have focused on three principal instruments: the levy of a substantial carbon tax to sharply raise the price of carbon and encourage economic agents to shift away from carbon sources of energy; the use of emission trading regimes that effectively achieved the same ultimate effects as a carbon tax; and regulatory regimes that have sought to curtail the amount of emissions associated with alternative sources of energy production (e.g., limits on gas mileage, requirements for sequestration of carbon emissions in coal-fired plants, etc.). Recent Green New Deal policy initiatives have sought to address the broader factors underlying the carbon intensity of many forms of consumption (*inter alia*, in transport, food production and housing) (see Friedman (2019); United States Congress (2019)) The overriding objective of all these initiatives—enshrined in the Paris Accord of 2016—has been to alter what has been called the “business as usual” trajectory of climate change—viz., that trajectory which will develop as a consequence of existing modes of production and consumption and taking account of the likely growth in economies and populations looking forward. Some have called for the world to move to zero net emissions of greenhouse gases by mid-century. Many scientists have gone further and argued that an aggressive reduction of emissions will be needed in the next decade if a number of physical and irreversible “tipping points” are not to be breached that would make the consequences of climate change particularly difficult in the rest of the century (see Rosen (2019) and Lenton et al (2019)).

In terms of fiscal policy, economists have thus sought to estimate the overall cost of these initiatives and more specifically, the fiscal implications of the government's role in their pursuit. The recent IMF policy papers (2019b, 2019c, 2019d) provide succinct descriptions of some of the policy regimes being considered as necessary and how they would impact the fiscal policy of governments. As noted, some initiatives, such as a very substantial carbon tax, could generate significant amounts of revenue, but with the expectation that much of this revenue gain would be offset somewhat by a reduction in other types of taxation (e.g., a cut in sales or value added taxation) and with some of the revenue gain used to finance both

mitigation and other unrelated policy initiatives. Other policy regimes, such as for example those associated with the Green New Deal, have not been as fully costed.

Understanding the costs of what would be required for mitigation is understandably complex. Disentangling the burden to be borne by government budgets will be a further challenge. Contributing to the complexity of the challenge is that it will require aggressive policy efforts, not just by one country but, given the global nature of the challenge, by virtually all countries, not only today but in coming years. There are two other difficulties. First, one is grappling with the challenge of changing the way in which energy and other sources of emissions are produced, the nature of what goods and services are demanded for consumption, and the technologies used in these efforts, in many disparate countries and cultures. Second, one must also take account of the growth in populations and economies, all of which will have to be incorporated in clarifying what policy efforts will be required to achieve the desired mitigation policy initiatives.

For the purposes of this paper, several points need to be emphasized. **First, the focus on an aggressive strategy of mitigation by the global policy community is wholly appropriate.** All scientific evidence points to the irreparable damage and harm that will arise from a rise in average global temperatures above 1.5°C. (as examples, see Wallace-Wells (2019), Sengupta and Cai (2019), Crausbay and Ramirez (2018), DeFries et al (2019), Lu and Flavelle (2019) and Nicholls et al (2011)).

Second, the challenge of mitigation is exacerbated by a number of uncertain and complex interacting factors which have already been unleashed by what climate change has already occurred to date or is likely soon to be unleashed even with the most aggressive mitigation efforts. As an example, emissions of methane from the melting of the permafrost in the arctic regions will further contribute to the greenhouse gases in the atmosphere and for which further cutbacks from anthropogenic sources would be necessary if temperature targets are to be achieved. Similarly, the warming of oceans may gradually change its capacity as a carbon sink that has buffeted to some extent the impact of greenhouse gas emissions in the past. The possibility of an environmental “Minsky Moment” cannot be disregarded, whereby a sudden tipping point is realized from a variety of geophysical factors.

Third, the challenge of mitigation *today* principally rests on the shoulders of no more than roughly five or six countries or economic blocs—viz., those that account for the principal sources of carbon emission as well as those whose carbon sink functions (e.g., from deforestation) are being degraded under current development policies. Roughly, these include the United States, Europe, China, India, and Brazil. One might also include in this list those countries who are key extractors of energy products (gas, petroleum, and coal), the curtailment in production of which would have seriously adverse effects on their economies. Some other countries that are not major emitters today will come on the policy screen soon

enough, reflecting both their rapid population growth (if not economic growth), and the demands of these populations for energy-intensive consumption.

Fourth, the mix of mitigation policy approaches required of these countries is likely to differ, with their fiscal consequences also likely to be different.

Fifth, for most countries, the challenges posed by climate change lie more with the consequential mix of physical and transition costs that will eventuate over time from whatever climate change trajectory results from the mitigation policy initiatives of the smaller group described above. The mitigation policy initiatives of many countries, while necessary, will **not** be the principal determinant of the climate change trajectory that will be experienced over time. This disparity between their role in causing climate change and their challenge in bearing its burden has been well noted in all global policy fora.

Sixth, the costs of adaptation have been largely seen in the context of the climate change trajectory that would arise if the world were successful in realizing either the Paris Accord or more aggressive mitigation strategies. This paper argues rather that **adaptation strategies should also be considered in the context of mitigation strategies that yield a much less desirable trajectory for climate change in coming decades.** The recent remarks by Mark Carney illustrate the importance of this issue. On December 28, he noted that

“if you add up the policies of all of companies out there, they are consistent with warming of 3.7°-3.8°C...the concern is whether we will spend another decade doing worthy things but not enough... and we will blow through the 1.5°C mark very quickly. As a consequence, the climate will stabilize at the much higher level” (BBC News, December 30, 2019).

What are the costs of deferring attention to the need for an adaptation strategy that anticipates much greater damage from climate change in coming decades? Will deferred action make future adaptation efforts even more costly and difficult?

2.3 RECENT IMF EFFORTS TO INTEGRATE THE EFFECTS OF LARGE CLIMATE-RELATED NATURAL DISASTERS INTO A COUNTRY'S FISCAL POLICY STRATEGY

The IMF's paper (2019c) on building resilience in developing countries vulnerable to large natural disasters highlights the need for disaster resilience strategies. It outlines a three-pillar approach that involves: investing in *structural resilience* to limit the impact of natural disasters; building *financial resilience* to create “fiscal buffers and using pre-arranged financial instruments to protect fiscal sustainability and manage recovery costs;” and creating “*post-disaster (and social) resilience* [that] requires contingency planning to ensure a speedy response to a disaster.” While the paper zooms in on natural disasters and thus does not address the much larger and more complex challenges that countries will face, it

still can be seen as offering a basis for a comparable three-pillar strategy to address the challenges that climate change will pose.

Briefly summarizing the IMF's approach, **structural resilience** is seen as a preventive approach involving investment in both "hard" policy measures (e.g. physical infrastructure) and "soft" measures (e.g. establishing "early warning systems, customizing building codes and zoning rules"). It recognizes that "in the absence of a comprehensive strategy to build resilience, investment in adaptation is often poorly coordinated if not sufficiently prioritized" and takes a back seat to other urgent social and development needs. It notes that the underinvestment in structural resilience reflects a "short term bias in policy making, tight fiscal constraints, and limits on borrowing capacity due to elevated debt levels or poor credit worthiness, and limited concessional financing."

The **financial resilience pillar** is implicitly linked to the concepts of fiscal sustainability and fiscal space but also includes considerations of the multi-level risk management approaches emphasized by the World Bank. It is the principal pillar that one might associate with a ministry of finance's role in adaptation. The concept of "self-insurance" entails the provision of "**fiscal buffers.**" While the focus is largely on contingency reserves, the buildup of financial assets implies a reduction of net debt on a government's balance sheet and thus the creation of fiscal space (whether at the national, state or local governmental level). It is an acknowledgement of the negative implicit financial burden associated with the government's role in adaptation, or more specifically in its reconstruction and rebuilding role in the aftermath of disasters arising from climate events.

A second element of the financial resilience pillar involves the **transfer of risk through insurance and other risk-sharing mechanisms.** The principal modalities available include traditional insurance (often backed by reinsurance) and parametric insurance (whereby insurers make payments when a specified qualifying event occurs which meets the trigger conditions necessary to activate a payout). Both mechanisms may be viewed as alternative modalities by which a government's fiscal space can be augmented, at least over the medium term, but with the contingent risk that reliance on these approaches may carry larger longer-term risks than reliance on alternative approaches to adaptation, including some which are associated with the first pillar. As an example, both approaches have been used in recent years by some Caribbean island economies to facilitate a regional sharing of the risks associated with a hurricane disaster that strikes an individual island economy. Two obvious costs have to be associated with these insurance approaches: first, the premiums may be costly. Conceptually they are analogous to debt service outlays that reduce expenditures available for other types of public goods and services and public investment.⁵ Second, insurers rarely provide these policies for periods in excess of five years.

⁵ A recent IMF paper by Cebotari and Youssef (2020) elaborates on the role that natural disaster insurance can play for countries.

A final source of financial resilience may derive from prearranged credit lines with international financial institutions or from an expectation that humanitarian assistance would be provided in the wake of a natural disaster.

The third pillar, the **provision of post-disaster relief**, in most low-income countries involves a discretionary budgetary response to emergencies. More developed low income and emerging market countries may have more systemic social protection approaches involving social safety nets or explicit types of insurance.

Beyond the important qualification that the IMF's approach is only an initial step towards addressing larger issues of climate change adaptation, there are five important issues still to be considered in addressing the challenges posed by climate change for fiscal policy.

First, the IMF strategy underscores that a finance ministry still needs to know how much financial resilience will be needed. How much of a contingency fund, or lower net debt target is appropriate, given a country's long-term exposure to climate change hazards? How much of a tradeoff should be sought in reliance on a buffer rather than continuous upgrading of insurance provision? How much will the size of the requisite buffer change over time as a function of how much the anticipated trajectory of climate change itself evolves over time? How much account is taken of what we know will be the buildup of climate change forces over time, the increased likelihood of different kinds of climate hazards, and the systemic structural shifts that could occur (including the nonviability of sectors and the complexity in the way in which "disasters" can occur)?

Second, as with most issues in budgetary policy, devolvement of decision-making to other government agencies is required for estimating what projects and programs will be necessary, particularly in relation to the first pillar projects. As often happens in other spheres of public policy, "silos" will develop in relation to climate change planning (see Tett, 2016). Key responsible agencies—particularly those dealing with the environment—are often not integrated with other key actors that need to play a role in thinking and acting on climate change adaptation. Moreover, much adaptation is necessarily the responsibility of lower levels of government, often ones with only limited fiscal autonomy.

Third, any adaptation strategy, particularly one that involves insurance, may entail "moral hazard" challenges. Integration of climate change risks across government agencies cannot be separated from other aspects of development policy and investment which may easily "assume away" climate risks because of the assumption that insurance or fiscal buffers are "dealing with adaptation in the event of a disaster." Another way to consider this issue is to examine how and whether climate change adaptation issues influence (if at all) how most development policies are thought about and specific projects and programs are formulated. The problem of "silos" is too normal and common to be ignored for this type of issue.

Fourth, the IMF paper is unclear as to how the strategy is intended to be integrated into the IMF's surveillance process? Is it anticipated that the IMF will routinely, perhaps in conjunction with the World Bank, carry out an assessment of the progress in developing and implementing such a strategy? Will full scale reports be issued every few years? How will the IMF build up a capacity of knowledge to incorporate climate change mitigation and adaptation into its surveillance efforts?

Fifth, the IMF's approach is grounded on "a comprehensive forward-looking diagnostic of the country's vulnerability to natural disasters." Much of the paper's discussion relates to the type of physical disasters that have occurred in coastal countries that have suffered extreme storm, wind and sea damage from hurricanes and tsunamis. Yet the challenge of adaptation to the impacts of climate change will be much broader and complex than the response that may be appropriate in the case of responding to a large "natural disaster" and the way in which their economic and social impact is felt. The IMF's approach, while an important step forward, still may be considered as too much of a ratification of a "business as usual" development strategy. This paper argues that the path of climate change requires a rethinking of this strategy, one that is broadened and strengthened to take account of the dramatic effects that climate change can have on many countries.

Sixth, much of the focus in the IMF's approach relates to the strengthening of the "resilience" of infrastructure and economic systems in response to the likely effects of climate change. But what do we mean in using the term "resilience"? Several dictionary definitions of resilience include: (i) "the power or ability to return to the original form, position, etc., after being bent, compressed, or stretched; elasticity"; (ii) "the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress"; (iii) "an ability to recover from or adjust easily to misfortune or change". While the third definition appears broad enough to serve as a basis for a strategy for adaptation, the other two raise **questions as to whether resilience should be the principal or only focus for climate change adaptation.**

Specifically, the effects of climate change may be such that many aspects of a country's current economic strategy may no longer be viable. A return to the previous approach or state may not be possible or desirable. Rather than "snapping back" to restore an economic structure as the requirement for achieving resilience, a government might wish to foster the realization of changes in a local economy that safeguards the social cohesion of an affected population group in a way that allows it to meet its needs (or at least restore much of its previous welfare).

Moreover, for many countries, the *current* development strategy may be such as to render the consequences of climate change much more damaging than would be the case if the current strategy were to be significantly altered. The most obvious illustration relates to countries that will be seriously afflicted by climate change in the next several decades and

where current fertility rates will double or triple the population that will be adversely affected. The urgency of addressing high fertility thus may be a critical component of an adaptation strategy.

3 GRAPPLING WITH THE UNCERTAINTIES AND CHALLENGES POSED BY CLIMATE CHANGE

Is the approach adopted by the IMF sufficient? Does it really address the problems at hand, or is it too narrowly focused on the “physical disaster” manifestation of climate change? In what follows, we will argue one needs to have a richer understanding of the way in which climate change in the 21st century is likely to eventuate and what adaptation strategies may need to be entailed. Certainly, the risks posed by climate change are no longer unexplored phenomena. The many reports issued by the IPCC and the ongoing research by the scientific community highlight how much we now know about the risks and hazards that would seem to be posed for any country. And yet to formulate policy in the thicket of this material is to quickly recognize the complexity and uncertainty of what we do not know and why the process of obtaining clarity for policies is fraught with difficulty.

Intertemporal dimensions

Climate change is an on-going phenomenon that has largely been the consequence of past CO² and methane emissions. Even if all CO² emissions and methane discharges suddenly stopped, further climate change has already been locked in, with multidimensional effects on all aspects of society for most countries of the world. Regrettably, all the adverse determinants of climate change—the subject of mitigation policy initiatives—are still occurring, whether from CO² emissions, methane discharges, deforestation, or from the interplay of existing climate change effects with multiple geophysical, ecological, and biological forces.

Thus, the effects of climate change are likely to worsen over time. How much they will worsen will depend in part on how successful mitigation policies will prove to be, over what specific time periods such policies will have an impact, and also as a function of factors that are simply too complex for most policymakers to assess. These include the various interaction effects of climate change on other key geophysical determinants—to mention a few, the speed of melting of the ice caps and the Greenland Ice sheets; changes in oceanic circulation patterns; the capacity of the ocean to absorb higher temperatures; the extent to which the ongoing melting of the permafrost releases highly charged methane into the atmosphere; and the changing composition of the soil and its interaction with bacteria and other species. Also, interactive with mitigation initiatives is the pace of development of

countries, their growth in population, per capita income, and the energy intensity of their consumption patterns.

In the scientific or adaptation modelling literature, all these uncertainties are typically distilled to alternative scenarios on the likely change in global temperatures. These are typically expressed as (i) “business as usual” (emissions proceeding as in the recent past without significant progress in reducing emissions; (ii) “moderate mitigation efforts, namely policies that represent substantial improvement but which still fall short of those seen as necessary to achieve the Paris Accord targets; and (iii) aggressive mitigation policies that succeed in holding the change in temperatures to no more than 2° C above preindustrial levels. How aggressive these policies will ultimately need to be remains uncertain. The policy effort might require more or less “aggressiveness” depending on the many uncertain feedback effects that scientists are still trying to understand. Indeed, depending on the nature of tipping points, such an outcome may prove almost impossible to realize, particularly if the pace of the required mitigation efforts is itself a critical variable. Some argue that substantial upfront efforts will be needed to avoid the effect of such tipping points.

Thus, **the trajectory of climate change that countries will encounter is highly uncertain.** Pragmatically, most countries would not err in their approach if they at least took account of the worst possible outcome—viz., the business as usual scenario. Even these adverse scenarios may prove optimistic. We now realize that the speed of climate change has been consistently underestimated in the last two decades and that the climate change effects that were assumed to be 20-30 years in the future are now occasionally already happening with unexpected frequency and damage.

The intertemporal dimensions of climate change are manifested in the fact that the experience of climate change hazards has changed over time. Indeed, these effects may prove more complex and more adverse than one would now anticipate. The world of tomorrow will not be the world of today, and that may increasingly be the norm. Policies of adaptation today may succeed only for a while but assuming change and the need for further adaptation in some spheres may be necessary. Policymakers thus need to be aware that in many spheres, their policy efforts will be in need of frequent modification or reconsideration. For some countries, this can be of an existential nature—coastal borders being shrunk dramatically; coastal cities swamped by sea level or vulnerable to storm surges; areas normally available for a certain kind of agriculture no longer being viable; areas fit for habitation requiring new approaches to ensure their viability (see Lu and Flavelle (2019); Nicholls et al (2011)). For economists used to discounting benefits, the marginal calculations may need to be supplemented with consideration of the nature of “future states” for different regions. “Ceteris Paribus” (holding other variables constant) becomes a hard concept to assume readily as one looks forward in time.

Multiple hazards

For any country, climate change will be associated with *multiple* hazards. A recent model by Mora et al (2018) illustrates this fact.⁶ It allows an analyst to place a cursor on any position on a map of the globe and to be informed about the *relative* importance of multiple potential hazards of climate change, with positive or negative effect, at any point in time between now and 2095 and under the three scenarios described above. Such hazards include such effects as: fire, drought, ocean change, freshwater deficits, precipitation, storms, heatwaves, warming, deforestation, floods and sea level rise. *Each* of these hazards could have significant and substantial consequences in the case of a particular country. Some might take the form of *discrete* events that result in damage or loss to different kinds of infrastructure, homes, schools, and specific economic sectors (in agriculture, forestry etc.) with impairment and losses in the production of a wide range of services over time. Government or the private sector might attempt to insure some physical assets against such risks when they are perceived as infrequent or randomly distributed.

Other hazards might be of a different kind—affecting the economic viability of specific areas of production and, if possible, necessitating adaptation to alternative technologies or alternative product lines. Others might affect the viability of places of habitation, necessitating large scale migration out of previously inhabited regions. Sea level rise, salinization of previously arable land, or excessive heatwaves may force such movements.

Complexity in the frequency or the timing of the occurrence of such hazards may be problematic. For many hazards—e.g. the exposure of coastal areas to serious storm damage from significant winds or storm surges—residents of the affected regions may increasingly recognize the nature of their exposure to such risks and their increased frequency relative to the past. In contrast, many kinds of hazards that now emerge have not been anticipated, reflecting intense new and unanticipated meteorological patterns. As an example, the recent fires afflicting many parts of Australia and California suggest an intensification and increased frequency of risks not previously encountered (see Webb and Xu (2018)). The untimely and intense precipitation that affected the US Midwest in 2019 is another illustration, with dramatically large flooding in areas not heretofore affected, disrupting normal patterns of agricultural planting, followed by subsequent periods of rain or dryness that disrupted the harvesting of what crops had been able to be planted (see Schwartz (2019)).

With the mind set of an insurance analyst, the policy maker would then need to consider, for any region within his or her country, the nature of that region's "exposure" to such hazards and the "vulnerability" associated with that exposure. Specifically, for an economist, drawing

⁶ Another recent model from Stanford's Natural Capital Project (see Chaplin-Kramer, 2019) allows one to pinpoint where people are most likely to lose vital benefits as ecosystems degrade.

on the dry meaning of an insurance optic, “exposure” would mean both what populations would be most at risk from that hazard as well as what economic, social and cultural assets might be at risk from the hazard occurring. The tableau of such exposures—the populations affected, the specific assets potentially at risk, and the economic sectors involved can become large and important.

The policy challenges at issue then become a function of the nature of the vulnerability. What are the economic, social, political and cultural losses that emerge if the hazard were to occur in a serious way? As indicated above, the model may indicate that the hazards of climate change for the region of a country may be minor in the next decade or so, but then become much more quantitatively serious looking out over several decades, *again taking note of the uncertainty as to which trajectory we are dealing with*. Even more difficult to grapple with are the interaction effects from the occurrence of these potential multiple hazards in a given region and their follow-up consequences for other parts of a country not directly impacted. Some may prove highly existential, rendering a region uninhabitable or largely unviable, either as a place to live or as a productive environment.

What becomes clear as one gets into the weeds of considering the consequences of such hazards for different regions of a country is that the challenge of understanding and taking stock becomes overwhelming. The only analytically viable approach to reaching such an understanding would take the form of scenario analyses that would highlight hypothetical but nevertheless detailed stories of what could potentially occur and what consequences for different population groups, economic sectors, and important assets could be contemplated. Imagine that certain regions are no longer viable places for habitation, and that one may have to contemplate significant resettlement of populations to less exposed regions of a country or to major urban centers (see Van Vuuren et al (2010)). This is certainly a potentially relevant scenario to consider for the many coastal regions of the world now predicted to be susceptible to major flooding as a consequence of sea level rise. Equally, imagine the consequences of a significant glacial melt in some countries, with heavy flooding followed by the nonviability of hydroelectric energy plants.

The perspective of the insurance industry from such types of risk analysis is particularly insightful. For an insurance analyst, considering the insurance of physical infrastructure or housing, it is possible to consider the probabilities of different hazards and to assess what premium might need to be charged to make insurance a profitable possibility. But the challenges of costing the adaptation that will be needed in a given scenario or of assigning probabilities to such situations are much more difficult than that associated with insuring physical infrastructure within a medium-term framework.⁷ And the role of the insurance industry in providing insurance to cover the costs of adaptation is likely to be unfeasible for the private insurance industry. Moreover, even for events seen as potentially insurable, the

⁷ Indeed, in the traditional analyses involving multiple scenarios, one does not assign probabilities to individual scenarios.

long-term time dimension required would prove a difficulty for the industry. As noted in a recent paper commissioned by the GCA:

“There is evidence of increasing use of multi-year contracts for physical assets, particularly catastrophe bonds, which typically have a 3- to 5-year duration. However, multi-year contracts of sufficient duration to cover a climate adaptation window of, say 10 years, would be challenging to implement under a regulatory framework that also demands solvency for insurers. Specifically, to ensure they could pay claim against a long-term and uncertain risk future, insurers would need larger capital reserves. These would need to be built into pricing that would make the cost of premiums prohibitive.”⁸

The role of government in adaptation

Further complicating any assessment of the *fiscal* implications of adaptation is the difficulty of clarifying what the government’s role should be in adapting to climate change. In an earlier publication, we argued that while much of the burden of adaptation would fall on the private sector, “it is unlikely that the public sector will remain unscathed [...] Areas of public sector involvement include outlays on infrastructure, [...] other public goods in the areas of disease prevention and agricultural extension and research, [...] and subsidies to facilitate the resettlement of populations.” (Heller (2003), p. 23). Certainly, governments will also need to clarify for the public what are likely to be the potential consequences of the climate change that is likely to occur, with the hope that market forces will penalize (or favor) those sectors and regions likely to be most adversely (or positively) affected.

Looking ahead, one could argue that a more active government role would include certain key areas: (i) addressing the vulnerability of physical infrastructure assets offering significant externalities (but recognizing that in some cases, the protection of such infrastructure may prove a futile exercise); (ii) anticipating the need for physical infrastructure in regions likely to be the focus of increased internal migration by population groups; (iii) providing a social safety net for those population groups most adversely affected by the increased nonviability of a region for habitation or for continued economic involvement; (iv) encouraging regulatory regimes that limit investments in sectors particularly exposed to recognized risks or in regions likely to be the most vulnerable; (v) the subsidization of insurance products in cases where the private insurance industry is unwilling to cover the risks of many hazards, but without enabling a moral hazard that incentivizes the private sector to undervalue the extent of the risks that such hazards may engender.

Our earlier perspective on the role of government might have been seen as limiting the extent to which the losses that may arise would be borne on a government’s balance sheet. Yet it would now appear irresponsible for governments to avoid serious consideration of the

⁸ Paula Jarzabkowski et al, July 2019, *Insurance for Climate Adaptation: Opportunities and Limitations*, p. 28. Also see Association of Climate Change Officers (2014), Audley et al (2019)

scenarios that could emerge from climate change or to propose policies or investments that essentially pretend that these hazards will not occur—that the world of tomorrow is just a logical continuity of the world of the recent past. If it is highly likely that many regions or sectors may become increasingly nonviable, this should be reflected in both budgetary priorities and in the regulatory and policy signals that are conveyed to a population. Approaches may also be needed to provide greater transparency on the implicit budgetary risks for the government’s balance sheet of adaptation efforts (perhaps in annexes to the budget).

Interactions with the public policy agenda

One of the more serious consequences of entertaining consideration of the risks of climate change for a country is that the vulnerability is magnified by the size of the population and assets at risk. Particularly in sub Saharan Africa, the Middle East, and parts of South Asia, expected high rates of fertility are likely to add further challenges in terms of the availability of fresh water and food, as well as in terms of investments to maintain per capita income. Policymakers that are unwilling to confront these additional challenges of high fertility and the consequent dangers posed by climate change risks in a higher population environment are inviting increased vulnerability.⁹

Equally challenging is the recognition that the understandable drive for increasing per capita income could invite further vulnerability as climate change risks intensify. In considering the economic policy agenda and the fiscal policy regime of many countries exposed to climate change risks looking forward, can it really be sufficient to simply ignore these risks or the consequences of the focus of the ongoing development policy agenda or sectoral investment strategy? Is it sufficient to simply sign off on the short-term to medium-term macroeconomic viability of a policy agenda that contains the seeds of significant losses looking forward over the longer term?

4 WHY CLIMATE CHANGE REQUIRES A BROADER APPROACH FOR ASSESSING “FISCAL SUSTAINABILITY” AND “FISCAL SPACE”

For almost all countries, the issues raised above on the adaptation challenges posed by climate change suggests that the availability of fiscal space over the longer term may be significantly overestimated. Some countries will inevitably find their budgets heavily burdened by the need to facilitate private sector efforts to adapt to climate change and to provide social welfare support to an increasing share of the population unable to cope with

⁹ Some gender specialists would argue the absence of women at high levels of political leadership invites a pro-fertility mindset that overrides those groups in society that bear the highest cost from high fertility.

its effects. For the many countries whose fiscal space is today already severely constrained or nonexistent, adding adaptation to the policy agenda will obviously be difficult without external financial support (see Jubilee Debt Campaign, 2020).

The above discussions also underscore the difficulty and complexity involved in making quantitative estimates of the potential financial burdens on the public sector associated with adaptation to climate change or in responding to the welfare impact on populations whose lives will be severely disrupted by the impact of natural disasters and environmental change. Both the uncertainties of what climate change trajectories to assume and of the range and complexity of the cost from climate change that will arise suggest the difficulty of any such exercise. Attempting to come up with a single estimate of fiscal space that accounts for long-term climate risks is likely to be a fool's game. But there are ways to approach quantification of the fiscal implications of climate change based on scenario analysis and stress tests that are worth considering.

4.1 THE ROLE THAT SCENARIO ANALYSIS CAN PLAY IN FACILITATING ANALYSIS OF LONG-TERM FISCAL SPACE IN THE CONTEXT OF CLIMATE CHANGE

In the absence of hard numbers on the financial burden that might arise from the effects of climate change, assessing the fiscal implications will require different approaches than normally used. Specifically, it would call for the periodic use of scenario analysis based on recently developed models on the likely effects of climate change. As noted above, there now are models able to provide much greater specificity on the range and magnitude of climate-related disruption that could be faced by individual countries (and indeed even specific within-country regions), looking forward at least 75 years and under alternative scenarios on the trajectory of climate change.

Such models provide a sufficient basis to construct economic and social scenarios for individual countries that can explore the likely economic and social ramifications of such climate change trajectories looking forward. Such scenarios can be elaborated to also reflect the manifold uncertainties on how climate change effects may be manifested—witness even today the unpredictability of droughts, excessive precipitation, flooding, fires, that are afflicting many countries, developed and undeveloped. Most important, such scenarios could be designed to also incorporate the non-climate change factors that will influence the likely economic and social impacts that will be felt. This relates to the expected growth of population in many countries; the projected growth in the economy and the sensitivity of particular sectors to climate effects. For many countries, the scale of the adverse effects will be much larger as a consequence of any failure to contain or adapt to these forces.

Scenario analysis also affords the possibility of introducing a quantitative dimension in assessing the costs of climate change adaptation, in effect facilitating the broadening of

approaches to the fiscal space concept. While one is not likely to be able to offer an all-encompassing number, country analysts would be able to estimate the financial consequences of *specific* climate change-related costs specific to a region as they might eventuate under different plausible scenarios. With such estimates, one would at least be in the position to assess the tradeoff between alternative investments (e.g., an education project) as opposed to having the financial capacity to address a specific climate change hazard. Over time, scientific efforts might facilitate greater insights as to the probabilities of particular climate change effects.

4.2 HOW TO INTRODUCE A QUANTITATIVE DIMENSION TO THE EFFECTS OF LONG-TERM CLIMATE RISKS ON FISCAL SPACE?

The challenge can be readily presented. One wants to look forward several decades. Scenario analysis provides a good starting point for characterizing a picture of how the economy and society may be affected by climate change under alternative potential trajectories, given the uncertainty on the effectiveness of global mitigation efforts. That picture can potentially identify the types of economic and social harm that may arise, but not necessarily the full quantitative consequences of that harm. It also leaves unanswered the question of what the government's own risk exposure is likely to be, or in other words, how much must the government rely on the private sector to bear the costs and burdens of adaptation.

Policymakers and the public can only judge what role the government should play, when tempered by their having some sense of the financial implications of different potential roles for the government and the affordability of such roles. But the question remains, how to estimate the overall financial consequences of climate change adaptation that might be encountered?

One potential source of guidance can potentially come from the experience of the financial sector and its regulators. Already, the insurance industry is encountering manifestations of climate change hazards in a number of spheres, whether fires, typhoon winds, storm surges, drought, excessive precipitation, coastal inundation, etc., in the case of individual countries.

In some cases, the nature of this experience may appear similar to the types of climate risks one may be projecting for a country or a region of a country in the context of future climate change. As such, the insurance industry has an ever-improving understanding of what the costs of such hazards might be as well as an acute understanding of what premium needs to be charged to a government seeking to insure against such hazards looking forward, though with a time profile rarely exceeding 10 years and more likely only five. Obviously, such premia also reflect the state of development (in terms of infrastructure) of the countries exposed to climate risks, thus qualifying the task of applying the data from one country to another country of very different socio-economic characteristics.

Still such cost estimates for premia, in principle, could be used to characterize the likely up-front cost to a government (a cost in present fiscal space) seeking to create future fiscal space from insurance payments in the context of the occurrence of climate change hazards. The use of such contemporaneous estimates might overstate the costs that one might anticipate in a long-term scenario analysis. One might need to discount the costs substantially, since it is a phenomenon that might only happen in several decades (though Stern's recommendations for a zero interest rates would modify this argument). However, arguing against this point is the recognition by many in the reinsurance industry that a retrospective perspective on the risks may understate the financial burdens that the industry may encounter in the future (a point of contention in the case of the recent fires in California). Some assignment of probabilities would equally be needed for hazards whose timing is uncertain.

Climate risks are also rapidly moving up the agenda of the banking sector – also driven by the fact that financial regulators are increasingly asking financial institutions to report on the climate risks they are exposed to. Moreover, a growing number of central banks are exploring the physical and transition risks of climate change to the financial system as a whole. Scenarios and associated costs play a significant role in these assessments.

Such estimates of financial cost would also prove valuable for fiscal policymakers in a number of ways. First, it would allow a clearer understanding of the potential tradeoffs faced by a government in deciding on other elements of its budget. If one can assign a measure of the budgetary cost to provide adequate insurance in the event of hazards, one can weigh that cost against the value to be realized from other expenditures. Certainly, it would illustrate some of the charges against fiscal space associated with at least some climate change-related costs. Second, a government policy maker would be able to judge whether a government has sufficient fiscal space to afford a particular role in climate change adaptation. If perceived as too costly, it suggests that a government must pursue a different strategy in facilitating private sector adaptation. It might mean that a government might need to fall back on a social safety net role rather than some more aggressive form of adaptation (such as strengthening the resilience of infrastructure or rebuilding of an area). Third, and importantly, insurance for climate change risks constitutes another mechanism for considering fiscal space (beyond simply the room for additional borrowing).

Current experience in many countries with forms of adaptation, resilience building, reconsideration of the economic viability of a region, and social safety net burdens is now providing a useful bounty of data—financial and experiential—on the challenges, the costs, and the issues that arise in adaptation. The GCA and the IPCC are increasingly proving valuable resources in providing such data. If scenario analyses for an individual country's exposure to climate risks suggest a mirroring of the experiences that are already being encountered by other countries, this should allow for a richer estimate of the likely costs that

a society will bear. It would further illuminate government policy decisions on what the government's role should be. Presumably, one would find that the extent of government involvement in such countries may be linked to whether fiscal space was available domestically or provided only by external resource transfers from donors.

Where does this leave us in considering the concepts of fiscal space and fiscal sustainability? Perhaps the key answer is that taking account of climate issues requires a broader optic on fiscal space which requires different methodological approaches. While the fiscal space concept may continue to have short to medium relevance in managing day-to-day fiscal policy, regarding longer-term fiscal policy, the issue of how climate change may affect a country's economic and social picture must become a much more dominant qualifying consideration. Some countries, with highly diversified and developed economies and geographic locations that suggest manageable consequences from climate change, may find only a limited need to revise their approach to the management of fiscal policy, even while addressing climate change and playing a role in assisting countries more adversely affected.

For others—those that have much less developed and diversified economies or whose geographic locations suggest much more consequential adverse effects from climate change on their environment, much more serious reconsideration of their approach to fiscal policy may be required. Otherwise, there would be a danger in treating available fiscal space for public sector investment as not threatened by the risks posed by climate change. Even in the short-term, the longer-term environmental challenges may not be easy to ignore. As a simple example, a seemingly meritorious investment in roads or infrastructure in a coastal area may prove to be a “white elephant” looking forward not that many years, with offshoots reflected in private investment that will equally be at risk.

Applying a negative filter associated with potential climate risks would be a necessary clarifying task. An important facet of the analysis would be to begin to more actively assign probabilistic assessments to the likelihood of climate change-related costs occurring. Over time, one would expect that the science of climate change modelling will begin to provide greater certitude on the probabilities that one might encounter. The need to draw on the experience of countries already encountering climate change will prove a necessary corrective in considering potential financial challenges faced by governments. A better understanding of these challenges might also prove persuasive to enhance mitigation efforts.

Moreover, for some of these countries, the issue of fiscal space, or of fiscal sustainability, may be transcended by the concept of political, social and environmental sustainability. Some countries may find their viability eroded or endangered by the loss of territory associated with coastal flooding. Some may find that important economic sectors, particularly in agriculture, will no longer be viable, unless innovations in R&D are able to offset the risks from climate, insect vectors, salinization or soil depreciation. Urban areas,

already expected to rapidly grow, may expand as a consequence of climate-induced population movements.

Thinking ahead as to how to respond to such potential risks needs to be broached. Countries will need to begin developing much greater institutional capacity in many government agencies to consider and respond to these risks. In such countries, even the role of government may need to be reconsidered. Particularly for those countries with highly limited fiscal space, governments will need to consider where the government's efforts should be focused in terms of climate change adaptation. For many, the elaboration of a much more resilient social safety net capacity may be the highest priority, since governments are not likely to have the financial capacity to participate in significant adaptation efforts in many sectors beyond providing some technical assistance expertise.

5 A STRENGTHENED APPROACH TO ADDRESSING THE FISCAL RISKS OF CLIMATE CHANGE ADAPTATION

This section offers some ideas on how countries should approach the challenge of adaptation to the risks and consequences of climate change. Before doing so, it is necessary to provide some context to the recommendations. In particular, from what perspective are these offered and to whom specifically are they offered? What makes the challenge of adapting to climate change different from how countries already now respond to other challenges that arise in formulating economic and social policies?

Clarifying the “voice” offering these recommendations

Coming from many years as a senior official at the IMF dealing with fiscal policy issues, most of the recommendations in this section are offered in the spirit of the IMF's approach to supporting countries' policy efforts through its surveillance efforts. Specifically, IMF staff seek to provide unvarnished but economically informed guidance to their macroeconomic counterparts, principally in the ministry of finance and central bank, as to the policy options that would strengthen their economy. While the focus is normally on the short to medium-term, issues of sustainability and long-term growth are also part of the IMF's implicit welfare function.

In addition, two further perspectives can be offered. First, some recommendations are directed at the IMF's own role and approach to thinking about the challenge of climate change and whether it might consider ways in which it might enhance the effectiveness of its role. Second, having previously written on issues of the long-term, we understand the strength of the political and behavioral forces that bias in favor of current generations over those of the future (Heller, 2003). But we believe strongly that the environmental and species losses from such preferences in the context of climate change are too serious to ignore.

What distinguishes climate change?

As has emerged from the previous discussion, with climate change, countries are potentially confronting forces which potentially will *continue* shaping and changing the environment where people live, work, produce, consume, and raise families. While some of these changes might prove to be for the good, at least for some living in certain regions of the globe, our reading of the science suggests that climate change will progressively have a negative impact on the environment, on the existence of many species, and on the viability of many aspects of economic and social life.

We use the word “potentially” because one would hope that mitigation initiatives are sufficiently aggressive as to dramatically change the trajectory of climate change such that the trends already in the system are at least stabilized within this century. We also recognize that technological innovations are possible that might realize what conventional mitigation strategies may fail to achieve.

Recognizing the nature of the phenomenon is important in clarifying the challenges facing the traditional economic policy maker. Specifically, one has to recognize that there are forces working *against* the success of many of the policies that might traditionally be seen as promoting economic growth and improved living standards. Even more challenging, we are dealing with a phenomenon that is complex in how it will manifest itself; uncertain in its timing, viz., the variability and frequency of events as well as in its evolution over time; and clouded by uncertainty whether global mitigation efforts will be effective and of the environmental consequences that are likely to eventuate.

Explaining the focus of these recommendations

As well recognized in the work of the IPCC from its inception, and more recently in the extremely important work of the GCA, adaptation will require action and institutional capacity at many levels of government and in many different sectors of policy. This paper is focused on recommendations that provide guidance at the level of a minister of finance or prime minister’s office, viz., those in a position to address the macroeconomic and fiscal constraints that limit adaptation efforts, but who are also in a position to influence the work of other institutional players shaping development strategy.

What are the implications of our discussion for those charged with either managing fiscal policy *today*, or those involved in supporting country policy efforts to understand macroeconomic policy challenges, particularly of the long-term (notably the IMF, the World Bank and other regional multilateral development banks)? Particularly for the many developing countries likely to be in the bullseye of uncertain adverse climate change events in coming decades, policy guidance cannot be of a business as usual approach. We have argued above that the IMF’s recent policy paper addressing the challenge of resilience to large natural disasters, while eminently sensible, is insufficient and reflective of a continued

short-run optic. But the IMF's three-pillar approach—viz., the preventive, financial resiliency, and ex-post addressing of the slow-moving human costs associated with impacts—nevertheless can itself be adapted to support countries as they address the broader challenges of climate change adaptation.

Enhancing surveillance on climate change through scenario analysis

In the early 2000s, the IMF and the World Bank put together teams to support countries as they produced poverty reduction strategy papers in connection with the Heavily Indebted Poor Countries and Multilateral Debt Relief Initiative. A similar IMF initiative could team with the World Bank and other agencies to facilitate the elaboration of scenarios on the long-term effects of climate change for individual countries under alternative climate change trajectories. A country's own experts would be integral and essential to the formulation of these scenarios. Ideally, the scenarios could be publicly available as part of the published background documents for IMF surveillance. The challenge in producing the scenarios would involve an initial up-front investment such that updating would be necessary only every 5-7 years, largely to reflect the extent to which global estimates of the climate change trajectory are felt to have changed substantively or to the extent that more precise views of the costs likely to be encountered have become available.

The objective of the exercise would be: (i) to engage with country authorities in a dialogue on the implications of the scenarios, both in terms of development strategies and in the likely role that governments would play, whether in terms of preventive structural resilience efforts, more extensive restructuring of regions or sectors, reconsideration of current sectoral development strategies, and/or potential social prevention efforts that a government might need to finance; (ii) to clarify for fiscal surveillance, the magnitude of the financial burdens that conceivably might be borne by a government, the extent of the challenge this would imply for the fisc, and thus enhance policy dialogue on how to approach these challenges; (iii) to draw on available data from the financial sector on the cost of insurance against major climate hazards that would allow some specification of the potential fiscal burden that might arise, depending on a government's views on its role in the adaptation, resilience, and potentially restructuring process; (iv) to clarify for the international community the magnitude of the financial resource challenges to be confronted by individual countries, particularly those with limited fiscal space (see below); (v) to clarify transparently to the public of individual countries the magnitude of the challenges that climate change will pose, the extent to which private sector agents will be forced to respond and to heighten the government's political accountability in responding (or not responding) to the challenge; and (vi) to provide a template for dialogue in subsequent annual surveillance discussions on how the government is managing its adaptation efforts.

Such scenario models could facilitate active consultation by the IMF and other agencies with government policymakers on what the consequences bode for a country looking forward. Any policymakers with a capacity for a retrospective view recognizes two or three decades is not that long a period and that what might seem like a “long-term” phenomenon will start happening sooner rather than later. Active risk management approaches need to be high on the agenda, again recognizing that a long-run optic needs to be embedded in short-term policy thinking. Climate change adaptation will also raise to the fore issues that require further discussion in the context of surveillance. These could include an opportunity to integrate the potential challenges and consequences of current development policies and raise questions in a surveillance context. These include understanding better the relative roles of public and private sector agents in adaptation and to clarify the spheres of responsibility of government.

As noted above, scenario analysis can be a starting point for a quantitative reassessment of long-term fiscal space—the broadening of the fiscal space optic—and clarify whether active engagement with the reinsurance community or access to cat bonds might further constrain short-term fiscal space (while offering the possibility of additional fiscal space in the event of significant climate change-related costs). The analysis can also further underscore the importance of industrial and larger emerging market economies meeting their commitments to provide financial support to the many low-income countries that will face severe climate threats.

Assessments will be needed from multilateral partners—e.g. the World Bank—as to whether climate change risks are being embedded into the perspective revealed by a country or region’s development plans. Does the development plan suggest a “business as usual” approach to assessing priorities or does it integrate the most recent estimates of what might be the impact from different climate change threats? What policies can facilitate increased resilience? Or does the nature of the climate risk suggest the need for a reconsideration of the underlying rationale for an economic sector or the viability of a region for habitation?

It should be noted that a scenario exercise could complement and be the basis for **expanding existing IMF efforts to support stress testing in response to large natural disasters** as well as other issues of climate change adaptation faced by member countries. The recent IMF paper on fostering resilience to natural disasters highlights recent assessments for the Bahamas and Jamaica of “scenario-based stress test[s] analyzing the macroeconomic impact of a severe hurricane in the former and a massive natural disaster in the latter.” It notes that the “IMF has recently joined the NGFS [the Network for Greening the Financial System] and is collaborating with its members to develop an analytical framework for assessing climate-related risks.”

Seeking to achieve greater clarity on the policy tradeoffs associated with adaptation efforts

Recognizing the uncertainties associated with climate change, scenario analysis will not in itself provide clarity as to how countries should balance the policy tradeoffs in allocating scarce fiscal resources for adaptation relative to other urgent policy challenges. One cannot ignore that in political economy terms, climate change-related costs that may only gradually increase over the next several decades may seem dwarfed for politicians faced with other difficult budgetary challenges in the context of limited fiscal space. Poverty challenges for those alive today need to be weighed against reducing poverty and economic disruption for future generations. Current investments in infrastructure may have a higher rate of return relative to the returns from a reduction in longer-term losses from climate change. At the same time, current infrastructure investments may also be fully aligned with the objective to increase adaptive capacity. The value of the kind of scenario analysis described above is to provide a transparent context for discussions on these potential policy tradeoffs and synergies.

Integrating the institutional prerequisites for adaptation

Most recent work on adaptation emphasizes that the macro financial challenge is only one part of a comprehensive strategy to confront the risks that climate change will pose. Such risks will touch on broader societal issues, and on the productivity of different sectors. And it is not only a challenge at the aggregate macro level but also one faced by different levels of government.

Thus, to be effective, the government's challenge in facilitating adaptation to climate change over the long term *cannot be a siloed effort*, one that is restricted to a single environment-related agency charged with representing the government on this issue. The recent work of the GCA has clearly underscored the necessity of a government-wide effort. Surveying the response to the IPCC's efforts in the early 2000s to foster individual government reporting on adaptation efforts, the oft-times lack of frequency and limited depth of country reports suggests the lack of penetration of the issue into the day-to-day work of government ministries, whose functions will need themselves to be adapted to respond to the challenges that climate-related costs will pose. The GCA has underscored that assessments need to be made as to whether climate change risks are explicit elements of the operational policy framework and analytical capacity of different sectoral ministries. While IMF surveillance discussions with a country can emphasize the importance of this issue, the IMF might work with countries to set targets for achieving progress in the institutional integration of climate change adaptation into sectoral programs, with climate change experts integrated into sectoral ministries. It can also support central government efforts to assist lower levels of government particularly exposed to climate-related hazards to mount similar efforts.

IMF technical assistance efforts can also be marshalled to assist governments in the implementation of such efforts. This has proven a key element of the IMF's response in the

past and the IMF has demonstrated its ability to ramp up its own capacity and that of global experts around the world in providing such TA. The challenge is to draw on the already substantial capacity and experience in many countries at the state and local level in order to aggressively assist countries that have less experience on adaptation issues.

Monitoring market signals: Linking with recent central bank initiatives to assess financial sector vulnerabilities to climate change

We have noted the initiative of the Central Banks and Supervisors Network for Greening the Financial System (NGFS) to undertake assessments of the vulnerability of financial institutions to climate change. What might be the systemic risks that arise if financial markets have a “Minsky Moment” where market perceptions suddenly change as to the impact that climate change effects might pose for important economies or where these might lead to discrete increases in the sovereign risk premia of particular countries (that might affect perceptions on the amount of available fiscal space)? The IMF’s Global Financial Stability Report has already begun to address this issue in its most recent edition, including a chapter on sustainable finance. In a recent article in the IMF’s publication *Finance and Development* (November 2019) relating to the integration of climate change considerations into financial sector surveillance, the IMF noted that “stress testing is a key component of the program, with these stress tests often capturing the physical risks related to disasters, such as insurance losses and nonperforming loans associated with natural disasters.”

Further work on this issue could be done, including threats posed by climate change to a country or government’s asset portfolio, broadly defined; the risks posed to its economy; to infrastructure assets; or to financial assets owned by government agencies. As an example, a recent article in the NY Times highlighted the extent to which major US banks have deflected their risks on mortgage lending in vulnerable coastal areas by selling their mortgage exposure to the US government’s principal mortgage agencies (see Flavelle (2019b)). The degree to which ratings agencies have incorporated climate change issues could also be a focus for analysis.

One important recent development emerging from the NGFS is their initiative to work on the details of “NGFS transition scenarios and guidelines on scenario-based climate risk analysis.” (see <https://www.ngfs.net>). If countries are to embark on the type of scenario analyses called for above, it would seem reasonable to have commonality on the broad climate trajectories that are the basis for the scenarios.

Collaboration with the scientific community in monitoring the pace of climate change

While the IMF is far removed from the scientific work on climate change, for its surveillance work with countries to be successful, it needs to be able to better understand what science suggests are the signals on the pace of climate change and the factors influencing the occurrence of climate change hazards. Clearly, much of this is distilled by the periodic reports

of the IPCC. Nevertheless, the IMF should be actively interacting with the IPCC and with other agencies to absorb what can be gleaned by the intensified monitoring of scientists of biosphere and geophysical signals. For the nonscientist, one becomes quickly aware of the complexity of the factors influencing these issues. They involve issues relating to: clouds; the quality of the seas; the stability of ice sheets in West Antarctica and Wilkes Basin of East Antarctica; the vulnerability of boreal forests in the subarctic; the state of melting of the permafrost in the Arctic and Greenland; the role, extent and impact of coral bleaching; the extent of forest loss observed in the Amazon; the evidence of any further slowdown in the AMOC (Atlantic Meridional Overturning Circulation), as well as the East Asian Monsoon and West African Monsoon.

The translation of this understanding at a concrete level to economists working on surveillance in particular regions will become a necessary complement to their work with countries.

Marshalling global transparency on the state of country efforts to address the challenge of adaptation

The international community has recognized the role that global transparency on the state of country policy efforts can play. One observes the Millennium Development Goals and more recently the Sustainable Development Goals, not to mention other efforts to shine a light on country performance (Doing Business Indicators, indices of Corruption, etc.). The Paris Accords have enabled monitoring of country mitigation efforts. An effort by the IMF to embed adaptation issues into its surveillance would also allow it to develop indicators that provide transparency on the relative performance of countries on these issues, ranking countries on the various aspects of how countries are dealing with climate change adaptation. One could envisage indicators characterizing the transparency of a country's own stated assessments of climate change risks; on the institutional capacity of a country to respond to these risks; and on the vulnerability of a country to different climate change risks. The global community already faces a challenge in how to work with countries that are downplaying or ignoring the issue of climate change adaptation, or who are counting on the international community to assume a major financing role. While the latter will necessarily be the case for many countries, given their lack of fiscal space, the challenge will be to avoid the moral hazard that such dependence can give rise to, or the temptation to use global financing as a source of financial mismanagement.

Grappling with the systemic consequences of climate change for the global economy

The consequence of bilateral country discussions on climate change needs to be addressed in multiple multilateral fora. The nature of the geopolitical environment that will emerge in the second half of the century will be determined by climate change developments, with humanitarian tragedies and population movements putting intensified pressure on many regions. The unfolding tragedy of immigration in Europe arising from the conflict in Syria and

existing population pressures in sub-Saharan Africa may be magnified from the effects of further population growth and climate change in sub-Saharan African, South Asia, and other parts of the Middle East. Beyond the role of developed economies to assist in the financing of climate change adaptation efforts, it is obvious already that these countries will face important financial, political and social pressures associated with the inevitable migration that will occur.

Fostering a stronger effort to build-up an international training capacity in the sphere of climate change adaptation.

At the international level, one would want to see major universities developing masters' level programs focused on training civil servants to understand the technical issues that will arise in structural government programs to incorporate adaptation issues. Analogous to the expansion of global health programs in Schools of Public Health in the last two decades, a similar effort needs to be mounted to account for climate change in Masters' Programs of Schools of Finance, Economics and Public Policy.

6 FINAL THOUGHTS

There is little doubt that climate change mitigation must be a dominant policy priority in the next several decades. Successful action, in particular by those countries that are responsible for the bulk of greenhouse gas emissions, is vital.

At the same time, virtually all countries in the world will face the growing challenge of climate change adaptation. This paper has highlighted the uncertainties and difficulties that policymakers will face in grappling with this challenge. Their efforts are rendered even more difficult because of the longer-term character of climate change - and here we are not talking about the 22nd century but of a near future that will shape the lives of many living today and of their children and grandchildren. Nevertheless, policy decisions relating to current needs and current budgets must be made, and legitimate policy tradeoffs must be addressed. Depending on assumptions and discount rates, the rate of return to spending on current policy priorities may be analyzed as higher than the gains from adapting to challenges of the 2040s and beyond. Weighing the relative benefits to those currently alive and voting rather than to those of the future has always been difficult, but that does not mean that myopic biases are, in welfare terms, appropriate.

This paper does not seek to provide hard answers to those faced with making these decisions. But the fact that the analysis and choices are really difficult does not make the effort irrelevant or not worth grappling with if the consequences may be existentially large. Similarly, the fact that markets don't internalize these issues is not a sufficient reason to ignore them. The failure of financial markets to discern a precipice is not unprecedented.

And of course, some may argue that the science is itself fraught with open questions, though the experience of the last two decades suggests that an abundance of caution has proven to underestimate the problem (see DeFries et al (2019)). The recent papers of the Nobel Prize winner, William Nordhaus, who in the early 2000s urged greater research before policy action, suggest that the premonition of many climate advocates at that time was correct.

The paper argues that climate change requires additional methodologies to apply the concept of “fiscal space” as a tool for appraising a government’s balance sheet from a long-term perspective. While governments can anticipate an implicit financial burden associated with the challenge of adapting to climate change, a complete quantification of that cost would be extremely difficult and highly conjectural. A broader “optic” of fiscal space is necessary than that offered by Ostry (2016) and used by the IMF. Alternative scenario analysis techniques are likely to be more useful in a policy context to highlight and illuminate the potential financial challenges that may need to be built into long-run financial policy frameworks. Such scenario analyses would allow at least for some quantification of the specific financial cost of particular climate change-related costs, particularly if enriched from the recent experience of the financial sector in dealing with climate change effects.

This paper suggests that the IMF and World Bank’s strong efforts in supporting aggressive mitigation should be complemented by an effort to help countries confront the issue of adaptation. To wait for a decade on this issue until we are clearer on the success of mitigation efforts is to delay policy development and implementation on adaptation that could reduce serious economic and social losses looking forward. Building up capacity for policy implementation is not an overnight proposition. The next decade will also be critical in furthering a dialogue with countries on what the scientific signals suggest about the likely climate change trajectory and the role that many potential tipping points might play in characterizing the critical risks.

The IMF and the World Bank are well placed to further this policy dialogue. The IMF’s annual surveillance discussions, often with World Bank participation, provides an opportunity for policy dialogue and the development of policy programs. The IMF’s recent policy papers appropriately highlight the issue, but much more should be required of the IMF to strengthen its overall role on this issue. Two times in the last thirty years has one seen such a major expansion of the IMF’s role, one that required it to quickly build up an expertise and capacity to work on issues that transcended its existing capacity (viz., in connection with the fall of the Soviet Union and with the emphasis on poverty reduction strategies in connection with debt forgiveness). Climate change will be a defining challenge of this century that will profoundly affect the fiscal and macroeconomic policy capacity of governments. In assisting finance ministries to address the budgetary challenges of climate change, the IMF is the premier institution whose relationship with these ministries can facilitate their efforts.

7 BIBLIOGRAPHY

- Association of Climate Change Officers, 2014, "Understanding the Role of the Government in Preventing and Responding to Major Disasters" (October 8).
- Audley, Kyle et al, 2019, "Emerging Risks in Insurance Climate Change," *Milliman White Paper* (August).
- Bank of England, 2019, *The 2021 biennial exploratory scenario on the financial risks from climate change*, Discussion Paper, (December).
- Cebotari, Aliona and Karim Youssef, 2020, "Natural Disaster Insurance for Sovereigns: Issues, Challenges and Optimality," *IMF Working Paper WP/20/3*
- Chaplin-Kramer, Rebecca, "Global modeling of nature's contributions to people," *Science Magazine*, (October 11, 2019)
- Crausbay, Shelley D., and Aaron R. Ramirez, 2018, "Defining Ecological Draught for the Twenty-First Century," *Bulletin of the American Meteorological Society*, vol 98, No. 12.
- DeFries, Ruth et al, 2019, *The Missing Economic Risks in Assessments of Climate Change Impacts*, Grantham Institute of Climate Change and the Environment, The Earth Institute, Columbia University, Potsdam Institute of Climate Impact Research (September).
- Federal Reserve Bank of San Francisco, 2019, "Strategies to Address Climate Change Risk in Low and Moderate-Income Communities," *Community Development Innovation Review*, vol. 14, No.1).
- Feyen, Erik, et al, 2020, "Macro-Financial Aspects of Climate Change," *Policy Research Working Paper 9109*, World Bank Group.
- Flavelle, Christopher, 2019a, "Bank Regulators Present a Dire Warning of Financial Risks from Climate Change," *New York Times* (October 17).
- Flavelle, Christopher, 2019b, "Climate Risk in the Housing Market Has Echoes of Subprime Crisis, Study Finds," *New York Times* (Sept 30).
- Friedman, Lisa, 2019, "What is the Green New Deal? A Climate Proposal, Explained," *New York Times*, (November 21).
- Furman, Jason and Lawrence Summers, 2019, "Who's Afraid of Budget Deficits? How Washington Should End its Debt Obsession," *Foreign Affairs*, vol. 98, Issue 2 (March/April), pp. 82-88
- Global Commission on Adaptation, 2019, *Adapt Now: A Global Call for Leadership on Climate Resilience*, (September)
- Heller, Peter S, 2003, *Who Will Pay? Confronting Aging Societies, Climate Change and other Long-Term Fiscal Challenges* (International Monetary Fund: Washington DC)

Howcroft, Elizabeth and Marc Jones, 2019, "ECB Considers Putting Climate Change Risks in Future Bank Stress Tests," *Reuters* (November 14).

International Monetary Fund, 2019a, "Sustainable Finance," chapter 6, *Global Financial Stability Report* (October).

International Monetary Fund, 2019b, *Fiscal Policies for Paris Climate Strategies: From Principle to Practice*, IMF Policy Paper (May).

International Monetary Fund, 2019c, *Building Resilience in Developing Countries Vulnerable to Large Natural Disasters*, IMF Policy Paper (June).

International Monetary Fund, 2019d, "How to Mitigate Climate Change," *Fiscal Monitor* (October).

International Monetary Fund, 2019e, "The Economics of Climate," *Finance and Development* (December).

International Monetary Fund, 2018, *Assessing Fiscal Space: An Update and Stocktaking*, (June).

Jarzabkowski, P., K. Chalkias, D. Clarke, E. Iyahan, D. Stadtmueller & A. Zwick, 2019, *Insurance for Climate Adaptation: Opportunities and Limitations* (Rotterdam and Washington DC).

Jubilee Debt Campaign, 2020, *The Growing Global South Debt Crisis and Cuts in Public Spending*

Lenton, Timothy et al, 2019, "Climate Tipping points—too risky to bet against," *Nature*, vol 575 Nov 28), pp. 592-595.

Lu, Denise and Christopher Flavelle, 2019 "Rising Seas Will Erase More Cities by 2050, New Research Shows," *New York Times* (October 29).

Molico, Miguel, 2019, "Researching the Economic Impacts of Climate Change: Implications for Monetary Policy and financial stability," *Bank of Canada* (November 19).

Mora, C., Spirandelli, D, Franklin, E.C. et al, 2018, "Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions," *Nature Climate Change*, vol. 8, pages 1062–1071(2018)

Nicholls, Robert J. et al, 2011, "Sea-level rise and its possible impacts given a 'beyond 4°C World' in the twenty-first century," *Philosophical Transactions of the Royal Society*, vol. 369, pp 161-181.

Nordhaus, William, 1994, *Managing the Global Commons: The Economics of Climate Change* Cambridge, MIT Press.

Nordhaus, William, 2018, "Projections and Uncertainties about Climate Change in an Era of Minimal Climate Policies," *American Economic Journal: Economic Policy*, vol 10, no. 3, pp. 333-360.

Ostry, Jonathan et al, 2010, "Fiscal Space," *IMF Staff Position Note SPN 10/11* (September).

Reuters, 2019, *France to Stress Test Banks, Insurers' Climate Risks Next Year* (November 21).

Rosen, Julia, 2019, "Why the Next Decade will Be Critical in the Fight against Climate Change," *Los Angeles Times* (March 29).

Schwartz, John, 2019, "A Wet Year Causes Farm Woes Far Beyond the Floodplains," *New York Times*, (November 21).

Sengupta, Somini and Weiyi Cai, 2019, "A Quarter of Humanity Faces Looming Water Crises, Study Says," *New York Times* (August 6).

Stern, Lord Nicholas, 2007, *The Economics of Climate Change: The Stern Review* (Cambridge University Press)

Tett, Gillian, 2016, *The Silo Effect: The Peril of Expertise and the Promise of Breaking Down Barriers* (Simon & Schuster).

Van Vuuren, Detlef P., et al, 2010, "The Use of Scenarios as the Basis for Combined Assessment of Climate Change Mitigation and Adaptation," *Global Environmental Change*," (December).

Vermeulen, Robert, et a., 2018, An Energy Transition Risk Stress Test for the Financial System of the Netherlands, *DNB Occasional Studies*, Vol. 16-7.

United States, Congress, 2019, *H. Res. 109: Recognizing the Duty of the Federal Government to Create a Green New Deal* (February 7)

Wallace-Wells, David, 2019, *The Uninhabitable Earth: Life after Warming*, (Tim Duggan Books)

Webb, Cody and Eric Xu, 2018, "The California Wildfire Conundrum" *Milliman.com Insight*