

Case No. 18-36082

**IN THE UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT**

KELSEY CASCADIA ROSE JULIANA, *et al.*,
Plaintiffs-Appellees,

v.

UNITED STATES OF AMERICA, *et al.*,
Defendants-Appellants.

On Interlocutory Appeal Pursuant to 28 U.S.C. § 1292(b)

**DECLARATION OF JOSEPH E. STIGLITZ, PH.D IN SUPPORT OF
PLAINTIFFS' URGENT MOTION UNDER CIRCUIT RULE 27-3(b)
FOR PRELIMINARY INJUNCTION**

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I, Dr. Joseph E. Stiglitz, hereby declare and if called upon would testify as follows:

1. I am a Professor at Columbia University with joint appointments in the Faculty of Arts and Sciences (Department of Economics), the Graduate School of Business (Department of Finance), and the School of International and Public Affairs. I have been retained as an expert on behalf of Plaintiffs in this litigation before the United States District Court for the District of Oregon (“District Court”). I serve as an expert in this case entirely pro bono.
2. I have prepared an expert report for this litigation (“Expert Report”), which forms part of the record in the District Court (D. Ct. Doc. 266-1). A true and correct copy of my Expert Report is attached hereto as **Exhibit 1**.
3. I submit this Declaration in support of Plaintiffs’ Motion for Preliminary Injunction, in order to provide the Court with information related to the public benefit of awarding Plaintiffs injunctive relief pending appeal, and the costs and tremendous risks of not so issuing an injunction.

Expert Qualifications and Experience

4. Prior to assuming my position at Columbia University, I held professorships at Stanford University, Yale University, Princeton University, and the University of Oxford, where I taught a wide variety of graduate and undergraduate courses in economics and finance. Public economics and

public finance, which study how governments raise funds and make expenditures, have been major pillars of my academic work.

5. From 1993 to 1997, I served as a member of President Clinton's Council of Economic Advisers, and from 1995 to 1997, as Chairman of the Council and a member of the President's Cabinet. As Chairman and Cabinet Member, I was heavily involved in formulating fiscal policy, sustainable economic policies (including environmental economic policies), financial sector regulation and banking policy, and coordinating policy with the U.S. Treasury.
6. Environmental economics and economic policy around natural resources has been another focus of my academic and professional work. I was one of the lead authors of the 1995 Report of the Intergovernmental Panel on Climate Change, which shared the 2007 Nobel Peace Prize with former Vice President Gore. I was co-chair of the High-Level Commission on Carbon Prices (we released our report in May 2017). I was also involved in environmental economic policy during my time on the Council of Economic Advisors, where one of my responsibilities was evaluating, designing, and implementing public policies that affect the environment, and while Chief Economist of the World Bank, where one of my responsibilities was evaluating and designing environmentally sustainable economic policies. I have also published many

peer-reviewed articles that examine how we treat externalities (e.g., pollution), public goods (e.g., the environment), and depletable and renewable natural resources.

7. I have received numerous fellowships and honors over my career. In 2001, I was awarded the Nobel Memorial Prize in Economics for my work on Information Economics. This work includes the study of how information asymmetries affect economic behavior, the determination of the conditions under which efficient sharing of risk occurs, and the economics of financial markets, which are directly relevant to this case. A true and correct copy of my curriculum vitae, containing a full summary of my relevant experience and qualifications, is attached as **Exhibit A** to my Expert Report, **Exhibit 1**.

Defendants Knowingly Perpetuate A Fossil Fuel Energy System that Imposes and Will Continue to Impose Enormous Costs on Youth Plaintiffs

8. The current national energy system, in which approximately 80 percent of energy comes from fossil fuels, is a direct result of decisions and actions taken by Defendants.¹ Defendants control and dictate the U.S. national energy policy in a myriad of ways. For example, they provide billions of dollars

¹ U.S. Energy Information Administration, Table 1.3 Primary Energy Consumption by Source, January 2019 Monthly Energy Review, <https://www.eia.gov/totalenergy/data/monthly/archive/00351901.pdf>

annually in direct and indirect subsidies to the fossil fuel industry;² control the fuel economy of cars and trucks through the Corporate Average Fuel Economy (“CAFE”) standard; set efficiency standards for appliances; permit the extraction, transportation, import, export, and combustion of fossil fuels; and provide funding for research and development.³

9. The fact that the U.S. national energy system is so predominately fossil fuel-based is not an inevitable consequence of history. The current level of dependence of our national energy system on fossil fuels is a result of intentional actions taken by Defendants over many years. These actions, cumulatively, promote the use of fossil fuels, contribute to dangerous levels of CO₂ emissions, and are causing climate change. The economic impacts of these actions are deleterious to Youth Plaintiffs⁴ and the Nation as a whole. Defendants’ actions promoting a fossil fuel based energy system are serving to undermine the legitimate government interests of national security and economic prosperity that they purport to advance.⁵

² See Exhibit 1, Expert Report, Section V.B.

³ “Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013”, U.S. Energy Information Administration, March 2015, <https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf>.

⁴ Section IV of my Expert Report details the enormous economic burdens and costs that will be largely shouldered by Youth Plaintiffs and Affected Children due to Defendants’ actions that contribute to the further accumulation of greenhouse gases.

⁵ Daniel R. Coats, Director of National Intelligence, “Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community,” *Office of the*

10. For decades, the U.S. government has had extensive knowledge that there were viable alternatives to a fossil fuel-based, national energy system, and with the appropriate allocation of further resources to research and development, it is likely that these alternatives would have been even more competitive than fossil fuels. Section V of my Expert Report explains how transitioning the U.S. economy off of fossil fuels is not only feasible but will benefit the economy.
11. Defendants have known for at least 40 years that the direct and indirect subsidies the federal government has been providing to fossil fuel producers hinder the adoption of renewable energy and the transition towards a less carbon-intensive economy. Yet, in spite of this knowledge, the federal government subsidies have continued, and have accelerated and exacerbated the costs to Youth Plaintiffs from climate change. Thus, there was a known, substantial risk of serious harm to Youth Plaintiffs that could have been eliminated through reasonable and available measures that Defendants did not take, thus causing the injuries that Youth Plaintiffs suffer and will suffer in

Director of National Intelligence, February 13, 2018, <https://www.intelligence.senate.gov/sites/default/files/documents/os-dcoats-021318.PDF> (at page 16: “The impacts of the long-term trends toward a warming climate, more air pollution, biodiversity loss, and water scarcity are likely to fuel economic and social discontent—and possibly upheaval....”).

the future absent a preliminary injunction and the more comprehensive remedy Youth Plaintiffs seek in this case.

12. Similarly, Defendants' long-standing use of inappropriately high discount rates in decision-making has perpetuated the fossil fuel-based, national energy system by systematically ignoring and undervaluing the costs imposed on Youth Plaintiffs by the fossil fuel-based, national energy system.

Plaintiffs' Requested Injunctive Relief Will Benefit the Federal Government and the Public

13. An injunction on future leases and mining permits for extracting coal on federal public lands and on future leases for offshore oil and gas exploration and extraction activities, alongside enjoining new fossil fuel infrastructure requiring federal approval will prevent, not cause, economic harm. Plaintiffs' request of a brief delay on the order of months to make these decisions in a manner that accounts for Plaintiffs' constitutional rights, and avoid incurring real economic and human costs, is an eminently reasonable and fiscally responsible request for the Nation writ large. Such a relatively short-term injunction will serve the public's best interest by avoiding locking the federal government, these Youth Plaintiffs, and the Nation into investments leading to (1) more fossil fuel consumption and (2) economic losses from poorly

invested public and private resources in a form of energy that must be eliminated for the Nation to thrive and prosper.

14. In assessing the economic costs and benefits of imposing a relatively short-term injunction of this nature, we weigh the economics of delay by comparing any negative costs of the delay with the benefits of delaying these activities. Equivalently, we can assess the benefit of expanding fossil fuel extraction and infrastructure today versus the cost of delaying those investments and use of public resources.
15. One of the economic harms of pursuing fossil fuel extractive and infrastructure activities during the pendency of this case is the risk that such fossil fuel extractive and infrastructure activities will be a waste of public and private resources. It makes us collectively poorer to spend money on a new oil pipeline, for instance, and then later determine we cannot use the oil pipeline for the originally expected life of that invested infrastructure. If Plaintiffs prevail in their case and obtain a judgment that the fossil fuel energy system is endangering their lives and liberties, in order to comply with the U.S. Constitution, Defendants will have to transition the Nation's energy system away from fossil fuels. As a result, it is very likely that new fossil fuel infrastructure will become obsolete and either need to be retired early or never placed in service, reducing the value of such infrastructure. Investing today in

new infrastructure that will become obsolete early is a waste of economic resources. It is also very likely that one or more of Defendants would need to seek to cancel leases for fossil fuel extraction on federal public lands, or corollary mining permits and other approvals for those activities. Those lessees are not parties to this case and not bound by any remedial orders. When agencies of the federal government cancel a lease, the resulting legal actions result in further wasting of public resources, an added cost that could be avoided by a short delay now to first determine whether it is constitutional to keep extracting fossil fuels and expanding fossil fuel infrastructure.

16. The economic gains to the federal government from the lease sales during the relatively short-term of this appeal are themselves likely substantially less than what the federal government stands to lose in litigation alone over canceled leases. Moreover, such leases have been consistently undervalued and sold as a subsidy to the fossil fuel industry, another accrued cost to the public that diminishes the economic benefits of the proceeds from lease sales.
17. In performing an economic analysis, one also would ask: Is there any significant economic cost to the federal government or the public of delaying pipeline permits or leasing federal public lands for coal extraction or offshore drilling? *The answer is no.* If our Nation were facing a period of energy shortage, that could be a relevant factor to consider. However, delaying

additional leasing and permitting of fossil fuel extraction and projects right now would have no significant impact on U.S. energy supply.

18. There is substantial uncertainty as to whether, after this case is resolved, Defendants would decide to award any future leases on federal public lands, or authorize any new fossil fuel infrastructure, and of which nature. Comprehensive national energy planning that takes into consideration the Court's resolution of this case will have broad ramifications for these types of decisions in the future. There is great uncertainty as to any future leases on federal public lands or any new fossil fuel infrastructure until this case is resolved. However, there is no uncertainty that allowing those actions to proceed today comes with significant fiscal cost and potential wasting of resources.
19. If real resources are expended in the development of infrastructure or granting leases on public lands between now and the time of the decision of the Court (while this matter is under litigation) and the Court decides in favor of the Youth Plaintiffs, then those resources are likely to be wasted. It will be impossible or, at the very least, very costly, to redeploy the investments made to other uses. Wasting resources makes our economy weaker. There is an array of better investments towards which the funds might have been spent where they would not have been so wasted. Delaying permitting or leasing prevents

this waste of scarce resources. As explained below, one of the reasons that such waste is likely to occur is that there is a large discrepancy between the perceived returns by certain potential investors and societal returns.

20. Future uncertainty will also result in a reduction or depression of the price the lessee is willing to pay. The value of money our federal government receives now, or during the pendency of this case, will be depressed by the uncertainty. It is fiscally irresponsible to put up federal public lands for lease while uncertainty overhangs. Our taxpayers will pay the price, whereas a short delay does not impose any cost.
21. The current level of the time value of money is an important reason why a short delay does not impose any cost as to any future leases on federal public lands or any new fossil fuel infrastructure until the uncertainty is resolved. Presently, the time value of money is zero or even negative because real interest rates are close to zero. In addition, the fossil fuels themselves are static. Coal will not move away. Offshore oil is not going to disappear from its depths beneath the sea. It took millions of years for those fossils to turn to fuel, while it has taken just over a century to convert a portion of those fuels to atmospheric CO₂ and thereby heat our planet and acidify our oceans.
22. There is an asymmetry here between the perspectives of private actors and society as a whole. The former may see a gain by being able to buy assets and

rights now, while prices are depressed as a result of the uncertainty cast by this litigation and broader concerns about climate change; if the private actors are ignoring climate science in their business decisions—as many in the industry steadfastly seem to be—they believe that they will get a windfall gain when their views predominate. That is why they may perceive an urgency in getting the deal done now. Moreover, these private actors will surely be aware of the history of public compensation for stranded assets, so they may perceive themselves in a no-lose situation. If these private actors are not allowed to go forward in the development of the infrastructure or rights acquired, they may demand compensation that can well exceed their expenditures. But these gains by private actors are more than offset by the much larger losses to society in general.

23. This injunction will not pose a threat to energy independence. The United States has already become the largest oil and gas producer in the world; our Nation exports more oil and gas than we import. Current fracking operations already produce the dominant source of energy presently. As President Obama made clear by his moratorium on coal, the Nation does not need more coal extraction to meet its energy demand. Further, the dropping costs of solar and wind energy make those energy sources readily available for public or private

investment as a replacement for avoided short-term investments in coal, offshore oil, or tar sands oil resources.

24. Disallowing more fossil fuel extraction or fossil fuel infrastructure build-out will not have any significant adverse effect on employment in the United States because we are presently at or near full employment. Thus, any claim of adverse impacts to jobs is not salient. The same analysis applies for economic growth. This injunction will not stifle economic growth given current market growth. In fact, an injunction of this nature could incentivize growth in the renewable energy industry, leading to an equivalent number of—or more—new jobs being created than would be created in the fossil fuel industry because solar energy in particular creates substantially more jobs per unit of energy generated than the fossil fuel extractive industries.
25. As indicated by the accompanying declarations of climate scientists such as Dr. James Hansen, there is mounting evidence of the climate system being near a tipping point. If that is the case, any additional investment in or development of fossil fuels could result in pushing us over a tipping point, even if that tipping point does not occur within the period of injunctive relief. As I discuss extensively in my attached Expert Report, scientific evidence shows further incremental increases in global temperature will lead to disproportionately greater costs imposed on our society and will saddle


Plaintiffs and Affected Children with an enormous, perhaps incalculable, cost burden. The benefits of making choices today that limit the economic costs of climate change far outweigh any economic costs associated with limiting our use of fossil fuels.

26. Prudence *and* economic cost-benefit analysis of the consequences provide a strong basis for concluding that the public benefits of delaying further fossil fuel extraction and infrastructure of the nature Plaintiffs seek far outweigh the benefits of allowing those activities to proceed during the pendency of this case.
27. In my expert opinion, there would be no harm imposed on our economy or society in any way (e.g., security or the environment) by a delay; and certainly no irreparable harm. But that is not true of the converse. The environmental damage could be irreparable. The fiscal costs imposed on the federal government as a result of receiving less than the true value of the resources could only be recovered through additional and distortionary taxation. The potential litigation costs and compensation for the newly created stranded assets would put further burdens on the federal government and our society. Some part of these costs, many irreparable or repairable only at great cost, would be borne by Plaintiffs in this case, including potentially through the specific harms alleged.

28. In my expert opinion, selling off more public fossil fuel resources and permitting more investment in fossil fuel infrastructure would be a mistake, with significant short-term costs and the very real potential for locking in incalculable costs. There is no urgency to promote more fossil fuels. There is no urgency for energy supply. There is no urgency for employment or economic growth. There is, however, real urgency to stop the climate crisis and the already-dangerous status quo from worsening, and to protect these young people's constitutional rights. There are very real and substantial societal costs and risks of moving forward with these fossil fuel enterprises while this lawsuit is pending.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed on February 6, 2019.

Respectfully submitted,



Joseph E. Stiglitz, Ph.D

Exhibit 1

**EXPERT REPORT
OF
JOSEPH E. STIGLITZ, PH.D.**

University Professor, Columbia University

Kelsey Cascadia Rose Juliana; Xiuhtezcatl Tonatiuh M.,
through his Guardian Tamara Roske-Martinez; et al.,
Plaintiffs,

v.

The United States of America; Donald Trump,
in his official capacity as President of the United States; et al.,
Defendants.

IN THE UNITED STATES DISTRICT COURT
DISTRICT OF OREGON

(Case No.: 6:15-cv-01517-TC)

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TABLE OF ACRONYMS AND ABBREVIATIONS

C:	Celsius
CAFE:	Corporate Average Fuel Economy
CAD:	Canadian Dollar
CBO:	Congressional Budget Office
CO ₂ :	carbon dioxide
CPI:	consumer price index
EPA:	U.S. Environmental Protection Agency
GDP:	gross domestic product
GHGs:	greenhouse gases
IMF:	International Monetary Fund
IPCC:	Intergovernmental Panel on Climate Change
NASA:	National Aeronautics and Space Administration
NOAA:	National Oceanic and Atmospheric Administration
OECD:	Organisation for Economic Co-operation and Development
OMB:	Office of Management and Budget
ppm:	parts per million
R&D:	research and development
USGCRP:	U.S. Global Change Research Program

I. QUALIFICATIONS AND PROFESSIONAL BACKGROUND

1. I am one of sixteen University Professors at Columbia University with joint appointments in the Faculty of Arts and Sciences (Department of Economics), the Graduate School of Business (Department of Finance), and the School of International and Public Affairs. Prior to assuming this position, I held professorships at Stanford University, Yale University, Princeton University, and the University of Oxford, where I taught a wide variety of graduate and undergraduate courses in economics and finance. I received my Ph.D. in Economics from MIT in 1967.
2. Over the course of my career I have published hundreds of peer-reviewed articles, written or edited more than 50 academic and popular books, testified several times before Congress, and written numerous opinion pieces for newspapers and magazines. My publications and research have extended into many different areas, including macroeconomics and monetary theory, development economics and trade theory, public and corporate finance, industrial organization and rural organization, welfare economics, and income and wealth distribution, many of which are germane to this case. Oxford University Press is in the process of publishing a six-volume set based on my research, *Selected Works of Joseph E. Stiglitz*. The first two volumes have been published and are entitled *Information and Economic Analysis: Basic Principles and Information* and *Economic Analysis: Applications to Capital, Labor, and Products Markets*.
3. Public economics and public finance, which study how governments raise funds and make expenditures, have been major pillars of my academic work. I served as a co-editor of the *Journal of Public Economics*, the leading economics journal dealing with matters of taxation and public economics, and have published broadly in this area. My textbook, *Economics of the Public Sector*, is a leading text first published in 1986 with the most-recent version released in 2015. Another of my books, *Lectures on Public Economics*, published in 1980 and reprinted in 2015 with a new introduction, has been widely translated. Many of my popular texts, including my recent books *The Great Divide* and *The Price of Inequality*, published in 2015 and 2012, respectively, critically examine our public institutions, and comment on public finance and public economics generally.

4. Environmental economics and economic policy around natural resources has been another focus of my academic and professional work. I was one of the lead authors of the 1995 Report of the Intergovernmental Panel on Climate Change, which shared the 2007 Nobel Peace Prize with former Vice President Gore. I was co-chair of the High-Level Commission on Carbon Prices (we released our report in May 2017). I was also involved in environmental economic policy during my time on the Council of Economic Advisors, where one of my responsibilities was evaluating, designing, and implementing public policies that affect the environment, and while Chief Economist of the World Bank, where one of my responsibilities was evaluating and designing environmentally sustainable economic policies. I have also published many peer-reviewed articles that examine how we treat externalities (e.g., pollution) and public goods (e.g., the environment).
5. I have received numerous fellowships and honors over my career. In 2001, I was awarded the Nobel Memorial Prize in Economics for my work on Information Economics. This work includes the study of how information asymmetries affect economic behavior, the determination of the conditions under which efficient sharing of risk occurs, and the economics of financial markets, which are directly relevant to this case. In 1979, I was awarded the John Bates Clark Medal by the American Economic Association, given biennially to the economist under 40 who has made the most significant contribution to economics.¹
6. I was the founding editor of the *Journal of Economic Perspectives*. I have served (or am currently serving) on the Editorial Board of numerous journals, including *The Economists' Voice*, the *Journal of Globalization and Development*, the *World Bank Economic Review*, the *Journal of Public Economics*, the *American Economic Review*, the *Journal of Economic Theory*, *The Review of Industrial Organization*, *Managerial and Decision Economics*, *Energy Economics*, the *Review of Economic Design*, and the *Review of Economic Studies*.

¹ The John Bates Clark Medal has been given annually since 2009.

7. I served as President of the International Economic Association from 2011–2014 and as President of the Eastern Economic Association in 2008. I also served as Vice President of the American Economic Association in 1985.
8. I have received more than 40 honorary degrees, and have received awards from foreign governments, including the Legion of Honor from France. I have also been elected to numerous academic and scientific societies in the United States and abroad, including the National Academy of Sciences, the Royal Society, the American Academy of Arts and Sciences, the American Philosophical Society, and the British Academy. In 2011, *Time* magazine named me to their *Time 100* list as one of the 100 most influential people in the world.
9. From 1993 to 1997, I served as a member of President Clinton’s Council of Economic Advisers, and from 1995 to 1997, as Chairman of the Council and a member of the President’s Cabinet. As Chairman and Cabinet Member, I was heavily involved in formulating fiscal policy, sustainable economic policies (including environmental economic policies), financial sector regulation and banking policy, and coordinating policy with the U.S. Treasury.
10. From 1997 to 2000, I served as Chief Economist and Senior Vice President of the World Bank, in which capacity I had the responsibility of advising countries around the world on the design of fiscal, tax, and monetary policies, competition policies, sustainable economic policies (including those regarding natural resources and the environment), intellectual property regimes, financial regulations, and trade policy.
11. I have served or am serving currently on many commissions and advisory committees addressing a myriad of economic policy issues, both in the U.S. and abroad, including the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues, the United Nations’ International Labour Organization World Commission on the Social Dimensions of Globalization, the High Level Panel of the African Development Bank, and the Economic Advisory Panel in South Africa.
12. At the behest of the President of the General Assembly of the United Nations, I served as Chair of the Commission of Experts on Reforms of the International Monetary and Financial System, to review the workings of the global financial system in the wake of

the 2008 economic crisis and suggest steps for U.N. member states to secure a sustainable economic future. Our final report was published in September 2009. In addition, I was appointed President of the Commission on the Measurement of Economic Performance and Social Progress by President Sarkozy of France, in 2008. This commission was formed to consider flaws in traditional macroeconomic indicators measuring economic performance and social progress and consider what might be the more relevant metrics, which are relevant to this case. Our final report was released in September 2009.

13. In 2000, I founded the Initiative for Policy Dialogue, for which I continue to serve as co-President. The Initiative for Policy Dialogue is a global network of academics and practitioners to enhance democratic processes for decision-making in developing countries. I am also Co-Chair of the High-Level Expert Group on the Measurement of Economic Performance and Social Progress, Organisation for Economic Co-operation and Development (OECD) and the Chief Economist of, and a Senior Fellow at, the Roosevelt Institute.
14. Previously, I served as Chair of the Management Board at the Brooks World Poverty Institute at the University of Manchester, on the Board of Trustees of Amherst College, my undergraduate *alma mater*, and as Co-Chair of Columbia University's Committee on Global Thought.
15. I have provided expert testimony in various fora throughout the United States, and before foreign courts and international tribunals. I have submitted *amicus curiae* briefs before the Supreme Court of the United States and before U.S. Circuit Courts of Appeal. My expert testimonies have related broadly to financial markets and derivatives, taxes, antitrust and competition, patent enforcement, and public interest generally (e.g., promotion of efficiency and/or minimization of welfare costs). I have also offered testimony regarding environmental economics, specifically, around offshore drilling.
16. My curriculum vitae, which provides more details of my qualifications, including a list of my publications, is attached as **Exhibit A**. **Exhibit B** contains a list of my previous expert testimony within the last five years. The materials that I, and volunteers supporting me at my direction, considered in preparing this report are cited in the footnotes and listed in **Exhibit C**.

17. I am working *pro bono* to prepare this expert report. My usual rate for work in litigation matters is \$2,000 per hour, which is the rate I will charge if another party seeks discovery under Federal Rule 26(b). I have no present or intended financial interest in the outcome of this matter. My work in this matter is ongoing, and I reserve the right to revise or augment the opinions set forth in this report should additional relevant information become available to me, or as I perform further analysis.

II. ASSIGNMENT AND SUMMARY OF CONCLUSIONS

18. Julia Olson and Philip Gregory, counsel for Plaintiffs in this matter, have asked me to provide my expert opinion on the economics of transitioning to a non-fossil fuel economy.² In particular, I have been asked: (a) to analyze from an economic perspective how climate change will harm the Youth Plaintiffs (and Affected Children) if Defendants continue to pursue policies that perpetuate a fossil-fuel-based energy system and defer action to mitigate climate change; and (b) to assess the economic benefits of transitioning to a non-fossil-fuel economy now rather than later. The opinions expressed in this report are my own. All opinions expressed herein are to a reasonable degree of scientific certainty, unless otherwise specifically stated.
19. I have formed four primary conclusions in this case, the bases for which are set forth more fully below:
- a. Scientific evidence shows further incremental increases in global temperature will lead to disproportionately greater costs imposed on our society. This has important consequences for how Defendants' actions harm the Youth Plaintiffs and Affected Children more generally. Continuation of the national fossil fuel-based energy system by Defendants is causing imminent, significant, and irreparable harm to the Youth Plaintiffs and Affected Children more generally. This kind of environmental harm, by its nature, cannot be adequately remedied by money damages and is often permanent or at least of long duration, i.e., irreparable. There is a point at which, once this harm occurs, it cannot be undone at any reasonable cost or in any reasonable period of time. Based on the best available science, our country is close to approaching that point.³

² I understand that the plaintiffs in this litigation are young people, who I will refer to as the "Youth Plaintiffs." However, my analysis also looks at the impact on other young people who are not named plaintiffs (and as-yet-unborn youth, the so-called future generations), but are just as (or even more) affected, whom I collectively refer to as "Affected Children."

³ This is a global problem. However, as I discuss below in Section V.B, the U.S. is a significant contributor to GHG emissions, and so actions by the U.S., have a significant impact on these global outcomes.

- b. Defendants' continuing support and perpetuation of a national fossil fuel-based energy system and continuing delay in addressing climate change is saddling and will continue to saddle Youth Plaintiffs with an enormous cost burden, as well as tremendous risks, which is causing substantial harm to the economic and personal well-being and security of Youth Plaintiffs. These costs and risks will be borne over each ensuing year that progress towards remediation is not undertaken by Defendants. Such costs and risks arise both from damage caused by accumulated greenhouse gas emissions and from the required outlays on future remediation and adaptation efforts, which grow more expensive as the accumulation of greenhouse gases in the atmosphere increases. There are particularly consequential risks arising from the potentially catastrophic impacts of climate change, which increase each year that Defendants defer action on greenhouse-gas mitigation efforts.

- c. Moving the U.S. economy away from fossil fuels is both feasible and beneficial, especially over the next 30 years (as technological and scientific evidence discussed below makes clear). Defendants could facilitate this transition with standard economic tools for dealing with externalities, for example a tax or levy on carbon (a price on the externality) and the elimination of subsidies on fossil-fuel production. Relatedly, decisions concerning the transition off of fossil fuels can be reached more systematically and efficiently by revising current government discounting practices, the methodology by which future costs are compared to present costs. Current and historical government decision making practices based on incorrect discount rates lead to inefficient and inequitable outcomes that impose undue burdens on Youth Plaintiffs and future generations. Basing decisions (policies, programs, and actions) on appropriate discount rates would help minimize the burdens that Defendants' current policies place on Youth Plaintiffs and future generations. That is to say, if Defendants' discounting policies and practices more accurately reflected the expected changes in relative prices over time (and their distribution, implicitly putting a lower discount rate on climate change benefits), the basis for Defendants' policy-making decisions would more closely align with economic principles and yield more efficient outcomes.

- d. Based on this reasoning, I conclude that Defendants can and should take meaningful actions to reduce GHG emissions from fossil fuels and mitigate climate change impacts now rather than defer action to some future date. Acting now will yield benefits for both Defendants and Youth Plaintiffs and reduce harm to Youth Plaintiffs, and the costs of mitigating climate change now are manageable. Defendants could make meaningful progress on climate change mitigation by acting today in accordance with the best available science. Moreover, Defendants meeting their constitutional and public trust obligations to redress climate change would improve societal well-being by any reasonable economic standard. In fact, some of the actions that Defendants could take to meet these obligations would actually have a negative cost. That is to say, in the long run, the net present value of benefits to society would exceed the net present value of costs that society would have to incur.⁴ This is referred to as Kaldor–Hicks efficiency in standard economic analysis, typically a hallmark of sound policymaking, from an economic perspective, whereby the net benefits of a policy change outweigh the net costs of such policy change. Thus, if Defendants were to make such changes as are argued for by other of Plaintiffs’ experts, the net societal gain would more than outweigh the net societal loss. In contrast, Defendants’ current policies of perpetuating the fossil fuel-based energy system impose unacceptably high costs and risks on the Youth Plaintiffs specifically and Affected Children more generally, and will continue to do so, well out of portion to the amounts that Defendants save currently by avoiding taking the appropriate actions.
20. The body of my report sets out the factual and analytical bases for my conclusions and opinions. The balance of my report proceeds as follows: Section III summarizes the scientific evidence on increasing greenhouse gases affecting global temperatures and why the time to act is now; Section IV discusses the costs that Youth Plaintiffs will face if Defendants continue to promote and permit a fossil-fuel-based energy system and no

⁴ This is not to say that each party is better off (which would be a Pareto improvement); but those parties who are better off by the policy change (e.g., non-polluters) are made better off by more than the parties made worse off by the policy change (e.g., polluters) are made worse off.

actions (or insufficient actions) are taken to wean society off fossil fuels; Section V analyzes how the transition away from fossil fuels is feasible and can be facilitated with standard economic tools; and, finally, Section VI concludes.

III. BACKGROUND ON THE RELATIONSHIP BETWEEN ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES AND CLIMATE CHANGE

21. The climate change young people are experiencing today is caused by the historic emissions of carbon dioxide (CO₂) and other greenhouse gases (GHGs), primarily from burning fossil fuels and other anthropogenic activities, including deforestation and agricultural practices.⁵ It is scientifically established that human activities produce GHG emissions, which accumulate in the atmosphere and the oceans, resulting in warming of Earth's surface and the oceans⁶, acidification of the oceans,⁷ increased variability of climate, with a higher incidence of extreme weather events, and other changes in the climate.
22. Dangerous impacts are already occurring from the current level of global warming of around 1°C above preindustrial temperatures. Climate scientists have established through the paleo record that warming of 1.5°C or 2°C above pre-industrial levels would be well outside the Holocene range of global temperatures within which humans have lived and

⁵ See, for example, Intergovernmental Panel on Climate Change, "Climate Change 2014: Synthesis Report Summary for Policymakers," pp. 4-5. Other Greenhouse Gases, like Methane, also trap heat within the earth. They differ in key technical properties, like the rate of dissipation. Throughout this report, I use the terms GHG and CO₂ emissions interchangeably.

There is a popular but misguided debate among so-called climate "skeptics" about the extent to which the observed increase in temperature is a result of the emissions of CO₂ and other GHGs. The scientific literature is clear (and has been clear for a long time): the increase in atmospheric concentration of GHGs predictably increases the Earth's temperature in the manner observed. This has been most recently reaffirmed by "Climate Science Special Report: Fourth National Climate Assessment, Volume I" U.S. Global Change Research Program, November 2017, pp. 96-97 https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf. (Hereinafter USGCRP Climate Science Special Report).

But even if there were other factors contributing to climate change, the analysis here is unchanged: Defendants could, with mild costs, take actions now that would avoid imposing the undue and excessive burdens and risks imposed on the Youth Plaintiffs in this case.

⁶ USGCRP Climate Science Special Report, p. 364.

⁷ USGCRP Climate Science Special Report, pp. 371-372.

societies developed.⁸ Moreover, leading experts believe that there is already more than enough excess heat in the climate system to do severe damage and that 2°C of warming would have very significant adverse effects, including resulting in multi-meter sea level rise.⁹ NOAA projects up to 0.63 m (2.1 feet) of sea level rise by 2050, 1.2 m (3.9 feet) by 2070, 2.5 m (8.2 feet) by 2100, 5.5 m (18 feet) by 2150, and 9.7 m (31.8 feet) by 2200.¹⁰ A 2-3 foot sea level rise would inundate and render uninhabitable large portions of the world's barrier islands and deltas and place major pressures on the infrastructure of low-lying coastal zones like South Florida, and 3 feet of seal level rise would “permanently inundate 2 million American's homes and communities.”¹¹ Sea level rise of this magnitude would impose irreversible harm and an immense financial burden on young people in coastal areas, along with significant indirect costs on young people elsewhere.

23. Experts have identified a number of known “feedback loops” in the climate system. These feedback loops cause warming to catalyze still further warming. For example, warmer arctic temperatures result in melting permafrost that releases methane, a GHG that further warms the planet. These feedbacks, in conjunction with the fact that CO₂ persists in the atmosphere for centuries, mean that the longer we delay action, the greater the risk that warming will trigger tipping points in the climate system and become irreversible, or reversible only at much increased cost. Given the self-reinforcing nature

⁸ J. Hansen et al., “Assessing ‘Dangerous Climate Change’: Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature,” *PLOS One*, 8:12, e81648, 2013, p. 9.

⁹ J. Hansen, et al., “Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2C global warming is highly dangerous,” *Atmospheric Chemistry and Physics Discussions*, 15, 20059-179, 2015, <http://faculty.sites.uci.edu/erignot/files/2017/06/Ice-melt-sea-level-rise-and-superstorms-evidence-from-paleoclimate-data-climate-modeling-and-modern-observations-that-2C-global-warming-is-highly-dangerous.pdf>.

¹⁰ “Global and regional sea level rise scenarios for the United States,” NOAA Technical Report NOS CO-OPS 083, January 2017, p. 23, https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf.

¹¹ H. Wanless, “Declaration of Dr. Harold R. Wanless in Support of Answer of Real Parties in Interest to Petition for Writ of Mandamus”, in *United States of America et al. v. United States District Court for the District of Oregon et al.*, Case No. 17-71692, Doc. No. 14-3, paras. 31-32, citing “Global and regional sea level rise scenarios for the United States,” NOAA Technical Report NOS CO-OPS 083, January 2017.

of climate change, prompt action is needed to both minimize future emissions and reduce the effects of historic emissions.

24. Experts have observed an increased incidence of climate-related extreme weather events, including increased frequency and intensity of extreme heat and heavy precipitation events and more severe droughts and associated heatwaves. Experts have also observed an increased incidence of large forest fires; and reduced snowpack affecting water resources in the western U.S. The most recent National Climate Assessment projects these climate impacts will continue to worsen in the future as global temperatures increase.¹²
25. Although the scale of the problems and risks that we face are immense, it is possible to reduce these risks by acting now to avoid irreversible harm to essential natural systems with its catastrophic consequences such as sea level rise, increased ocean temperatures, ocean acidification, heat waves, increased drought, and the associated impacts on water quality and availability, human health, and agriculture. Such impacts would harm our economy directly and introduce much increased risk in the form of variability in and uncertainty around climate outcomes.
26. Dr. Hansen and other experts in this case have provided a prescription for an emissions reduction and carbon sequestration pathway back to CO₂ levels below 350 ppm by 2100, which they say would substantially lessen the risk of catastrophic sea level rise and other climate harms.¹³ Returning to temperatures and atmospheric CO₂ levels that avoid dangerous anthropogenic climate change has a limited window (because of tipping points in the climate system), which is still open but is closing rapidly. Defendants must take action now to reduce these risks.

¹² USGCRP Climate Science Special Report, pp. 19-22.

¹³ James Hansen et al., “Assessing ‘Dangerous Climate Change’: Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature,” *PLOS One*, 8:12, e81648, 2013.

IV. DEFENDANTS' ACTIONS THAT PERPETUATE A FOSSIL FUEL ENERGY SYSTEM AND INSUFFICIENT ACTION ON CLIMATE CHANGE ARE IMPOSING AND WILL CONTINUE TO IMPOSE ENORMOUS COSTS ON YOUTH PLAINTIFFS

27. The current national energy system, in which approximately 80 percent of energy comes from fossil fuels, is a direct result of decisions and actions taken by Defendants.¹⁴ Defendants control and dictate the U.S. national energy policy in a myriad of ways. For example, they provide billions of dollars annually in subsidies to the fossil fuel industry;¹⁵ control the fuel economy of cars and trucks through the Corporate Average Fuel Economy (“CAFE”) standard; set efficiency standards for appliances; permit the extraction, transportation, import, export, and combustion of fossil fuels; and provide funding for research and development.¹⁶ The fact that the U.S. national energy system is so predominately fossil fuel-based is not an inevitable consequence of history. With the oil crises of the 1970s, recognition of the risks of dependence on oil was developed (though these risks were markedly different from those with which we are concerned today). Even then, it was clear that there were viable alternatives, and with the appropriate allocation of further resources to R&D, it is likely that these alternatives would have been even more competitive. Thus, the current level of dependence of our energy system on fossil fuels is a result of intentional actions taken by Defendants over many years (including subsidization of fossil fuels and *inactions* in the form of not providing adequate support for alternatives).¹⁷ Cumulatively, these actions promote the use of fossil fuels, contribute to dangerous levels of CO₂ emissions, and cause climate change. The economic impacts of these actions are deleterious to Youth Plaintiffs and the nation as a whole. In other words, Defendants’ actions promoting a fossil fuel based

¹⁴ U.S. Energy Information Administration, Table 1.3 Primary Energy Consumption by Source, August 2017 Monthly Energy Review, <https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T01.03&freq=m>.

¹⁵ See, Section V, below.

¹⁶ “Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013”, U.S. Energy Information Administration, March 2015, <https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf>.

¹⁷ I would note that inactions in this sense are affirmative decisions by Defendants not to act.

energy system are serving to undermine the legitimate government interests of national security and economic prosperity that they purport to advance.¹⁸

28. When conducting an economic analysis of the effects of climate change and appropriate responses thereto, Defendants must take into account a number of salient aspects of climate change. I have already noted some of these aspects: not just global warming in the sense of on-average increases in temperature, but also an increase in extreme (and damaging) weather events, rising sea levels, the public health consequences, and many other direct and indirect impacts of climate change. Still another aspect of climate change that is crucial in framing an appropriate response are the long lag times inherent in the climate system, implying that the full climate impact of any given accumulation of GHGs may not be apparent for many years.¹⁹ Moreover, critical to the effects (as already noted) is the increase in concentration of GHGs. The fact that GHGs dissipate very slowly from the atmosphere (particularly in the case of CO₂²⁰) and that the costs of taking

¹⁸ Daniel R. Coats, Director of National Intelligence, “Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community,” *Office of the Director of National Intelligence*, February 13, 2018, <https://www.intelligence.senate.gov/sites/default/files/documents/os-dcoats-021318.PDF> (at page 16: “The impacts of the long-term trends toward a warming climate, more air pollution, biodiversity loss, and water scarcity are likely to fuel economic and social discontent—and possibly upheaval....”).

¹⁹ Because of these lags, we have not yet seen the full rise in temperature that will occur as a result of the CO₂ that has already been emitted. As noted above, the Earth’s average surface temperature has already risen by approximately 1°C since the Industrial Revolution. The concentration of CO₂ in the atmosphere is increasing at the rate of 2-3 ppm per year. Scientists tell us that even if CO₂ were stabilized at current levels, there would be at least another 0.5°C “in the pipeline.” The delayed response is known as climate lag. The reason the planet takes several decades to respond to increased CO₂ is the thermal inertia of the oceans. Consider a saucepan of water placed on a gas stove. Although the flame has a temperature measured in hundreds of degrees C, the water takes a few minutes to reach boiling point. This simple analogy explains climate lag. The mass of the oceans is around 500 times that of the atmosphere. The time that it takes to warm up is measured in decades. For example, a paper by Dr. Hansen (and others) estimates the time required for 60 percent of global warming to take place in response to increased emissions to be in the range of 25 to 50 years. See, Hansen, J.E. et al., “Earth’s Energy Imbalance: Confirmation and Implications,” *Scienceexpress*, April 28, 2004, <http://science.sciencemag.org/content/early/2005/04/28/science.1110252>.

²⁰ Accumulations of CO₂ are particularly problematic because they dissipate so slowly. See, e.g., “Carbon is forever,” *Nature Reports Climate Change*, November 20, 2008. This article discusses results from Dr. Hansen’s research, stating: “Several long-term climate models, though their details differ, all agree that anthropogenic CO₂ takes an enormously long time to dissipate. If all recoverable fossil fuels were burnt up using today’s technologies, after 1,000 years the air would still hold around

Continued on next page

CO₂ out of the atmosphere through non-biological carbon capture and storage are very high²¹ means that the consequences of GHG emissions should be viewed as effectively irreversible. Accordingly, if Defendants do not take serious action to mitigate climate change now, Youth Plaintiffs and Affected Children will largely shoulder the costs caused by Defendants' actions that contribute to the further accumulation of GHGs and Defendants' failure to act to redress the harm. We can expect these burdens to manifest themselves in at least four ways.

29. **First**, despite their relative lack of economic power in society today, Youth Plaintiffs themselves will suffer the disproportionate, increased financial burdens of climate change as the impacts of climate change propagate throughout the economy. For example, rising sea levels will lead to massive reductions in property value (indeed, the value of land that is underwater will fall to zero). Some Youth Plaintiffs, such as Levi D., and Affected Children will (with high probability) be deprived of the use of submerged lands, and many of them will almost surely experience large capital losses, as markets eventually fully reflect the realities of climate change. In addition, Youth Plaintiffs and Affected Children will, as future taxpayers, help bear the enormous cost of relocating the people and infrastructure that are now on this land to higher ground. Youth Plaintiffs and Affected Children will also bear the cost of instituting temporary stopgap measures, such as dikes to hold back rising sea levels, and some of them will have to bear directly themselves relocation costs.

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a third to a half of the CO₂ emissions. 'For practical purposes, 500 to 1000 years is 'forever,' as Hansen and colleagues put it. In this time, civilizations can rise and fall, and the Greenland and West Antarctic ice sheets could melt substantially, raising sea levels enough to transform the face of the planet."

²¹ See, for example, House, K.Z., et al., "Economic and energetic analysis of capturing CO₂ from ambient air," *Proceedings of the National Academy of Sciences*, 108(51) (December 2011): 20428-20433, <http://www.pnas.org/content/108/51/20428.full.pdf>. The authors concluded: "Our empirical analysis of energetic and capital costs of existing, mature, gas separation systems indicates that air capture processes will be significantly more expensive than mitigation technologies aimed at decarbonizing the electricity sector. Unless a technological breakthrough that departs from humankind's accumulated experience with dilute gas separation can be shown to "break" the Sherwood plot and the second-law efficiency plot—and the burden of proof for such a process will lie with the inventor—direct air capture is unlikely to be cost competitive with CO₂ capture at power plants and other large point sources."

30. **Second**, Youth Plaintiffs and Affected Children will face increased burdens as taxpayers because, as Defendants and climate scientists project, climate change will increase future losses related to climate variability, sometimes of a catastrophic nature.²² In previous cases of catastrophic loss, society as a whole has borne much of the cost in the form of disaster relief payments from the public sector.²³ Recent examples of catastrophes in which a large proportion of the losses were borne by the public sector include Hurricane Katrina, Hurricane Sandy, Hurricane Harvey, Hurricane Irma, and Hurricane Maria. Each of these disasters has (or will) cost the public sector billions of dollars in disaster relief. For instance, Hurricane Sandy cost the U.S. government over \$50 billion, which is three times larger than the \$18.7 billion of insured losses from that disaster, and over 70

²² “The Impact of Climate Change on Natural Disasters,” NASA, https://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php. “Global Warming and Hurricanes,” National Oceanic and Atmospheric Association, <https://www.gfdl.noaa.gov/global-warming-and-hurricanes/>. “Climate Change Indicators: Weather and Climate,” EPA, <https://www.epa.gov/climate-indicators/weather-climate>. See also, K. Trenberth et al., “Attribution of climate extreme events,” *Nature Climate Change* 5 (2015): 725-730.

²³ “Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget”, Congressional Budget Office (CBO), June 2016, <https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51518-hurricane-damage.pdf>.

Public sector relief is needed in these cases because private risk-pooling solutions, such as property and casualty insurers, do not and cannot cover even a majority of the realized losses. This is true for three primary reasons. *First*, a significant portion of the population is uninsured or underinsured for certain types of losses such as the risk of flood, especially in areas that have not been historically prone to flooding. *Second*, public property may not be insured at all. *Third*, property and casualty insurers are sometimes insufficiently capitalized to cover the enormous losses that such events can potentially cause, and their insolvency forces policyholders to turn to the government for assistance.

This point is illustrated by Hurricane Harvey in 2017, where some estimates of the costs run to nearly \$200 billion, which represents about 1 percent of gross national product. See, e.g., Doyle Rice, “Harvey to be costliest natural disaster in U.S. history, estimated cost of \$190 billion,” *USA Today*, August 31, 2017, <https://www.usatoday.com/story/weather/2017/08/30/harvey-costliest-natural-disaster-u-s-history-estimated-cost-160-billion/615708001/> and Reuters, “Hurricane Harvey Damages Could Cost up to \$180 Billion,” *Fortune*, September 3, 2017, <http://fortune.com/2017/09/03/hurricane-harvey-damages-cost/>. The Treasury Secretary went so far as to speculate that the Federal government’s debt limit would have to be raised to free up spending for disaster recovery, and the Governor of Texas estimated that such relief could require \$180 billion. *Id.*

Estimates for Hurricane Maria have been on the order of \$100 billion. See, Jill Disis, “Hurricane Maria could be a \$95 billion storm for Puerto Rico,” *CNN*, September 28, 2017, <http://money.cnn.com/2017/09/28/news/economy/puerto-rico-hurricane-maria-damage-estimate/index.html>.

percent of the total economic damage of the disaster as estimated by the CBO.²⁴ Hurricane Katrina cost the U.S. government over \$110 billion, 75 percent of the total economic damages of the disaster.²⁵ With increased catastrophic losses due to climate change, we can expect that the U.S. government's role as a safety net will expand.²⁶ As this trend continues, taxpayers of the future, including Youth Plaintiffs, will have to make whole the losses of property owners. The continuation, let alone the expansion, of the public sector's role as a safety net will be enormously costly, impose an increased burden and economic disadvantage on Youth Plaintiffs and Affected Children compared to older generations, and result in fewer government resources to be spent on public services.²⁷

31. The National Centers for Environmental Information tracks the impact of weather events on the United States. As they report, from 1980 to 2017 the U.S. has experienced “219 weather and climate disasters since 1980 where overall damages/costs reached or exceeded \$1 billion (including CPI adjustment to 2017). **The total cost of these 219 events exceeds \$1.5 trillion.**”²⁸ (Emphasis in original.) In describing the impact on the U.S. in 2017 (the last full year):²⁹

²⁴ “Catastrophes: U.S.,” Insurance Information Institute, <http://www.iii.org/fact-statistic/catastrophes-us>, “Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget”, Congressional Budget Office (CBO), June 2016, <https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51518-hurricane-damage.pdf>.

²⁵ “Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget,” Congressional Budget Office (CBO), p. 17, <https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51518-hurricane-damage.pdf>.

²⁶ “Underinsurance of Property Risks: Closing the Gap,” Swiss Re, No. 5/2015, http://institute.swissre.com/research/overview/sigma/5_2015.html.

²⁷ The CBO estimates that, by 2075, hurricane losses alone will total 0.22 percent of GDP, or \$39 billion in 2016 dollars, an increase of 40 percent from today's annual levels, and over half of that loss will be borne by the U.S. government. “Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget,” Congressional Budget Office, <https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51518-hurricane-damage.pdf>.

²⁸ “Billion-Dollar Weather and Climate Disasters: Overview,” National Centers for Environmental Information, 2018, <https://www.ncdc.noaa.gov/billions/>.

²⁹ *Id.*

In 2017, there were 16 weather and climate disaster events with losses exceeding \$1 billion each across the United States. These events included 1 drought event, 2 flooding events, 1 freeze event, 8 severe storm events, 3 tropical cyclone events, and 1 wildfire event. Overall, these events resulted in the deaths of 362 people and had significant economic effects on the areas impacted.

32. As the above makes clear, it is not just hurricanes that can cause such costly events. The 2017 wildfire season in California was particularly harsh. Insurance claims at the end of 2017 were approximately \$9.4 billion (with many properties being underinsured or not insured, the total damage is higher),³⁰ and estimates of the total impact on economic activity were \$180 billion (including damages, closures, costs to fight fires, lost sales, etc.).³¹ In 2016, Canada had a similar experience in Fort McMurray, Alberta; insurance payments were the costliest in Canadian history at CAD 3.58 billion,³² and this covered only 70 percent of the total economic loss.³³ Particularly insidious with forest fires is that they also lead to massive injections of CO₂ into the atmosphere. As the Climate Science Special Report (a compilation by the U.S. Global Change Research Program, spanning multiple government agencies) noted about the Alberta wild fires specifically: “They can also radically increase emissions of greenhouse gases, as demonstrated by the amount of carbon dioxide produced by the Fort McMurray fires of May 2016—more than 10% of Canada’s annual emissions.”³⁴ The federal government expends significant financial

³⁰ W. Richter, “We may never be able to know the true cost of California’s massive wildfires,” *Business Insider*, December 7, 2017, <http://www.businessinsider.com/santa-rosa-california-fires-cost-damage-2017-12>.

³¹ “AccuWeather predicts 2017 California wildfire season cost to rise to \$180 billion,” *AccuWeather*, December 8, 2017, <https://www.accuweather.com/en/weather-news/accuweather-predicts-2017-california-wildfire-season-cost-to-rise-to-180-billion/70003495>.

³² “Northern Alberta Wildfire Costliest Insured Natural Disaster in Canadian History – Estimate of insured losses: \$3.58 billion,” Insurance Bureau of Canada, July 7, 2016, <http://www.ibc.ca/ab/resources/media-centre/media-releases/northern-alberta-wildfire-costliest-insured-natural-disaster-in-canadian-history>.

³³ W. Koblensky, “Fort McMurray in top 10 worst insured losses globally,” *Insurance Business Canada*, March 29, 2017, <http://www.insurancebusinessmag.com/ca/news/environmental/fort-mcmurray-in-top-10-worst-insured-losses-globally-63960.aspx>.

³⁴ USGCRP Climate Science Special Report, p. 415.

resources each year on both fire suppression efforts and in the aftermath of wildfires, and while costs do vary from year to year, in general, they are rising.³⁵

33. Other potential examples include agricultural losses. Whether or not insurance reimburses farmers for their crops, there can be food shortages that lead to higher food prices (that will be borne by consumers, that is, Youth Plaintiffs and Affected Children). There is a further risk that as our climate and land use pattern changes, disease vectors may also move (e.g., diseases formerly only in tropical climates move northward).³⁶ This could lead to material increases in public health costs in terms of vaccinations and treatments, at least some portion of which will be borne by future taxpayers, i.e., Youth Plaintiffs and Affected Children. Moreover, the Youth Plaintiffs and Affected Children will be at risk of experiencing directly one or more of these increased health hazards, only a portion of the costs of which will be picked up by insurance or public assistance. There is a risk too that the increased health costs will be reflected in increased insurance premiums, affecting all those relying on private insurance, including some or all of the Youth Plaintiffs and Affected Children.
34. All of these factors will also lead to increasing inequality, as those with financial means are more able to privately bear the costs of these disasters, while those without financial means will not. Those with means will also be able to relocate, perhaps avoiding (for themselves) the burdens of rising sea levels. This will impose a greater burden on those less able to pay for the direct, local consequences of climate change. Such increasing inequality is bad not only for those made worse off, but also for society as a whole, as a more unequal society is one with poorer economic performance.³⁷ This will impose

³⁵ See, e.g., K. Hoover & B. Lindsay, “Wildfire Suppression Spending: Background, Issues, and Legislation in the 115th Congress,” Congressional Research Service, October 5, 2017, <https://fas.org/sgp/crs/misc/R44966.pdf>.

³⁶ See, e.g., G. Mercer, “The Link Between Zika and Climate Change,” *The Atlantic*, February 24, 2016, <https://www.theatlantic.com/health/archive/2016/02/zika-and-climate-change/470643/>.

³⁷ See, e.g., OECD, “Inequality hurts economic growth, finds OECD research,” September 12, 2014, <http://www.oecd.org/newsroom/inequality-hurts-economic-growth.htm> and Prakash Loungani and Jonathan D. Ostry, “The IMF’s Work on Inequality: Bridging Research and Reality,” IMF, February 22, 2017, <https://blogs.imf.org/2017/02/22/the-imfs-work-on-inequality-bridging-research-and-reality/> (“Another important conclusion of IMF research: rising inequality poses risks to durable

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further costs on the Youth Plaintiffs and Affected Children as they have to adapt to a structurally weaker economy due to increasing inequality (as elaborated on below, inequality is also exacerbated by Defendants' subsidy system that takes from taxpayers and gives to fossil-fuel corporations).

35. **Third**, Youth Plaintiffs will face increased burdens because the more time that passes, the more expensive it becomes to address climate change.³⁸ It is highly likely that, as the consequences and magnitude of climate change become manifest, there will finally be a global consensus for a globally equitable and efficient response.³⁹ At that juncture, the only way to prevent the accumulation of greenhouse gases beyond a tolerable level will be “negative emissions,” i.e. taking carbon out of the atmosphere, effectively attempting to undo the damage that is currently being done.⁴⁰ That will be enormously expensive relative to what it would have cost to begin curtailing emissions today.⁴¹ Further, there is no guarantee that Youth Plaintiffs will be able to timely and effectively repair this

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economic growth. This puts addressing inequality squarely within the IMF's mandate to help countries improve economic performance.”).

³⁸ See, e.g., “Climate change in the United States: Benefits of Global Action”, EPA. Beccherle, Julien and Tirole, Jean, “Regional Initiatives and the Cost of Delaying Binding Climate Change Agreements”, *Journal of Public Economics* 95 (December 2011): 1339-1348. Jakob, Michael and Tavoni, Massimo, “Time to act now? Assessing the costs of delaying climate measures and benefits of early action”, *Climate Change* 114 (2012): 79-99.

³⁹ See, for example, Climate change in the United States: Benefits of Global Action, EPA, <https://www.epa.gov/sites/production/files/2015-06/documents/cirareport.pdf>.

⁴⁰ See, for example, “The cost of delaying action to stem climate change,” Executive Office of the President of the United States, July 2014, p. 13, https://obamawhitehouse.archives.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf.

⁴¹ Even as these costly actions to undo the damage are undertaken, the effects of failing to act now will likely be felt, in ways described earlier in this report. Each and every one of the Youth Plaintiffs will face a risk of being personally affected, e.g., by increased taxes, increased direct losses, and increased exposure to health risks and to climate variability itself.

A recent estimate pegged the costs of CO₂ extraction to be on the order of \$8 to \$18.5 trillion, or over \$100 billion per year over 80 years, to return to a 350 ppm target by 2100. These costs are much higher with continued high emissions (i.e., if we do not cease fossil fuel use and rely only on carbon capture and storage), being on the order of \$100 trillion or more. See, J. Hansen et al., “Young People’s Burden: Requirement of Negative CO₂ Emissions,” *Earth System Dynamics*, vol. 8, 2017, pp. 577-616, at 591-592.

damage. In other words, the actions of Defendants in promoting and perpetuating a fossil fuel-based energy system impose a disproportionately higher financial burden and economic disadvantage on Youth Plaintiffs and Affected Children, undermining their economic security and depriving them of the stronger economy that they would have had in the absence of unmitigated climate change.

36. *Fourth*, in the absence of mitigation efforts, there is a significant risk of catastrophic impacts of climate change; indeed, there is overwhelming evidence that such catastrophic impacts are likely to result. Defendants' failure to invest in climate change mitigation and thereby insure against that outcome imposes an enormous degree of risk on Youth Plaintiffs, not experienced by older generations. Events such as the rapid melting of ice sheets and consequent increases in global sea levels or temperature increases on the higher end of the range of scientific forecasts have the potential to entail severe, perhaps even irreparable, consequences.⁴² To confront properly the possibility of climate catastrophes, Defendants must take prudent steps now to reduce the chance of the most severe consequences of climate change. The longer Defendants postpone such action, the greater will be the atmospheric concentration of GHGs and the risk (due to the self-reinforcing and path-dependent⁴³ nature of climate systems and long lags between actions and results, as discussed above). Just as businesses and individuals guard against severe financial risks by purchasing various forms of insurance, Defendants can take actions now that reduce the chances of triggering the most severe climate events. There is no third party from which Defendants could purchase insurance to protect Youth Plaintiffs from the damages that are consequent to Defendants' actions. The only alternative for Defendants is to take actions without delay to reduce the atmospheric concentration of CO₂ in order to restore Earth's energy balance and avert catastrophic and irreversible

⁴² See, Section III, above.

⁴³ By path dependence, I mean that prior actions affect the future trajectory of the economy in ways that are not irreversible, or reversible only at high costs. Accordingly, what is a prudent strategy today depends on decisions made yesterday (and many years ago). Put differently, prior decisions are not something that we can now just walk away from; those prior decisions directly affect the world we live in today and affect the analysis of what is a prudent strategy going forward.

climate change impacts.⁴⁴ Unlike conventional insurance policies, climate and energy policy that serves the purpose of climate insurance also results in cleaner air, improved energy security, and other benefits, many of which are difficult to monetize, like biological diversity or preserving culturally important places, but are nonetheless significant.

37. The benefits of undertaking such actions are disproportionate to the costs, even without taking account of the huge benefits that arise from the reduction of risk itself. This has been documented, for example, in the High-Level Commission on Carbon Prices.⁴⁵ Due to feedback loops, the magnitude of climate change may change much more than the proportionate increase in atmospheric concentrations of GHGs. Likewise, the increases in atmospheric concentrations of GHGs may increase disproportionately relative to emissions,⁴⁶ and the cost of damage wrought by climate change can increase much faster still.⁴⁷ More is being learned about the behavior of the climate system, including the potential timing and likelihood of these worst-case scenarios. However, the paleo-climate record gives scientists at least one good indication of the consequences of different levels of atmospheric CO₂. The last time in the geologic record that CO₂ levels were over 400 ppm, the seas were 70-90 feet higher than sea level today.⁴⁸ The experience of the last

⁴⁴ J. Hansen, “Exhibit A: Declaration of Dr. James E. Hansen in Support of Plaintiffs’ Complaint for Declaratory and Injunctive Relief,” in *Juliana et al. v. United States et al.*, Case No. 6:15-cv-01517-TC, Doc. No. 7-1., 2015, paras. 39, 67, 85.

⁴⁵ The Commission showed that even a modest tax on carbon combined with the elimination of subsidies and certain other regulatory measures and modest public investments would be able to prevent a rise of temperature beyond the 1.5°C to 2°C.

⁴⁶ See, for example, “The study of Earth as an integrated system,” NASA, https://climate.nasa.gov/nasa_science/science/ and National Research Council of the National Academies, “Climate Change: Evidence, Impacts, and Choices,” *The National Academies of Sciences, Engineering, and Medicine*, 2012, http://nas-sites.org/americasclimatechoices/files/2012/06/19014_cvtx_R1.pdf.

⁴⁷ This is discussed in the Stern Review. See, for example, Figure 6.6 showing the exponential increase in reduced GDP per capita as global mean temperature increases. Nicholas Stern, “Stern Review: The Economics of Climate Change”, p. 159, http://unionsforenergydemocracy.org/wp-content/uploads/2015/08/sternreview_report_complete.pdf.

⁴⁸ H. Wanless, “Declaration of Dr. Harold R. Wanless in Support of Answer of Real Parties in Interest to Petition for Writ of Mandamus”, in *United States of America et al. v. United States District Court for the District of Oregon et al.*, Case No. 17-71692, Doc. No. 14-3, para. 52.

quarter century is that there have been many surprises of underestimating adverse climate impacts (e.g., early estimates of sea level rise had not taken into account the effect of the melting of the arctic icecap or the release of methane gases from the tundra).⁴⁹

38. Fair treatment of Youth Plaintiffs by Defendants requires taking due account of some of the worst, but still plausibly possible, cases. In such cases, national income will be lower because of the adverse effects of climate change,⁵⁰ imposing doubly an increased financial burden and economic disadvantage on Youth Plaintiffs and Affected Children: they will face the costs of remediation and adaptation with fewer resources with which to do so. Even if national incomes continue to rise in real terms, the costs of taking remedial climate action are an ever-increasing burden on Youth Plaintiffs and Affected Children as well. Moreover, as discussed in the climate science summary above, we are quickly approaching (or some argue we may have already passed) certain “tipping points” that will dramatically increase costs in a non-linear fashion.⁵¹ Thus, it is not a practical solution to say Youth Plaintiffs and future generations may be more wealthy in the future (in fact, GDP may be lower in the future because of climate effects) and can bear the costs more efficiently than Defendants today (because those costs continue to increase disproportionately and have long-lasting adverse effects). The assumption of ever-increasing national income has significant implications for Defendants’ cost-benefit

⁴⁹ See, for example, Schneider, Stephen H. and Root, Terry L. Ecological implications of climate change will include surprises, *Biodiversity and Conservation* 5 (1996): 1109-1119.

⁵⁰ In one recent study, researchers found that temperature change due to unmitigated global warming will leave global GDP per capita 23 percent lower in 2100 than it would be without any warming. See Burke, M., Hsiang, S. M., & Miguel, E., (2015) “Global non-linear effect of temperature on economic production,” *Nature*, 527 (7577): 235-239.

A per capita 23 percent lowering of GDP is the on-average result, which understates the full potential impact in two ways (much as the on-average temperature increases understate the increase in catastrophic events, as I discussed above). *First*, a 23 percent on-average result includes many states of the world where the average may be much worse. *Second*, a 23 percent on-average result will not affect all persons or all regions equally; those near the bottom of the income distribution that have no savings will suffer from lack of ability to consume, and almost surely these effects will be felt more in coastal regions, from which those near the bottom of the income distribution will lack the financial resources to relocate, further exacerbating their financial difficulties.

⁵¹ See also, “The study of Earth as an integrated system,” NASA, https://climate.nasa.gov/nasa_science/science/.

analysis and development of discount rates and the social cost of carbon, as described in more detail in Section V.C, below.

39. Moreover, it will be necessary to devote a significant proportion of national income to dealing with the consequences of climate change; the standard term is that there will be high costs of adaptation.⁵² Especially disturbing are the impacts on developing countries, many of which are in tropical zones, which will be particularly hard hit. In the U.S., Youth Plaintiffs will not be able to insulate themselves from the global repercussions. The costs of adaptation to climate change by developing countries are well beyond anything that those countries can afford (or will be able to afford in the future). Youth Plaintiffs may recognize that they have a moral responsibility to global citizens elsewhere in the world because of the actions of the U.S., including Defendants, and thus they will bear a burden because of the failure of Defendants to take appropriate actions.⁵³ However, even were they not to do so, the markedly lower incomes in developing countries will set off large migration pressures, which we are already seeing today.⁵⁴

⁵² According to the United Nations Environment (UNEP) report, the cost of adapting to climate change in developing countries could rise to between \$280 and \$500 billion per year by 2050. There will be a significant financing gap unless new and additional finance for adaptation is made available. See UNEP 2016. The Adaptation Finance Gap Report 2016. United Nations Environment Programme (UNEP), Nairobi, Kenya

⁵³ Of course, Defendants do not control global climate emissions. The U.S. is the second-largest current emitter of CO₂ at 15 percent of global emissions (behind only China), and by far the largest historical emitter of CO₂ and GHGs. See, EPA, “Global Greenhouse Gas Emissions Data,” *United States Environmental Protection Agency*, data as of 2014, <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Country> and J. Gillis and N. Popovich, “The U.S. Is the Biggest Carbon Polluter in History. It Just Walked Away From the Paris Climate Deal,” *The New York Times*, June 1, 2017, <https://www.nytimes.com/interactive/2017/06/01/climate/us-biggest-carbon-polluter-in-history-will-it-walk-away-from-the-paris-climate-deal.html>.

However, action by the world’s largest historical contributor of GHGs and the world’s largest economy (the U.S.) would help further the goals of the Paris agreement and other countries’ efforts to reduce GHG emissions. Moreover, it could reduce the incentive for other countries to shirk their climate change efforts by attempting to gain a competitive edge by not addressing climate change (a race to the bottom, so to speak). In any event, however, the fact that other countries, particularly developing countries, may not take as strong an action as is needed is not justification for Defendants using out-dated economic models and analysis to foist high costs on Youth Plaintiffs and Affected Children more generally.

⁵⁴ See, for example, Coral Davenport and Campbell Robertson, “Resettling the First American ‘Climate Refugees,’” *The New York Times*, May 3, 2016, <https://www.nytimes.com/2016/05/03/us/resettling->

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Managing this migration (including possibly putting up hard-and costly-to-enforce barriers to it) will impose large costs on Youth Plaintiffs, undermining their economic security.⁵⁵ Moreover, in a globally interconnected system, lower incomes abroad will adversely affect the demand for American goods and services, thereby reducing U.S. GDP from what it otherwise would be, with consequent risks for Youth Plaintiffs and Affected Children.

40. I understand that Defendants argue their policies were necessary for the economic and national security of the U.S.⁵⁶ Such arguments do not withstand economic scrutiny. Whatever benefits might have existed in the middle of the 20th century, it has been decades since such policies were rational. This has been recognized by leading security experts. For example, since at least 2007, members of the U.S. military have recognized that “serious consequences to our national security ... are likely from unmitigated climate

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[the-first-american-climate-refugees.html](#) and Aryn Baker, “How Climate Change is Behind the Surge of Migrants to Europe,” *Time*, September 7, 2015, <http://time.com/4024210/climate-change-migrants/>.

⁵⁵ As discussed in the Stern Review, some estimates suggested up to 200 million people may become permanently displaced by climate change by the middle of this century, noting that almost as many people leave their homes because of environmental disasters as flee political oppression. See, Nicholas Stern, “Stern Review: The Economics of Climate Change”, p. 77, http://unionsforenergydemocracy.org/wp-content/uploads/2015/08/sternreview_report_complete.pdf. See also, K. Burrows & P. Kinney, “Exploring the Climate Change, Migration and Conflict Nexus,” *International Journal of Environmental Research and Public Health* 13(4) (2016): 443, noting that the number of people displaced by climate change by 2050 is estimated to be between 50 million, on the low end, and 1 billion, on the high end.

⁵⁶ See, e.g., “Office of Fossil Energy FY 2019 Budget,” U.S. Department of Energy, <https://www.energy.gov/fe/about-us/our-budget> (“The Office of Fossil Energy (FE) programs are focused on activities related to the reliable, efficient, affordable, and environmentally sound use of fossil fuels that are essential to our Nation’s security and economic prosperity.”).

See also, Jason Furman and Gene Sperling, “Reducing America’s Dependence on Foreign Oil As a Strategy to Increase Economic Growth and Reduce Economic Vulnerability,” Obama White House Archives, August 29, 2013, <https://obamawhitehouse.archives.gov/blog/2013/08/29/reducing-america-s-dependence-foreign-oil-strategy-increase-economic-growth-and-redu> (“...the President’s focus on increasing America’s energy independence is not just a critical national security strategy, it is also part of an economic plan to create jobs, expand growth and cut the trade deficit.” The first element of President's Obama plan was “Increasing domestic production of oil.”).

change.”⁵⁷ In a report released in 2007, eleven retired military generals and admirals detailed the variety of threats to America’s national and economic security that climate change poses:⁵⁸

In already-weakened states, extreme weather events, drought, flooding, sea level rise, retreating glaciers, and the rapid spread of life-threatening diseases will themselves have likely effects: increased migrations, further weakened and failed states, expanded ungoverned spaces, exacerbated underlying conditions that terrorist groups seek to exploit, and increased internal conflicts. In developed countries, these conditions threaten to disrupt economic trade and introduce new security challenges, such as increased spread of infectious disease and increased immigration. Overall, climate change has the potential to disrupt our way of life and force changes in how we keep ourselves safe and secure by adding a new hostile and stressing factor into the national and international security environment.

41. From an economic perspective, one of the key insights is that, just at the time when money is scarce (and our economy is weak) because of climate change, there will be greater need for funds. Thus, government will be less able to provide the requisite finance for key public services, depriving Youth Plaintiffs and Affected Children of the economic benefits enjoyed by older generations. This makes it even more compelling for Defendants to take all the precautionary measures today that they can.
42. As noted by the High-Level Commission on Carbon Prices (the “High-Level Commission”), which I co-chaired, the estimated economic costs of climate change in many of the standard models, and in particular Defendants’ estimates of the social cost of carbon (under the Obama administration), are:⁵⁹

⁵⁷ “National Security and the Threat of Climate Change,” The CNA Corporation, 2007, p. 44, https://www.cna.org/cna_files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf.

⁵⁸ “National Security and the Threat of Climate Change,” The CNA Corporation, 2007, pp. 44-45, https://www.cna.org/cna_files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf.

⁵⁹ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices”, 2017, Washington, DC: World Bank, Appendix A.

...biased downward because they fail to consider many vitally important risks and costs associated with climate change—particularly the widespread biodiversity losses, long-term impacts on labor productivity and economic growth, impacts on the poorest and most vulnerable, rising political instability and the spread of violent conflicts, ocean acidification, large migration movements, as well as the possibility of extreme and irreversible changes.

43. Thus, it is prudent for Defendants to take precautionary actions, not based on the “average” estimate of what the damage might be, but rather based on estimates of realistically plausibly possible “worst cases.” Because, as detailed below, Defendants could take actions at modest costs, and it would be reckless not to undertake those actions; it would be needlessly endangering the future prospects and the economic and personal security of Youth Plaintiffs and Affected Children.

V. TRANSITIONING THE U.S. ECONOMY OFF OF FOSSIL FUELS IS NOT ONLY FEASIBLE BUT WILL BENEFIT THE ECONOMY

A. TRANSITIONING OFF OF FOSSIL FUELS IS FEASIBLE

44. There is broad consensus among economists, and the High-Level Commission concluded, that limiting temperature increase to “well below 2°C” is achievable with reasonable and modest measures, and that the costs of those measures are far smaller than the costs of the damage that climate change could inflict.⁶⁰
45. The High-Level Commission estimated that the costs of curtailing emissions to a level to achieve the goals set forth by the Paris Agreement (“well below 2°C”) would be modest.⁶¹ The High-Level Commission noted that the carbon tax, that they explained could induce the requisite change in emissions, could substitute for other more distortionary taxes. If governments made such a substitution, the aggregate cost of curtailing carbon emissions could even be less than zero, providing net benefits to the economy. Furthermore, at a time when so much discussion focuses on the Federal government’s deficit spending (and our national debt), the elimination of billions of dollars of often-hidden subsidies to the fossil fuel industry would improve the country’s fiscal situation and economic performance generally. As discussed below in Section V.B, the full amount of post-tax subsidies in the U.S. has been estimated at nearly \$700 billion a year, more than half of the Federal government’s forecasted deficit for the next fiscal year.⁶² Eliminating all fossil fuel subsidies (implicit and explicit, many of which

⁶⁰ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices”, 2017, Washington, DC: World Bank, p. 1.

⁶¹ When I use the term “costs” here, I refer to the net effect of undertaking such policy changes—that is, such costs can be negative (when the benefits outweigh the costs). As is standard in economic analysis, I analyze the *marginal* effects, that is, the marginal (i.e., additional as compared to the *status quo*) net outlays that will be required for effectuating a given policy choice. Because certain policy choices can have long-term benefits that outweigh long-term costs, negative costs are a distinct possibility.

⁶² Coady et al., “How Large Are Global Energy Subsidies?”, IMF Working Paper, Fiscal Affairs Department, 2015, paper and underlying data available at: <https://www.imf.org/en/News/Articles/2015/09/28/04/53/sonew070215a>.

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go to large corporations) could, therefore, both curtail fossil-fuel production, through forcing companies to bear more of the true costs of fossil-fuel production, and substantially reduce our national deficit in one fell swoop. Equity would also be improved with corporations paying more and individuals, such as the Youth Plaintiffs and Affected Children, benefiting.

46. There are many reasons to be optimistic that emissions could be curtailed further than previously thought. These benefits are a result of continued technological development in the renewables sector. Because of technological improvements, the costs of renewables and storage are decreasing. The price of solar panels has dropped by more than half in recent years (80 percent reduction from 2008 to 2016).⁶³ In 2016 alone, the average dollar capital expenditure per megawatt for solar photovoltaics and wind dropped by over 10 percent.⁶⁴ As these technologies continue to improve and the efficiency increases, while manufacturing costs drop, these technologies will more easily substitute for existing fossil fuel infrastructure.
47. Transitioning to a non-fossil-fuel-based economy will require additional investment in our energy sector. Such sectoral shifts in our economy are not uncommon. In fact, a hallmark of a well-functioning market economy is its ability to shift between sectors as

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See also a report published by the Overseas Development Institute and Oil Change International, which found that as of 2014, the U.S. government provides approximately \$20 billion annually in producer side subsidies through various tax exceptions/deductions.

Doukas, Alex, “G20 subsidies to oil, gas and coal production: United States”, Overseas Development Institute, 2015, <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9979.pdf>).

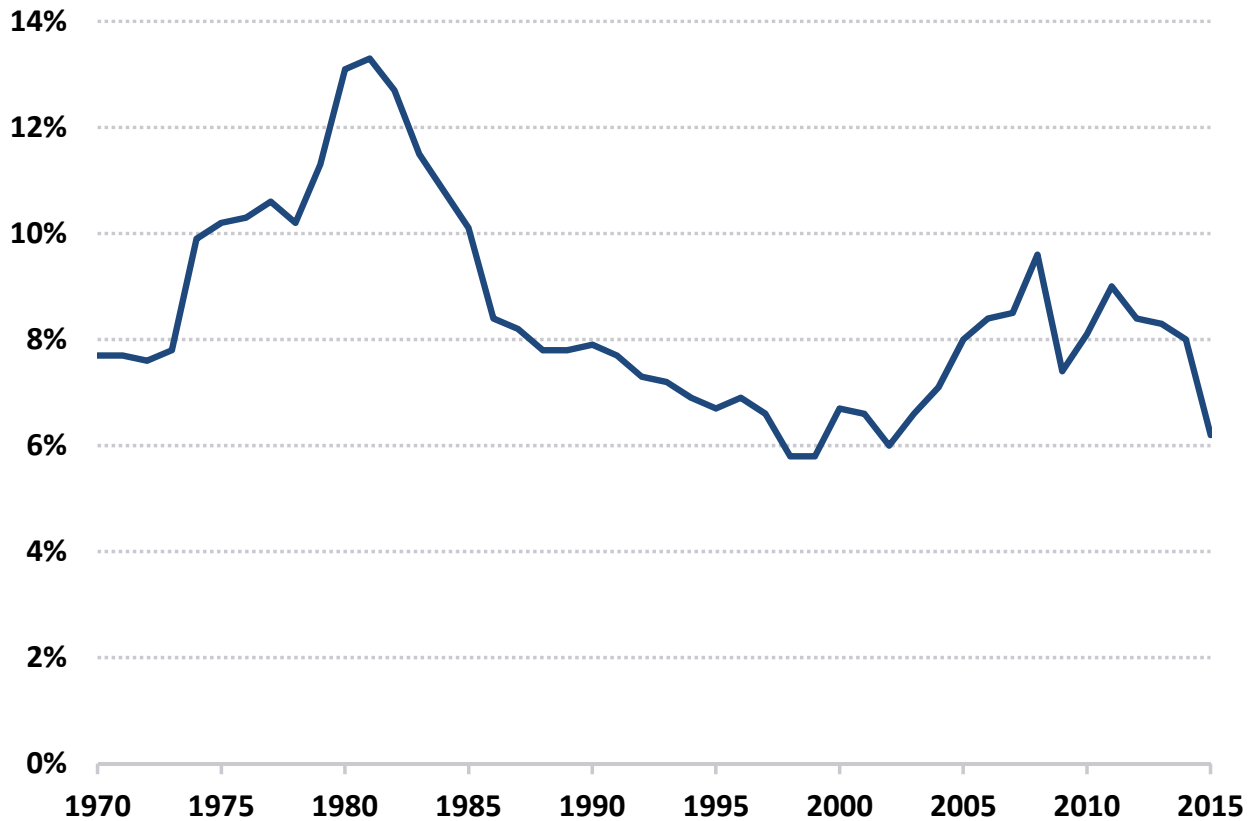
With the recent tax cuts, the deficit is currently forecasted to be about \$1 trillion in the next fiscal year. See, Associated Press in Washington, “US deficit to approach \$1tn after Trump tax cuts and spending bill, CBO says,” *The Guardian*, April 9, 2018, <https://www.theguardian.com/us-news/2018/apr/09/us-deficit-trump-tax-cuts-trillion-cbo-projection>.

⁶³ See, e.g., Ryan Whitman, “We could be headed for a solar power renaissance as costs keep dropping,” *ExtremeTech*, December 19, 2016, <https://www.extremetech.com/extreme/241300-headed-solar-power-renaissance-costs-keep-dropping>.

⁶⁴ Frankfurt School-UNEP Centre/BNEF, “Global Trends in Renewable Energy Investment 2017,” 2017, <http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf>.

technology changes and demand fluctuates. For example, we have seen shifts from agriculture to manufacturing to services over the course of the twentieth century, and we saw a shift towards the financial sector (from less than 3 percent to over 8 percent of GDP) from the 1950s to its peak in 2006 (immediately before the financial crisis).⁶⁵ Our spending on our energy sector has also fluctuated, as the chart below shows energy expenditures as a percent of GDP from 1970 to 2015. While the high levels of spending in the early 1980s (over 10 percent) were during periods of economic turbulence with high inflation and an energy crisis, there have been other periods, such as the 2000s and the early 1970s where there was economic growth and high spending on our energy system. Moreover, our economy has endured sudden, unplanned disruptions in the past (again, for example, the financial crisis); moving our economy to one without fossil fuels would come with a slight cost, but would be an event we can plan for to minimize disruptions (and would bring net benefits in the form of risk reduction).

⁶⁵ See, e.g., Robin Greenwood and David Scharfstein, “The Growth of Finance,” *Journal of Economic Perspectives*, 27(2) (Spring 2013): 3-28.

Figure 1: Energy Expenditures as Share of GDP (Percent)

Source: U.S. Energy Information Administration, March 2018 Monthly Energy Review, Table 1.7 Primary Energy Consumption, Energy Expenditures, and Carbon Dioxide Emissions Indicators.

48. There are a number of important new “energy smart” technologies that can play a role in reducing dependence on energy, making our existing energy infrastructure more efficient.⁶⁶ Smart grids, for example, can turn on appliances when renewable electricity is plentiful—and ramp down electric loads when renewable power wanes. Advanced energy storage technologies are increasingly diverse and many, like ice energy storage, are simpler and can be more cost effective than chemical batteries. Electric vehicles can also be considered “energy smart” technology, as their charging and discharging of batteries can be flexible, creating great potential to improve the efficiency of our national energy infrastructure. These technologies reduce overall energy consumption, so that even without the introduction of less carbon intensive energy sources, they can reduce

⁶⁶ Frankfurt School, UNEP Centre, “Global Trends In Renewable Energy Investment 2017,” <http://fs-uneep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf>.

carbon emissions. Many energy efficiency technologies actually have a negative cost to implement, especially if one includes in the costs the implicit costs associated with GHG emissions (costs to society that are currently externalized).⁶⁷

49. The major U.S. corporations that have committed themselves to dramatic emissions reductions—as well as state and local governments that have committed to emissions reductions—support the feasibility of a swift transition.⁶⁸ Creating predictability is of significant economic value in aggressively seeking to reduce emissions; i.e., it makes clear to players in the future economy that they can plan accordingly with very high confidence. In addition, this greater certainty facilitates the production of goods and services at lower costs. For instance, the Chief Executive Officers of Apple, BHP Billiton, BP, DuPont, General Mills, Google, Intel, Microsoft, National Grid, Novartis Corporation, Rio Tinto, Schneider Electric, Shell, Unilever, and Walmart all called on the President to stay the course with respect to United States’ participation in the Paris Agreement.⁶⁹ So too, were the Defendants to adopt a high and reliable price of carbon, households and firms would know that it paid economically to adopt low- or zero-emission technologies and products.
50. In pursuing clean-energy technology, there is also the potential for increasing overall economic production and stimulating aggregate demand and economic growth. As I

⁶⁷ See, e.g., European Commission, “The Macroeconomic and Other Benefits of Energy Efficiency”, https://ec.europa.eu/energy/sites/ener/files/documents/final_report_v4_final.pdf.

⁶⁸ In 2017, for example, nine states making up the Regional Greenhouse Gas Initiative consortium agreed to a cap-and-trade program that seeks a 30 percent reduction in carbon pollution from energy plants by 2030. See, Colin Young, “9 states, including Mass., Agree to Accelerate Emission Reductions in Next Decade,” *WBUR*, August 23, 2017, <http://www.wbur.org/news/2017/08/23/9-states-including-mass-agree-to-extend-carbon-reduction-goals-to-2030>.

Other state-driven strategies include California’s January 2018 announcement to have 5 million zero-emission vehicles in use by 2030; Hawaii mandating that all of the state’s electricity come from renewable sources by the mid-21st century; and Vermont’s commitment to reduce emissions to 80-95 percent below 1990 levels by 2050. See, “U.S. Leads in Greenhouse Gas Reductions, but Some States are Falling Behind,” Environmental and Energy Study Institute, March 27, 2018, <http://www.eesi.org/articles/view/u.s.-leads-in-greenhouse-gas-reductions-but-some-states-are-falling-behind>.

⁶⁹ See, e.g., Center for Climate and Energy Solutions, “Top companies urge White House to stay in the Paris Agreement,” Center for Climate and Energy Solutions Press Release, April 2017, <https://www.c2es.org/newsroom/releases/major-companies-urge-white-house-stay-paris>.

wrote a few years ago in *The Guardian*, “retrofitting the global economy for climate change would help to restore aggregate demand and growth.”⁷⁰ Consistent with this, the High-Level Commission, which I co-chaired with Lord Stern,⁷¹ found that “climate policies, if well designed and implemented, are consistent with growth, development, and poverty reduction. The transition to a low-carbon economy is potentially a powerful, attractive, and sustainable growth story, marked by higher resilience, more innovation, more livable cities, robust agriculture, and stronger ecosystems.”⁷²

51. However, instead of supporting existing clean energy technology that would benefit the economy and create jobs, Defendants are acting in ways to suppress and hinder clean energy, which also leads to job losses and harms the economy. For example, in January 2018, President Trump approved tariffs on imported solar cells that start at 30 percent. The tariffs are unlikely to benefit American solar manufacturing jobs, but, according to the Solar Energy Industries Association, are likely to result in the loss of 23,000 American jobs this year and the delay or cancelation of billions in solar investments. The tariffs are also expected to lead to a net reduction in solar installations by roughly 11 percent between 2018 and 2022, a 7.6-gigawatt reduction in solar PV capacity, which means approximately 1.2 million homes will not be powered by renewable solar energy. Such tariffs are both harmful for the environment and the economy.⁷³
52. Not promptly undertaking actions to pursue clean-energy technology continues to expose Youth Plaintiffs and Affected Children to the risk of extreme costs and damages, not just from climate change itself, but from the required outlays on future remediation and adaptation efforts and a weaker, less efficient, and more expensive U.S. economy.

⁷⁰ Stiglitz, J., “Climate Change and Poverty Have Not Gone Away,” *The Guardian*, January 7, 2013, <https://www.theguardian.com/business/2013/jan/07/climate-change-poverty-inequality>

⁷¹ Lord Stern succeeded me as Chief Economist of the World Bank and subsequently was a leading economic advisor to the UK Treasury, as Second Permanent Secretary and head of the Government Economic Service.

⁷² High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices,” 2017, Washington, DC: World Bank, p. 1.

⁷³ Julia Pyper, “New Tariffs to Curb US Solar Installations by 11% Through 2022,” *Greentech Media*, January 23, 2018, <https://www.greentechmedia.com/articles/read/tariffs-to-curb-solar-installations-by-11-through-2022#gs.YNvydYQ>

B. POLLUTION IS A CLASSIC EXTERNALITY THAT CAN BE COMBATED WITH STANDARD ECONOMIC TOOLS THAT PROMOTE SOCIAL WELFARE

53. Currently, around 80 percent of the energy consumed in the U.S. comes from fossil fuels.⁷⁴ In contrast, renewable energy sources comprise 11 percent of total energy consumption. That percentage has only risen by 2 percent (9 to 11 percent) from 1949 to 2017.⁷⁵
54. The burning of fossil fuels generates large amounts of pollution. Pollution is the archetypal negative externality. In economics, an externality arises when the cost or benefit of an activity of one party imposes a cost or benefit on another. In the pollution example, the polluter makes a good (its primary activity), but in the course of doing so generates pollution that imposes a cost or burden on another (e.g., a fisherman who fishes in the waters that become polluted will catch fewer fish). A positive externality example might be a technological development that benefits more than the inventor alone (e.g., the developer of the worldwide web who made it freely available).
55. The issue that arises with a negative externality is that the producer of the externality (e.g., the polluter) considers only their private costs when making production decisions and not the total costs of their activity (the costs borne by the polluter and the fisherman). Standard economic theory argues that private markets can be relied on to make efficient decisions, if, and only if, the (marginal private) costs confronting individuals equal the (marginal) social costs, and the (marginal private) benefits confronting them equal the (marginal) social benefits. When there is an externality, social and private costs and/or benefits are not aligned. A classic way to intervene in this situation is for government to tax the causes of negative externalities (thereby raising the effective private cost closer to

⁷⁴ U.S. Energy Information Administration, Table 1.3 Primary Energy Consumption by Source, March 2018 Monthly Energy Review, <https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T01.03&freq=m>.

⁷⁵ U.S. Energy Information Administration, Table 1.3 Primary Energy Consumption by Source, March 2018 Monthly Energy Review, <https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T01.03&freq=m>.

the social cost and forcing the producer to bear the full cost of their actions).⁷⁶ Having a well-functioning price system—where price setters take into account all costs—is important for economic efficiency and overall social welfare.

56. At present, the U.S. lacks a comprehensive carbon-pricing regime that accounts for the negative externalities of burning fossil fuels such that private markets can be relied on to make efficient decisions. Thus, producers and sellers of fossil fuels consider only their private costs and benefits, and the costs that their activities are imposing on society through, among other factors, increased GHG emissions and long-term climate effects of the sort I discussed earlier are not considered or internalized as part of the price.
57. Beyond the lack of a comprehensive carbon-pricing regime, a faulty system that is full of hidden subsidies for fossil fuels, as noted above, hinders the transition towards a less carbon-intensive economy. These subsidies also accelerate and exacerbate the costs to Youth Plaintiffs from climate change.
58. These subsidies take many forms. For instance, upstream oil and gas exploration and production companies in the U.S. receive several tax breaks that go beyond those afforded to businesses generally, such as deducting intangible drilling costs as a current business expense (not capitalized over the life of the well), depletion allowances,⁷⁷ and offshore drilling tax royalty relief (which permits the claiming of foreign royalties as taxes (and makes them creditable against U.S. taxes) for taxpayers taxed in two countries). When companies make an investment, it is natural that they be allowed to depreciate the cost of the capital as a tax-deductible expense over the lifetime of the asset.

⁷⁶ Sometimes, governments have to rely on “second best” interventions. Thus, government can subsidize alternatives (or positive-externality activities), which lowers the effective price of substitute products. Lowering the price of a substitute product can have the effect of increasing demand for the substitute (e.g., clean energy) and reducing the demand for the original product (e.g., fossil fuel-based energy). But leaving the negative externality-generating activity without a “charge” for its external effects leaves a distortion in place.

⁷⁷ I have studied the economics of depletion allowances, together with Sir Partha Dasgupta, in my academic work. See, J.E. Stiglitz, “Monopoly and the Rate of Extraction of Exhaustible Resources,” *The American Economic Review* 66(4) (September 1976): 655-661 and P. Dasgupta and J.E. Stiglitz, “Uncertainty and the Rate of Extraction Under Alternative Arrangements,” *Institute Mathematical Studies in the Social Sciences*, tech. rep. no. 179 (September 1975).

But with depletion allowances, an oil company can deduct 15 percent of the revenue as a “depletion allowance,” regardless of the amount of investment it made to find the oil.⁷⁸ The company receives the depletion allowance—as if it invested money—even if it makes no investment. The value of this provision itself is enormous; some estimates say it could save the U.S. Treasury over \$11 billion in 10 years if it were eliminated.⁷⁹ (Money not received by Treasury is, in effect, money given to the fossil fuel industry.) Coal companies can receive similar corporate tax reductions, and are able to purchase or lease land from Defendants at below market rates.⁸⁰ These tax breaks artificially reduce the private cost of fossil fuels to producers and consumers (but not the social cost), which makes renewable sources of energy appear less competitive to consumers.⁸¹ In the U.S., these tax breaks for fossil fuel companies have resulted in an economy heavily dependent on fossil fuels and infrastructure designed around fossil fuels.

59. Similarly, at various times, oil, gas, and coal leases have been conducted in ways in which fossil fuel companies are able to obtain leases at prices far below what the competitive equilibrium price would be, depriving taxpayers of money they need for a variety of public purposes, while distorting the market to make participation in oil, gas, and coal more economically attractive.⁸² The efficient auctions that have been used in

⁷⁸ This provision dates to 1913. See, e.g., Rebecca Leber, “Happy 100th Birthday, Big Oil Tax Breaks,” *Think Progress*, March 1, 2013, <https://thinkprogress.org/happy-100th-birthday-big-oil-tax-breaks-3c9731c4bc85/>. See also, Seth Hanlon, “Big Oil’s Misbegotten Tax Gusher,” *Center for American Progress*, May 5, 2011, <https://www.americanprogress.org/issues/economy/news/2011/05/05/9663/big-oils-misbegotten-tax-gusher/>.

⁷⁹ See, Seth Hanlon, “Big Oil’s Misbegotten Tax Gusher,” *Center for American Progress*, May 5, 2011, <https://www.americanprogress.org/issues/economy/news/2011/05/05/9663/big-oils-misbegotten-tax-gusher/>.

⁸⁰ Doukas, Alex, “G20 subsidies to oil, gas and coal production: United States”, Overseas Development Institute, 2015, <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9979.pdf>.

⁸¹ Bridle, Richard, Kitson, Lucy, “The Impact of Fossil-Fuel Subsidies on Renewable Electricity Generation”, International Institute for Sustainable Development, December 2014, <http://www.iisd.org/sites/default/files/publications/impact-fossil-fuel-subsidies-renewable-electricity-generation.pdf>.

⁸² This was the case, for instance, in the early 1980s, when large numbers of tracts were simultaneously put up for auctions, so many that the average tract had less than two bidders. I discussed some of the

Continued on next page

other areas (e.g., for the auctioning of the electro-magnetic spectrum) were typically never used. A 2016 report from the President’s Council of Economic Advisors regarding coal leases recognized several of these points explicitly, noting, for example, that the coal leasing program “has been widely criticized in recent years by economic and environmental experts for providing a poor return to the taxpayer and for not adequately addressing the environmental costs of coal extraction, processing, and combustion.”⁸³ The report also found that previous and then-current policies of Defendants had misaligned incentives: “the program has been structured in a way that misaligns incentives going back decades, resulting in a distorted coal market with an artificially low price for most Federal coal and unnecessarily low government revenue from the leasing program.”⁸⁴ The report suggests that to fully reflect the social costs of coal extraction—i.e., price the externality completely—the costs are so high that the resulting royalty rate may be “well-over 100 percent.”⁸⁵

Continued from previous page

research in this instance in my Nobel lecture. See, J.E. Stiglitz, “Information and the Change in the Paradigm in Economics,” Prize Lecture, December 8, 2001, pp. 489-490, https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2001/stiglitz-lecture.pdf.

See also, J.J. Leitzinger and J.E. Stiglitz, “Information Externalities in Oil and Gas Leasing,” *Contemporary Policy Issues* 5 (March 1984): 44-57 and J.E. Stiglitz, “What is the Role of the State?” Chapter 2 in M. Humphreys, J.D. Sachs, and J.E. Stiglitz (eds.) “Escaping the Resource Curse,” 2007, Columbia University Press, pp. 23-52 at p. 31: “When competition for the resources is limited—and especially when it is known that it is limited—then the prices that prevail will be lower. There are three ways of limiting competition. The first is suddenly to put up for lease a large number of tracts— increase the supply so that the bidding on each tract is limited. This is what President Reagan did in the early 1980s. It was like a fire sale—as if the government had to get rid of its holdings immediately. But in fact, there was no reason for it; it was not as if the oil was going to disappear, or as if the United States needed to raise cash quickly. On a very large fraction of tracts, there was only one bidder (and, of course, the oil companies knew this). In a study I conducted with Jeff Leitzinger (1984) we quantified the impact on the price the government received. The government got a fraction of what it would have earned had the tracts been put up in a more orderly process, and the extra profits went into the coffers of the oil companies.”

⁸³ “The Economics of Coal Leasing on Federal Lands: Ensuring a Fair Return to Taxpayers,” Executive Office of the President of the United States, June 2016, at p. 2, https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160622_cea_coal_leasing.pdf.

⁸⁴ *Id.*

⁸⁵ *Id.* at p. 29.

60. An important source of protection against global warming is carbon-sequestration—holding carbon in trees, plants, wetlands, or soils. Carbon molecules that are thus held are carbon molecules that are not in the atmosphere.⁸⁶ There are large amounts of public land holding millions of acres of trees, but the government has an industry-driven policy framework in which (a) the timber industry, which acquires the right to cut down the timber, does not pay for the carbon costs of their activities; (b) the timber industry is typically subsidized through roads constructed by the Department of Agriculture, which manages these public forests; (c) the timber industry, like the fossil fuel industry, receives favorable tax benefits; and (d) the timber industry acquires these assets at prices that are below prices that would prevail in a competitive market that accounted for all private and public costs of logging.⁸⁷
61. The provision of these tax benefits and the sale and/or lease of these public assets at below competitive market prices by Defendants harms the U.S. today, and these Youth Plaintiffs and Affected Children, in multiple ways. The harm to the U.S. arises because improper pricing that ignores the externalities of logging leads to inefficient uses of forests, logs, and wood products that would not materialize if the price of logs reflected the carbon costs of cutting down the trees and releasing CO₂ into the atmosphere. These actions by Defendants support the destruction of forests, which are needed to sequester CO₂ (not to mention all the critical ecosystem benefits forests provide). The poorly functioning price mechanism deprives our society of governmental revenues that could be used for multiple purposes, including investment in emission reductions and investments in R&D that would facilitate the transition towards a green economy; and forces taxes to be imposed elsewhere, with distortionary costs—so that total costs to society are well in excess of the losses of tax revenues. The resulting weaker economy

⁸⁶ For a more thorough articulation of this framework, see J.E. Stiglitz, “Sharing the Burden of Saving the Planet: Global Social Justice for Sustainable Development: Lessons from the Theory of Public Finance,” Columbia University Academic Commons, <https://doi.org/10.7916/D8KDD24MX> and Mary Kaldor and Joseph E. Stiglitz, eds., *The Quest for Security: Protection without Protectionism and the Challenge of Global Governance*, New York: Columbia University Press, pp. 161-190.

⁸⁷ See, e.g., “Congressional Subsidies for Private Logging,” Taxpayers for Common Sense, December 13, 2001, <http://www.taxpayer.net/library/article/congressional-subsidies-for-private-logging>.

means that Youth Plaintiffs are inheriting an economy that is not only dirtier than it otherwise would have been, but also weaker.

62. There are also indirect explicit subsidies that contribute to the continued reliance on fossil fuels, such as government investments and policies that promote emission producing methods of transportation or manufacturing.
63. Another implicit subsidy granted by governments is to not charge the fossil fuel industry for the negative externalities they create, such as carbon emissions. As discussed above, carbon emissions, and pollution in general, are negative externalities that can affect society and the economy, yet the vast majority of negative-externality carbon emissions across the globe are not priced.⁸⁸ Pricing CO₂ emissions and emissions of other GHGs would greatly enhance revenues available to government to address a variety of societal needs, as I discussed in Section IV above. A basic principle of taxation is that it is better to tax bad things like pollution than good things like savings and work. Again, the resulting weaker economy means that Youth Plaintiffs are inheriting an economy that is not only dirtier than it otherwise would have been, but also weaker. In this instance, not only are Defendants not raising revenue in an efficient way (subsidizing rather than taxing carbon emissions), Youth Plaintiffs are burdened with the socioeconomic costs that arise with pollution, such as additional healthcare costs.
64. Defendants have recognized for at least 40 years that these direct and indirect subsidies to fossil fuel producers hinder the adoption of renewable energy and improvements in

⁸⁸ See, e.g., High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices,” 2017, Washington, DC: World Bank, at p. 35: “The carbon prices observed span from less than US\$1/tCO₂e to US\$126/tCO₂e, 85 percent of global emissions are not priced today...”

Because all emissions generate externalities, for an efficient economy, all emissions should be taxed. In a few instances, the adverse effects of not taxing the emissions can be mitigated by the imposition of regulations.

renewable energy technologies. For example, a 1978 memo to President Carter regarding solar power found that.⁸⁹

Widespread use of solar energy is also hindered by Federal and state policies and market imperfections that effectively subsidize competing energy sources. These policies include Federal price controls on oil and gas, a wide variety of direct and indirect subsidies, and utility rate structures that are based on average, rather than marginal costs. Also, the market system fails to reflect the full social benefits and costs of competing energy sources, such as the costs of air and water pollution.

65. If Defendants stopped providing subsidies and/or implemented carbon pricing policies that allow the U.S. government to further fund research and development of green technologies to decarbonize the economy, such measures would have a large positive impact in the long term. These positive effects are not limited to mitigating the environmental effects; there are monetary gains, too. Some estimates of the financial benefit to the U.S. economy of accelerating technological developments for lowering carbon emissions suggest that they would amount to \$1 trillion by 2050.⁹⁰
66. This monetary estimate does not take into account possible spillover effects from advancing technology that could provide further value to the economy (e.g., in the same way that the space race or developments in the world wars brought us many advancements in basic science that made their way into consumer and industrial products). Even without technological change, the net financial costs to the economy may be negative, taking into account the financial benefits of eliminating carbon subsidies and replacing them with carbon taxes and the consequent development of a more efficient low-carbon energy system.
67. A short-term measure Defendants can readily implement is to cease approvals for any new fossil fuel infrastructure, pending completion of a national climate recovery plan. Any new coal projects or coal extraction harms Youth Plaintiffs. For example, it

⁸⁹ Attachment to Memorandum from Jim Schlesinger to The President, “Domestic Policy Review of Solar Energy: A Response Memorandum to The President of the United States,” December 5, 1978, at p. iv.

⁹⁰ Richard G. Richels, Geoffrey J. Blanford, “The value of technological advance in decarbonizing the U.S. economy,” *Energy Economics* 30(6) (2008): 2930-2946, ISSN 0140-988.3.

increases GHG emissions locking in higher concentrations of GHGs in the atmosphere as Youth Plaintiffs grow up and live their lives, with all the attendant costs and impacts that I have described thus far. Enabling investments in long-lasting “fossil” infrastructure (like coal-burning power plants and oil and natural gas pipelines) means that for decades going forward, there will continue to be incentives to engage in costly carbon emissions. Once the plants are built, the owners have an incentive to continue using it to recover their investment (and in so doing, generate GHG emissions). Furthermore, should a fossil-fuel plant be shut down before the natural end of its economic life, there will be allegations of lost economic value (the owners’ private loss on their investment). Such allegations will become a political argument against taking further actions curbing emissions. (These arguments will almost surely be put forward even though the public benefits of shutting down the coal fired plants may be enormous—as I have noted—and even though a standard argument in economics is that by-gones-are-by-gones. Mistaken investments in the past should not continue to justify distorted power generation. Elsewhere, however, the “politics” of stranded assets has played an important role—that is to say; private owners of large, sunk investments have (successfully) argued for preferential treatment for them to recoup their private investments, despite the attendant social costs.)

68. I should also respond to an expected argument from Defendants that, even if the U.S. were to lower its GHG emissions, other countries would increase their production of goods that create GHGs. This might be referred to as a “substitution” argument. There are two rejoinders to this:
 - a. First, I turn to standard economic theory. That is, that in any given equilibrium the lowest-cost providers are providing any given resources. Thus, if the U.S. is providing GHG-dependent products today, it is because the marginal cost of the U.S. providing such products is below the next-cheapest alternative. If the U.S. were to cease producing, say, 100 “units” of GHGs, the next-cheapest alternative would increase its production by less than 100 “units” (because if it made economic sense for the next-cheapest alternative to produce more than 100 “units” they would already be doing so). As such, any substitution will be less than perfect and reductions in

U.S. emissions will be offset less than one-to-one by alternative supplies (i.e., there will be a net reduction).

- b. Second, specific to GHG emissions, recent technical studies have shown that U.S. emissions will not be perfectly offset.⁹¹ This is consistent with the general theory I mentioned above. While climate change is a global problem, the U.S. is a significant contributor to GHG emissions, and so actions by the U.S., both directly, and by the leadership which such actions provide, has a significant impact on these global outcomes. Indeed, the U.S. stands out as the sole country announcing that it is not committed to the reduction of carbon emissions, having announced that it will leave the Paris Agreement. Despite the U.S.'s actions, other countries remain committed. Thus, if the U.S. were to recommit itself to climate action, there is no significant risk of other countries polluting more, so as to offset the benefits of U.S. reductions in carbon emissions.

69. The government has recognized since the 1980s that the U.S. will need to take a leadership role in climate change. For example, a government memorandum from 1989 discusses the desire for the U.S. to have a leadership role in addressing climate change. The memorandum also makes clear that when it comes to addressing climate change the U.S. “simply cannot wait -- the costs of inaction will be too high.”⁹²

C. DEFENDANTS’ USE OF DISCOUNTING IN DECISION-MAKING UNDERESTIMATES THE COSTS OF CLIMATE CHANGE ON YOUTH PLAINTIFFS AND FUTURE GENERATIONS AND THE BENEFITS OF MITIGATION, WITH DELETERIOUS CONSEQUENCES

70. In running the government, Defendants must repeatedly make decisions about projects and policies. They must evaluate alternative choices with which they are confronted. In this section, I explain that the way Defendants do this systematically undermines the

⁹¹ See, e.g., P. Erickson and M. Lazarus, “Would constraining US fossil fuel production affect global CO₂ emissions? A case study of US leasing policy,” *Climatic Change*, 2018, <https://doi.org/10.1007/s10584-018-2152-z>.

⁹² Memorandum from Frederick M. Bernthal to Richard T. McCormack, Department of State, February 9, 1989, attachment “Environment, Health and Natural Resources Issues,” and responses to “Question #1.”

interests of Youth Plaintiffs in a way which cannot be justified. Indeed, economic science provides sound alternative methodologies for the evaluation of policies and projects which systemically lead to better outcomes for society in general, and would not systematically discriminate against Youth Plaintiffs in the way that existing policies do.

71. While there are a number of longstanding and well-established perspectives in economics which recognize that delaying the kinds of precautionary actions suggested above is deleterious to societal welfare, government practices and procedures underlying important decision-making systematically undervalue the costs to be borne by future generations (including Youth Plaintiffs and Affected Children).
72. The issue devolves around how governments should value benefits and costs that arise at some future date relative to those that occur today. Typically, less value is given to future effects than to current effects. The question is, how much less. Since the most catastrophic effects of climate change may not be felt for years (see paragraph 27 and footnote 19, above), saying that what happens in the future does not matter much biases public decision making against taking actions to protect Youth Plaintiffs.
73. The standard methodology for making such assessments is called cost-benefit analysis. In a cost-benefit analysis, using a discount rate is commonplace; however, that discount rate must be appropriate. As I have noted, issues around discounting are especially important in the context of climate change because the full benefits may not accrue for many years after society incurs costs to limit the emissions of GHGs.⁹³
74. Formal intertemporal analysis on which so much of modern economics is based originated with the path breaking work of Frank Ramsey, who argued that there was no ethically defensible justification for discounting the well-being (utility) of future

⁹³ There is also a problem with how discounting is often applied when we consider future costs compared to future benefits. Standard economic theory says that risky future benefits (e.g., uncertainty regarding an investment's return) are discounted to account for that risk. That is, risky benefits are worth less than riskless benefits. When we consider costs, however, analysts often *reduce* risky costs: uncertainty regarding future costs should decrease the value of a project (i.e., increase its costs), not increase the value of a project.

generations.⁹⁴ In the almost one century since his work, no one has developed a persuasive argument to the contrary.⁹⁵

75. There is an argument that future consumption should be discounted, since future incomes are assumed to be higher, and standard arguments of diminishing marginal utility imply that if that is the case, the value of consumption will be lower. But the high discount rates used by Defendants can only be justified by the assumption of high future increases in standards of living. Since 2008, there is overwhelming evidence that the pace of productivity has declined markedly, implying that we cannot count on past rates of increases prevailing in the future. There is one school of thought (studied and advocated by Prof. Robert Gordon at Northwestern) that argues even the current pace of

⁹⁴ Clearly, if one thought that the world would end, say in 50 years, as a consequence of a nuclear war, unrelated to climate change, one would not need to take into account events beyond the 50-year extension. We rule out such possibilities, or assume that they are of sufficiently low probability as not to affect our analysis.

For mathematical tractability, many analyses assume a small, positive pure intergenerational discount rate. While ethically indefensible for our purposes, the results are not much different from those obtained with a zero discount rate.

⁹⁵ In the middle of the twentieth century, two teams of researchers, each with a prominent Nobel Prize winner, formulated “guides” to cost benefit analysis. See Dasgupta, Sen, and Marglin, prepared for UNIDO (the United Nations Industrial Development Organization) (P. Dasgupta, S.A. Marglin, A. Sen, *Guidelines for project evaluation*, United Nations Industrial Development Organization, Vienna (1972) (United Nations publication sales no.: E.72.II.B.11)) and Little and Mirrlees, prepared for OECD Development Center (I.M.D. Little and J.A. Mirrlees, *Manual of Industrial Project Analysis in Developing Countries vols. 1 and 2*, OECD, Paris (1968, 1969). Amartya Sen received the Nobel prize in 1998, Partha Dasgupta was knighted in 2002, Ian Little was the Deputy Director of the Economic Section at the U.K. Treasury and a distinguished Oxford development economist, and Sir James Mirrlees received the Nobel Prize in 1996.

In the 1970s, discounting became important as the country thought through how to respond to the oil price shocks: what were the requisite changes to its energy system? Though this was done in an era before the costs of carbon emissions were widely understood, the principles are still relevant. See J.E. Stiglitz, “The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best,” *Discounting for Time and Risk in Energy Policy*, R. Lind (ed.), Baltimore: The Johns Hopkins University Press, 1982, pp. 151-204.

There have been various guidelines published on this topic for internal government use, see, for example: OMB Circular No. A-94, “Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits” (Mar. 27, 1972) and OMB Circular No. A-94, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs”, Oct. 1992.

productivity—far lower even than in the recent past—may decline still more.⁹⁶ Whether one agrees with Gordon’s assessment or not, this recent discussion has brought out four key points:

- a. There is considerable uncertainty about the pace of increase in living standards.
 - b. The pace of increase in living standards is endogenous—it depends on what actions we take.
 - c. If there is significant climate change, and if we continue on our current path, there is a significant risk of a decrease in standards of living.
 - d. The marginal value of consumption is likely to be high in those states of nature where climate change is greater, and where the adverse effects of climate change are large. That is to say, the value of additional consumption—the ability to build or consume more—and therefore its price will be higher when the effects of climate change are greater. Thus, in those places where the effects of climate change are most pronounced—where damage is the greatest and remediation need and costs are the highest—the *social cost* of such remediation will also be at its highest, exacerbating the damages to Youth Plaintiffs (both because when damages are high, the cost of remediation is also high, and because levels of consumption—what is left over after paying for remediation costs, and taking into account the damage done by climate change—are low).
76. It would be foolhardy—and wrong—for public policy to proceed as if there were no risk, either of a decrease in living standards, and especially of a lowering of those standards as a result of a failure to appropriately curtail emissions.
77. Standard economics over the past half century has emphasized the importance of risk aversion, and that risk affects our actions. Common usage of discounting in public finance fails to take account of risk appropriately. When individuals are risk averse, they

⁹⁶ See, R.J. Gordon, *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*, Princeton University Press, 2016. See also, R.J. Gordon, “Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds,” *NBER Working Paper*, No. 18315, August 2012, <http://www.nber.org/papers/w18315.pdf>.

are willing to buy insurance against a risk—to pay a considerable risk premium. This is also true for the business sector and society in general. This is especially important when we assess the appropriate response to the threat of climate change. The planet Earth cannot buy insurance from another planet against the risk of climate change here, but we can take precautionary actions. At the very least, this implies that the discount rate used for assessing climate change actions should be markedly different from that used for conventional short-term projects. As Chairman of the Council of Economic Advisers, I headed a review committee for the Office of Management and Budget (OMB) reviewing the guidelines for discounting, and that was the conclusion we reached in the late 1990s—that one must account for changes in relative price over time, and when our environment becomes more valuable in the future (i.e., as the value of preserving it becomes higher) that must be reflected in the economic analysis.⁹⁷ This was consistent with the position taken in the 2nd assessment of the IPCC, and in a paper I co-authored with the late Nobel laureate Kenneth Arrow and others.⁹⁸

78. More than half a century ago, President Johnson sent a message to Congress that we faced two paths: the cheaper option, in the short-term, of carrying down the path of pollution, or the more expensive option (at the time), of restoring the country and its natural heritage to the people.⁹⁹

We are able to see the magnitude of the choice before us, and its consequences for every child born on our continent from this day forward. Economists estimate that this generation has already suffered losses from pollution that run into billions of dollars each year. But the ultimate cost of

⁹⁷ Our report was issued in 1996: “Economic Analysis of Federal Regulations Under Executive Order 12866,” The White House, January 11, 1996, https://obamawhitehouse.archives.gov/omb/inforeg_riaguide/.

⁹⁸ K. Arrow, W.R. Cline, K-G. Maler, M. Munasinghe, J. E. Stiglitz, and R. Squitieri, “Intertemporal Equity and Discounting,” in *Global Climate Change: Economic and Policy Issues*, M. Munasinghe (ed.), World Bank Environment Paper 12, Washington, D.C. 1995, pp. 1-32. Reprinted in an abbreviated format as “Intertemporal Equity, Discounting, and Economic Efficiency,” *Climate Change 1995: Economic and Social Dimensions of Climate Change*, J. Bruce, H. Lee, and E. Haites (eds.), Cambridge: Cambridge University Press, 1996, pp. 125-144.

⁹⁹ “Preserving Our Natural Heritage,” Message from the President of the United States, transmitting “Programs for Controlling Pollution and Preserving our Natural and Historical Heritage,” February 23, 1966.

pollution is incalculable. We see that we can corrupt and destroy our lands, our rivers, our forests, and the atmosphere itself all in the name of progress and necessity. Such a course leads to a barren America, bereft of its beauty, and shorn of its sustenance. We see that there is another course more expensive today, more demanding. Down this course lies a natural America restored to her people. The promise is clear rivers, tall forests, and clean air – a sane environment for man.

79. For the last 50 years, Defendants have shirked from the “more demanding” course of restoring “America ... to her people.” Defendants’ policies that discount the future of Youth Plaintiffs and Affected Children at inappropriately high rates continue to steer America on the path of incalculable losses and away from that more demanding and sane course. The costs of fixing the damage today are much higher than they would have been in 1966 when President Johnson sent his message; but, the costs today are much lower than what they will be after another 50 years of fossil fuel pollution and inaction.

VI. CONCLUSION

80. The choice between incurring manageable costs now and the incalculable, perhaps even irreparable, burden Youth Plaintiffs and Affected Children will face if Defendants fail to rapidly transition to a non-fossil fuel economy is clear. While the full costs of the climate damages that would result from maintaining a fossil fuel-based economy may be incalculable, there is already ample evidence concerning the lower bound of such costs, and with these minimum estimates, it is already clear that the cost of transitioning to a low/no carbon economy are far less than the benefits of such a transition. No rational calculus could come to an alternative conclusion. Defendants must act with all deliberate speed and immediately cease the subsidization of fossil fuels and any new fossil fuel projects, and implement policies to rapidly transition the U.S. economy away from fossil fuels.
81. This urgent action is not only feasible, the relief requested will benefit the economy. More importantly, this action is necessary if Defendants are to prevent the extreme cost and damages Youth Plaintiffs and Affected Children are facing and will face to an even greater extent if Defendants continue on a path that does not account for what is scientifically necessary to protect the climate system they depend on for their future well-being and their personal and economic security.



Joseph E. Stiglitz, Ph.D.
April 13, 2018

**EXHIBIT A:
CURRICULUM VITAE**

CURRICULUM VITAE

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Co-founder and Co-President of the Initiative for Policy Dialogue (IPD)

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Chief Economist of The Roosevelt Institute

Previous Positions

Co-Chair, Columbia University Committee on Global Thought

Chair of the Management Board, Brooks World Poverty Institute, University of Manchester

Chair, International Commission on the Measurement of Economic Performance and Social Progress, appointed by President Sarkozy, 2008-2009.

Chair, Commission of Experts on Reforms of the International Monetary and Financial System, appointed by the President of the General Assembly of the United Nations, 2009.

Professor of Economics and Senior Fellow, Hoover Institution, Stanford University, 1988–2001; professor emeritus, 2001--

Stern Visiting Professor, Columbia University, 2000

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Senior Fellow, Brookings Institution, 2000

Chairman, Council of Economic Advisers (Member of Cabinet), 1995–1997

Member, Council of Economic Advisers, 1993–1995

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Senior Fellow, Institute for Policy Reform

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Drummond Professor of Political Economy, Oxford University, 1976-1979

Oskar Morgenstern Distinguished Fellow and Visiting Professor, Institute for Advanced Studies and Mathematica, 1978-1979

Professor of Economics, Stanford University, 1974-1976

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Tapp Research Fellow, Gonville and Caius College, Cambridge, 1966-1970

Visiting Professor, Department of Economics, University of Canterbury, Christchurch, New Zealand, June-August, 1967

Assistant Professor of Economics, M.I.T., 1966-1967

Education

B.A. Amherst College, 1964

Ph.D. in Economics, M.I.T., 1966-1967

Unearned Degrees

M.A., Cambridge University, 1970

M.A., Oxford, 1976

Honorary doctorates

D.H.L., Amherst College, 1974

University of Leuven, 1996

Ben Gurion University, 1997

Academia de Studii Economice, Bucharest, December 1999

University of Namur, March 2000

Technical University, Lisbon, June 2000

Northwestern University, Doctor of Laws, June 2000
New School University, February 2001
Bard College, May 2001
University of Toronto, June 2001
Charles University, Prague, June 2001
Glasgow University, July 2001
University of Buenos Aires, November 2001
University of Andes, October 2001
Sofia State University “Saint Clement Ohridski,” Bulgaria, 2002
Wirtschafts Universitat, Vienna, January 2002
University of Macau, March 2002
Pomona College, May 2002
Université catholique de Louvain la Neuve Belgium, February 2003
Doshisha University, April 2003
University of Barcelona, May 2003
Azerbaijan State Economic University, 2003
Waseda University, April 2004
Georgetown University, May, 2004
Indiana University, May 2004
Pace University, May, 2004
University of Oxford, June 2004
University of Bergamo, Italy, July 2004
Université d’Antananarivo, Madagascar, August 2004
Drexel University, June 2005
Universidad de La Plata, August 2005
Durham University, September 2005
Lingnan University, Hong Kong, December 2005
University of the Basque Country, May 2006
Università degli Studi di Genova, May 2006
Universidad Mayor de San Andrés, Bolivia, May 2006
Renmin University, China, March 2007
University of Venice, Italy, May 2008
University of Liège, Belgium, May 2008
University of Manchester, UK, October 2008
Luiss Guido Carli University, Rome, February 2010
University of Hyderabad, India, January 2013

University of Córdoba, Argentina, August 2012
University of Hyderabad, India, January 2013
Cambridge University, United Kingdom, June 2013
Universite Paris-Dauphine, France, June 2013
Harvard University, May 2014
Arizona State University, May 2014
HEC Paris, January 2015
University of Split, May 2015
University of the Republic of Uruguay, December 2015
Chinese University of Hong Kong (CUHK), May 2016
Sant'Anna School of Advanced Studies, University in Pisa, Italy, May 2017
Università Politecnica delle Marche, Ancona, Italy, November 2017

Fellowships and Honors

National Science Foundation Fellowship, 1964–1965
Fulbright Fellowship, 1965-66
Social Science Research Council Faculty Fellowship, 1969-1970
Guggenheim Fellowship, 1969-70
Fellow of the Econometric Society, 1972

John Bates Clark Award, American Economic Association, 1979

Fellow, American Academy of Arts and Sciences, 1983
Fellow, National Academy of Science, 1988
International Prize of the Academia Lincei, 1988
UAP Scientific Prize, Paris, France, 1989
Corresponding Fellow of the British Academy, 1993
Rechtenwald Prize, Germany, 1998
Fellow, American Philosophical Society, 1998

Nobel Prize in Economics, 2001

Honorary Fellow, Gonville and Caius College, University of Cambridge, 2001
Distinguished Leadership in Government award, Columbia Business School, 2002
Le Prix Européen du Livre d'Économie, Special Mention for *Globalization and its Discontents*, November 2002
Honorary Professor, Al Farabi Kazakh National University, November 2003
Honorary Fellow, St. Catherine's College, Oxford, 2003
Order of the Gran Cruz con Placa de Oro, Republica de Colombia, 2003
Le Prix Européen du Livre d'Économie, First Prize, for *Roaring Nineties*, Paris, 2003
Bruno Kreisky Prize for Political Books, Vienna, 2003

Ordinary Academician, Pontifical Academy of Social Sciences, May 2003

John Kenneth Galbraith Award, American Agricultural Economics Association, August 2004

Serbian Scientific Society, December 2005

Honorary Professorship, Wuhan University, Hubei Province, China, March 2006

Changjiang Scholar, China Center for Economic Research, Peking University, China, March 2006

La Medalla de la Orden Nacional "Al Mérito," Ecuador, July 2006

National Center for Law and Economic Justice Benefit Award, May 2006

Honorary Fellowship, Fitzwilliam College, May 2006

Honorary Professorship, Guizhou University, China, March 2007

Honorary Professorship, Yunnan University, China, March 2007

Honorary Professorship, Central University of Finance and Economics, Beijing, China, March 2007

Honorary Dean, Hanqing School, Renmin University, Beijing, March 2007

Le Prix Manpower for *Making Globalization Work*, October 2007

Honorary Professor, Universidad de San Martin De Porres, Lima, Peru, December 2007

Honorary Professor, Universidad Nacional de San Antonio Abad del Cusco, Peru, December 2007

Lead author and member of the Steering Committee, Working Party 3, of the 1995 (Second Assessment) Report of the Intergovernmental Panel on Climate Change, which shared the **2007 Nobel Peace Prize**

John F. Kennedy Memorial Fellowship, Fulbright New Zealand, March 2008

Honorary Professorship, Tsinghua University, Beijing, China, March 2008

International Labour Organization, Decent Work Research Prize, June 2008

The Royal Society, Foreign Member, May 2009

Gerald Loeb Award, Commentary category, June 2010. (Among the highest honors in journalism, the Loeb Awards recognize the work of journalists whose contributions illuminate the world of business, finance and the economy for readers and viewers around the world.)

Inaugural Rodney Wylie Eminent Visiting Fellow, University of Queensland, July 2010

Francis Perkins Working People's Award, 2010 presented by the Fiscal Policy Institute, October 7, 2010, for recognizing the importance of sound economic analysis to the well-being of working people everywhere; for groundbreaking work on the circumstances under which government can improve market performance; and for vital contributions to public policy at the international, national, and state levels.

The Karel Englis Honorary Medal for Merit in the Social and Economic Sciences, awarded by the Academy of Sciences of the Czech Republic, 2010

100 Years of American Economic Review: The Top 20 Articles, February 2011, for “Monopolistic Competition and Optimum Product Diversity,” with A. Dixit, *American Economic Review*, 67(3), June 1977, pp. 297-308 and “On the Impossibility of Informationally Efficient Markets,” with S. Grossman, *American Economic Review*, 70(3), June 1980, pp. 393-408.

2011 100 Most Influential People in the World List, Time Magazine, “TIME 100”, April 2011

Legion of Honor, rank of Officier, France, February 2012

Economic Theory Fellow, Society for the Advancement of Economic Theory, July 2012

Corresponding Academic, Royal Academy of Economic Sciences and Finance, Spain, September, 2012

Global Economy Prize, Kiel Institute, Germany, June 2013

Robert F. Kennedy Book Award, for *The Price of Inequality*, September 2013

Daniel Patrick Moynihan Prize, May 2014

Member, the American Academy of Political and Social Science, 2014

Jean-Jacques Laffont Prize, June 2014

Selected in Economic Journal’s 125th Anniversary Issue as a seminal article, March 2015, for “A New View of Technological Change,” with A. Atkinson, *Economic Journal*, 79(315), September 1969, pp. 573-578.

George S. Eccles Prize for Excellence in Economic Writing, for Creating a Learning Society, Columbia Business School, May 2015

2015 POLITICO 50 List, POLITICO Magazine, September 10, 2015

Columbia University Press, Distinguished Book Prize, for Creating a Learning Society, September 2016

Bloomberg 50 Most Influential People in the World of Finance, September 2016

Progress Medal for Scholarship and Leadership on Fairness and Well-being, Society for Progress, September 2016

National Association of Business Economics (NABE) Paul A. Volcker Lifetime Achievement Award for Economic and Monetary Policy, March 2017

Estoril Global Issues Distinguished Book Prize, for *The Euro*, May 2017

Sigillum Magnum, University of Bologna, November 2017

Donald Gordon STIAS Fellow, Stellenbosch Institute for Advanced Study, November 2017

International Positions, Boards, etc. (selected)

Past President, Eastern Economics Association, 2008

President, International Economics Association, 2011-2014; Committee Member, 2014-

Co-Chair, Institute for New Economic Thinking (INET) Global Economic Transformation Commission, 2017-

Member, High-level Commission on Carbon Prices, 2016-

Member, United Nations High-Level Advisory Board on Economic and Social Affairs Center for a New Economy's Growth Commission for Puerto Rico, 2016-

Member, CFTC-SEC Advisory Committee on Emerging Regulatory Issues

World Bank, Chief Economist's Council of Economic Advisers, 2000-

ILO World Commission on the Social Dimensions of Globalization, 2003

High Level Panel of the African Development Bank, 2006-2007

Chairman, SI Commission on Global Financial Issues, 2009

Member, Economic Advisory Panel of the South African Minister of Economic Development, 2010

Member, Prime Minister's Advisory Committee of Progressive Intellectuals, Spain, 2008-2011

Member, International Advisory Board, Renault-Nissan (2000-2004)

Member, International Advisory Board, Docomo, 2008-2011

Member, International Advisory Board, Statoil, 2011-

Member, Economic Advisory Board, Brennan Center for Justice, 2015-

Commissioner, World Health Organization's High-Level Commission on Health Employment and Economic Growth, 2016

Board Member, Acumen Fund

Board member, Alliance for Climate Protection, 2011-

Member, Executive Supervisory Committee, CERGE-EI, Prague

Executive Board, Economic Research Forum, Cairo

Honorary Member, Board of Directors, Center for Global Development

Foreign Member, Russian Academy of Sciences, elected in 2003

Member, Barcelona Graduate School of Economics Advisory Scientific Council, 2007-

Member, Fiscal Commission Working Group, Scotland, 2012-

Member of French Government's Independent Council for Growth and Full-Employment, 2014-

Intergovernmental Panel on Climate Change (Steering Committee, Working Party 3, second assessment, a Lead Author of 1995 Report)

Chairman, Economic Policy Committee, OECD. 1993-1995

Member of the Board, Resources for the Future

Member of the Board of Trustees, Amherst College

Trustee, Folger Library, Washington, 2000-2005

International Advisory Board, Korea Financial Services Commission

U.S./Israel Joint Economic Decision Group (JEDG), 1993-1996
Member, Mid-east Economic Peace Forum, Amman, 1995
Chair, U. S. Delegation, OECD Ministerial, 1996
Member, U.S. Delegation, G-7 Jobs Summit, France, 1996
Chair, U.S. Delegation, G-7 and Developing Country Telecommunications Conference,
South Africa, 1996
World Bank Delegate, G-22
Headed, U.S. Delegations to India, China, Russia, Ukraine

Consulting (selected)

Ford Foundation Energy Policy Study, 1973
Department of Labor (Pensions and Labor Turnover), 1974
Department of Interior (Offshore Oil Leasing Programs), 1975
Federal Energy Administration (Intertemporal Biases in Market Allocation of Natural
Resources), 1975-76
World Bank
O.E.C.D.
Electrical Power Research Institute
Office of Fair Trading (U.K.) Consumer Protection Legislation
Bell Communications Research
Bell Labs
U.S. State Department - AID
Inter-American Development Bank
State of Louisiana (Attorney General)
State of Texas (Attorney General and Governor's Office)
Office of Tax Analysis, U.S. Treasury
Federal Reserve Board
Office of Technology Assessment
State of Alaska
Seneca Indian Nation
Micronomics
Department of Justice
Senior Advisor, Sebago Associates
New York State, Attorney General's Office
States of California, Washington, and others on Banking Competition

Selected Invited Lectures

Far Eastern Meetings of the Econometric Society, Tokyo, 1970
Association of University Teachers of Economics, Warwick, 1974
Westfalich Academy of Science
Fifth Annual Lecture of the Geneva Association, delivered at Zurich, March 1983
David Kindall Lecture, University of Illinois, 1985
Frank W. Paish Lecture, Association of University Teachers of Economics, Bath, United Kingdom, 1985
Journal of Money, Banking and Credit Lecture, Western Economic Association, Las Vegas, 1985
Invited Plenary Session Lecture, Meetings of the Sociedade Brasileira de Econometria, Belem, Brazil, December 1986
Upjohn Lecture, Western Michigan University, 1986
Johansen Lectures, Oslo, 1986
Frontiers of Economics Lecture, World Bank, 1986
Harry Lyman Hooker Distinguished Visiting Professors Series, McMaster University, 1986
Shepherd Lecture, State University of Iowa, 1986
Shell Lecture, City University, London, 1986
Rand Chair Distinguished Speaker Series, SUNY-Buffalo, 1987
Fisher-Schultz Lecture, European Meetings, Econometric Society, Copenhagen, 1987
Jacob Marschak Lecture, Far Eastern Meetings, Econometric Society, Tokyo, 1987
Invited Plenary Lecture, American Accounting Association, Cincinnati, 1987
Central Bank of Uruguay, Annual Conference for South American Economists, 1988
Argentina Economic Association, 1988
NÖG Lecture, Austrian Economic Association, 1988
John Crawford Lecture, Economic Congress of Australia (Joint Meeting of Economic Society, The Econometric Society, The Australian Agricultural Society and The Economic History Society of Australia and New Zealand, Canberra), 1988
Stevenson Lectureship, University of Glasgow, Scotland, December 1988
Plenary Session Latin American Meeting of the Econometric Society, Santiago, Chile, August 1989
Musgrave Lecture, University of California, Santa Cruz, March 1990
AT&T Lecture Series, Notre Dame University, April 1990
Wicksell Lectures, University of Stockholm, May 1990
Institute of Public Administration Annual Conference, Dublin, December 1990

IPR-IRIS Conference, Prague, March 1991
Caffee Lecture on Reformulation of Monetary Theory, Rome, April 1991
Lindhal Lectures on Fiscal and Monetary Policy, Uppsala, Sweden, April 1991
Irish Economic Association Annual Conference, Keynote Lecture, Dublin, May 1991
Federal Reserve Bank of Cleveland, May 1991
Villa Mondrage International Economic Seminar, Rome, June 1991
Far Eastern Meeting of the Econometric Society, Seoul, June 1991
Korea Development Institute, Seoul, June 1991
National Association of Business Economists, Los Angeles, September 1991
Marshall Lecture, European Economic Association Annual Meeting, Cambridge, UK, September 1991
NBER/CEPR Conference on Unemployment and Wage Determination, Boston, October 1991
NBER Taxation Program, Cambridge, MA, October 1991
Institute for Policy Reform 1991 AID Economists' Conference, Raleigh-Durham, November 1991
United Nations Conference on Trade and Development, Geneva, December, 1991
CEPR Conference on Finance and Development in Europe, Santiago, Spain, December 1991
Schumpeter Lecture, Kyoto, 1992
Marshall Lecture, Cambridge, 1996
Wider Lecture, Helsinki, 1997
EIB Lecture, Florence, 1997
Indian Development Bank 50th Jubilee Lecture, 1998
Prebisch Lecture, Geneva (UNCTAD), 1998
Annual Lecture, Government Economists Association, Chicago, 1998
University of Pittsburgh McKay Lecture, 1998
Institute of International Finance, Cordoba, Argentina, 1998
American Economic Association, Distinguished Lecture on Economics in Government, 1998
Bangladesh Economic Association, 1999
National Economic Research Institute Jubilee Lecture, 1999
Mattioli Lectures, Milan, 1999
Schwartz Lecture, Northwestern, 1999
McKenzie Lecture, Rochester, 1999
Nobel Symposium in Economics: The Economics of Transition, Saltsjöbaden, Sweden, 1999

Oxford Amnesty Lecture, 1999
Bruno Lecture, Beunos Aires, 1999
Papandreou Lecture, Athens, 1999-2000
Center for Contemporary Arab Studies, Georgetown University, 2000
Calouste Gulbenkian Foundation, Lisbon, 2000
Money, Macro and Finance Research Group Millennium Conference, London, 2000
HKEA First Biennial Conference, Hong Kong, 2000
Fifteenth Annual Henry George Lecture, University of Scranton, 2000
(Keynote speaker, invited lecture, at national or regional economic meetings in Bogota, Montivideo, Colombo, Manila, Seoul, Tokyo, Bangkok, Marrakech, Cairo, Kampala, Nairobi, Dacca, Kuala Lumpur, San Salvador, San Jose (Costa Rica))
Goldman Lecture in Economics, Wellesley University, 2001
Arthur M. Okun Lecture Series, Yale University, 2001
Global Employment Forum, International Labor Office, Geneva, 2001
Fourteenth Annual Emile Grunberg Lecture Series, The University of Akron, 2001
Sixth International Congress, Centro Latinoamericano de Administración para el Desarrollo, 2002
Austrian Federal Ministry for Economic Affairs and Labour discussion forum, Vienna, January 2002
Miliband Lecture, London School of Economics, 2002
Keynote address, New School Graduate Program in International Affairs, “Economic Management and Political Collapse in Argentina” conference, April 2002
National Economic Council, Caracas, 2002
World Knowledge Forum, Seoul, 2002
Cercle de Economistes, Aix en Provence, 2002
Okigbo Memorial Lecture Series, inaugural edition, Enugu, Nigeria, 2002
Brazilian Economic and Social Development Bank fiftieth anniversary seminar, Rio de Janeiro, 2002
Second Prebisch Lecture, Economic Commission for Latin America and the Caribbean, Santiago, Chile, 2002
El Consejo de Economía Nacional conference, Caracas, 2002
Twentieth anniversary of Economics Faculty at the University of Urbino, Italy, 2003
Asian Development Bank Distinguished Speakers Program, Manila, 2003
Clarendon Lecture, Oxford University, 2003
Korean Development Institute, 2003
The Fourth Annual JAMA Lecture, The Elliott School of International Affairs, George Washington University, March 2003
Columbia Business School Distinguished Lecture Series, 2003

Conferencia Internacional Bogotá, 2003
Aaron Wildavsky Forum for Public Policy, Berkeley University, 2004
Second Gunnar Myrdal Lecture, United Nations Economic Commission for Europe, Geneva, 2004
Tanner Lecture, Oxford University, 2004
Keynote Address, Conference on Financial Disintermediation, The Bank Indonesia and Asian Development Bank, Denpasar, Bali, December 2004
Keynote Address, Ministerial Conference on Intellectual Property for Least Developed Countries, World Intellectual Property Organization, Seoul, 2004
Keynote Lecture, Seventh National Conference on Economics, A Coruña, Spain, 2005
Nobel Lecture series, Chinese University of Hong Kong, March 2005
Tenth Sir Arthur Lewis Memorial Lecture, Basseterre, St. Kitts and Nevis, November 2005
Distinguished Lecture in Economics and Public Policy, Clare College, 2006
Yates Lecture, The Murphy Institute, Tulane University, New Orleans, 2006
Jacques de Larosiere Lecture, European Bank for Reconstruction and Development, London, 2006
Takata Yasuma Memorial Lecture, Kyoto University, 2006
Geary Lecture, Economic and Social Research Institute, Dublin, 2006
Keynote Address, University of San Francisco Law School Symposium on Regulatory Federalism, 2006
Fourth Annual KC Basu Lecture, National University of Juridical Science, Calcutta, 2007
Keynote Address, Conference on “Welfare State in the International Economy” University of Texas at Austin, 2007
Annual Frey Lecture on International Property, Duke University, 2007
China Development Forum, 2006-2017
Howard University Omicron Delta Epsilon Economic Honors Society Dinner, 2007
Grotius Lecture, 101st Annual Meeting of the American Society for International Law, Washington, DC, 2007
Khazanah National Bank Global Lectures, Kuala Lumpur, Malaysia, 2007
Waseda University 125th Anniversary Celebration, Tokyo, 2007
Foundation Day Lecture, University of Manchester, UK, 2008
Kenneth Arrow Lecture, Columbia University, New York, 2008
Tenth Annual D.T. Lakdawala Memorial Lecture, New Delhi, 2008
Eminent Speakers Series, African Development Bank, Tunis, 2010
Daniel Patrick Moynihan Lecture, Washington, D.C., 2014
HEC Honorary Degree conferral presentation, Paris, 2015
Adana Young Businessmen Association Lecture, Turkey, 2015

WEF Latin America Lecture and Panel, Colombia, 2015
Royal Geographical Society Lecture, London, 2015
Our Common Future under Climate Change Conference, UNESCO, Lecture, Paris, 2015
UN Conference on Financing for Development, Ethiopia, 2015
Jackson Hole Summit Lecture, 2015
Clinton Global Initiative Annual Meeting, New York, 2015
World Bank/IMF Annual and Spring Meetings, Alternative Forum, Lima, 2015
The Center for Public Policy Debate Lecture, Sao Paolo, 2015
4th BRICS International Competition Conference Lecture, South Africa, 2015
Keynote Speaker, UNIDO General Conference, Vienna, 2015
Calouste Gulbenkian Foundation Lecture, Lisbon, 2015
Research Institute for Development, Growth, and Economics Forum Lecture, Buenos Aires, 2015
University of Zurich Lecture, 2016
World Economic Forum Lecture and Panel, Switzerland, 2016
Bank of Japan, Shinzo Abe, and Taro Aso Lecture, Toyko, 2016
Keynote speaker, The University of Ottawa, 2016
High Level Leadership Seminar Lecture, Namibia, 2016
The Chinese University of Hong Kong Lecture, Hong Kong, 2016
Council on Foreign Relations, New York, City, 2016
Advanced Graduate Workshop on Poverty, Development and Globalization Lecture, India, 2016
Annual Meeting of the African Export-Import Bank Lecture, Seychelles, 2016
Keynote speaker, The Biennial Cooperative Economy, Italy, 2016
Keynote speaker, International Summit of Cooperatives, Quebec City, 2016
Keynote speaker, Princeton University's Griswold Center for Economic Policy Studies Conference on Inequality, 2016
Presentation at the European Parliament to present "Overcoming the Shadow Economy," a report on reforming tax secrecy havens with Mark Pieth, published in Friedrich Ebert Stiftung International Policy Analysis Paper, with participation of half of the members of the Parliament, 2016
University of Havana and ANEC (The Cuban Society of Marketing of the National Association of Economists and Accountants of Cuba) Lecture, Cuba, 2016
Annual Meeting of the American Economic Association, Chicago, 2017
World Economic Forum Lectures, Davos, January 2017.
National Association of Business Economics (NABE) Paul A. Volcker Lifetime Achievement Award for Economic and Monetary Policy Lecture, March 2017

Japan Ministry of the Environment Japan (MOEJ) Vision Committee lecture, Tokyo, March 2017.

International Economic Association (IEA) World Congress, Opening Plenary Lecture, Mexico City, June 2017.

International Economic Association (IEA) World Congress Lecture, Mexico City, June 20, 2017.

American Sociological Association (ASA) Annual Meeting Lecture, Montréal, Canada, August 12, 2017.

Bank of England Conference, Lecture, October 4, 2017.

African Export-Import Bank Conference, Memorial for Babacar Ndiaye, Washington, DC, October 15, 2017.

STIAS Lecture Series, Stellenbosch Institute for Advanced Study, South Africa, November 14, 2017

Growth Summit hosted by the Bureau for Economic Research, Economic Research Southern Africa and the Research Project on Employment, Income Distribution and Inclusive Growth, Cape Town, South Africa, November 15, 2017.

Hill Briefing: Trade, Legal Experts across the Political Spectrum Agree ISDS Must Be Eliminated from NAFTA, Washington, DC, December 5, 2017.

Fragility of Truth, Nobel Week Dialogue, Gothenburg, Sweden, December 9, 2017.

AI, Worker-Replacing Technological Change and Income Distribution, 13th Annual Conference on Economic Growth and Development (ISI), New Delhi, India, December 18, 2017.

Trump and Globalization; Making Trade Globalization Inclusive; Unemployment, Welfare and Innovation, American Economic Association Annual Meeting, Philadelphia, January 5-7, 2018.

Beyond the Paradise Papers; Towards a Better Capitalism, World Economic Forum Annual Meeting 2018, Davos-Klosters, Switzerland, January 23, 2018.

Improving the Distribution of Wealth: Lecture in Memory of Anthony Atkinson, London School of Economics and Political Science, February 16, 2018.

Editing

Co-editor, *Journal of Globalization and Development*

Previous editing positions

Founding Editor, *Journal of Economic Perspectives*

Editorial Board, *World Bank Economic Review*

Associate Editor, *Review of Economic Design*

Board of Consulting Editors, *Economic Notes* (Monte dei Paschi Di Siena, Italy)

Member, Scientific Committee, *Assicurazioni*, Rome, Italy

Editorial Board, *The Geneva Papers on Risk and Insurance Theory*

Editorial Board, *Revista de Econometrica*

Associate Editor, *Journal of Economic Theory*, 1968-73

Co-editor, *Journal of Public Economics*, 1980-83

American Editor, *Review of Economic Studies*, 1968-76

Associate Editor, *American Economic Review*, 1968-76

Associate Editor, *Energy Economics*

Associate Editor, *Managerial and Decision Economics*

Editorial Board, *The Review of Industrial Organization*

Co-editor, *The Economists' Voice*

Other Activities

Counselor of the Academic Committee, National Economics Foundation

International Advisory Committee, Barcelona Graduate School of Economics

International Advisory Board, Open Society Foundation

Committee on Graduate Education in Economics, American Economic Association

Member, M.I.T. Corporation Visiting Committee in Economics, 1971-1983

Member, Committee on Urban Public Economics, 1973

Secretary, Econometric Society, 1972-1975

Council, Econometric Society, 1984–1990

Steering Committee, Conference on Mathematical Economics, NBER

Member, Economics Panel, National Science Foundation, 1972-1976

Executive Committee, American Economic Association, 1982-1984; ex-officio, 1985–

Vice-President, American Economic Association, 1985

Special Review Panel, NSF, 1986

Visiting Committee, University of California, Department of Economics, 1989

Member, Nikkei International Academy, 1991

Member, Center for Economic Studies, 1991

Member, SEC-organized task force on accounting in the new economy, 1999-2001

Articles

1966

“Investment, Income, and Wages,” (abstract), with G. A. Akerlof, *Econometrica*, 34(5), Supplementary Issue, 1966, p. 118. (Presented at December meetings of the Econometric Society, New York.)

1967

“Allocation of Investment in a Dynamic Economy,” with K. Shell, *Quarterly Journal of Economics*, 81, November 1967, pp. 592-609.

“A Two-Sector, Two Class Model of Economic Growth,” *Review of Economic Studies*, 34, April 1967, pp. 227-238.

1968

“A Note on Technical Choice Under Full Employment in a Socialist Economy,” *Economic Journal*, 78(311), September 1968, pp. 603-609.

“Output, Employment and Wages in the Short Run,” with R. Solow, *Quarterly Journal of Economics*, 82, November 1968, pp. 537-560.

1969

“Allocation of Heterogeneous Capital Goods in a Two Sector Economy,” *International Economic Review*, 10, October 1969, pp. 373-390. (Presented at the 1965 Chicago Symposium on the Theory of Economic Growth.)

“Behavior Toward Risk With Many Commodities,” *Econometrica*, 37(4), October 1969, pp. 660-667.

“Capital Gains, Income and Savings,” with K. Shell and M. Sidrauski, *Review of Economic Studies*, 36, January 1969, pp. 15-26.

“Capital, Wages and Structural Unemployment,” with George A. Akerlof, *Economic Journal*, 79(314), June, 1969, pp. 269-281.

“Distribution of Income and Wealth Among Individuals,” *Econometrica*, 37(3), July 1969, pp. 382-397. (Presented at the December 1966 meetings of the Econometric Society, San Francisco.)

“The Effects of Income, Wealth and Capital Gains Taxation on Risk-Taking,” *Quarterly Journal of Economics*, 83(2), May 1969, pp. 263-283.

“The Implications of Alternative Saving and Expectations Hypotheses for Choices of Technique and Patterns of Growth,” with D. Cass, *Journal of Political Economy*, 77, July-August 1969, pp. 586-627. (Presented at the 1967 Chicago Symposium on the Theory of Economic Growth.)

“A New View of Technological Change,” with A. Atkinson, *Economic Journal*, 79(315), September 1969, pp. 573-578.

“A Re-Examination of the Modigliani-Miller Theorem,” *American Economic Review*, 59(5), December 1969, pp. 784-793. (Presented at the 1967 meetings of the Econometric Society, Washington, D.C.)

“Rural-Urban Migration, Surplus Labor and the Relationship Between Urban and Rural Wages,” *East African Economic Review*, 1-2, December 1969, pp. 1-27.

“Theory of Innovation: Discussion,” with Evsey D. Domar, *American Economic Review*, AEA Papers and Proceedings, 59(2), May 1969, pp. 44-49.

1970

“A Consumption Oriented Theory of the Demand for Financial Assets and the Term Structure of Interest Rates,” *Review of Economic Studies*, 37(3), July 1970, pp. 321-351. (Presented at the August 1968 meetings of the Econometric Society, Boulder, Colorado.)

“Factor Price Equalization in a Dynamic Economy,” *Journal of Political Economy*, 78(3), May-June 1970, pp. 456-489.

“Increasing Risk: I. A Definition,” with M. Rothschild, *Journal of Economic Theory*, 2(3), September 1970, pp. 225-243. Subsequently published in *Foundations of Insurance Economics*, G. Dionne and S. Harrington (eds.), Kluwer Academic Publishers, 1992.

“Non-Substitution Theorems with Durable Capital Goods,” *Review of Economic Studies*, 37(4), October 1970, pp. 543-553.

“Reply to Mrs. Robinson on the Choice of Technique,” *Economic Journal*, 80(318), June 1970, pp. 420-422.

“The Structure of Investor Preferences and Asset Returns, and Separability in Portfolio Allocation: A Contribution to the Pure Theory of Mutual Funds,” with D. Cass, *Journal of Economic Theory*, 1, June 1970, pp. 122-160.

1971

“Differential Taxation, Public Goods, and Economic Efficiency,” with P. Dasgupta, *Review of Economic Studies*, 38(2), April 1971, pp. 151-174.

“Increasing Risk: II. Its Economic Consequences,” with M. Rothschild, *Journal of Economic Theory*, 5(1), March 1971, pp. 66-84.

1972

“Addendum to Increasing Risk: I. A Definition,” with M. Rothschild, *Journal of Economic Theory*, 5(2), October 1972, p. 306.

“Four Lectures on Portfolio Allocation with Many Risky Assets,” *Mathematical Methods in Investment and Finance*, Szege-Shell (eds.), Amsterdam: North-Holland Publishing, 1972, pp. 76-108.

“On Optimal Taxation and Public Production,” with P. Dasgupta, *Review of Economic Studies*, 39(1), January 1972, pp. 87-103.

“On the Optimality of the Stock Market Allocation of Investment,” *Quarterly Journal of Economics*, 86(1), February 1972, pp. 25-60. (Presented to the Far Eastern Meetings of the Econometric Society, June 1970, Tokyo, Japan.)

“Risk Aversion and Wealth Effects on Portfolios with Many Assets,” with D. Cass, *Review of Economic Studies*, 39(3), July 1972, pp. 331-354.

“Some Aspects of the Pure Theory of Corporate Finance: Bankruptcies and Take-Overs,” *Bell Journal of Economics*, 3(2), Autumn 1972, pp. 458-482.

“The Structure of Indirect Taxation and Economic Efficiency,” with A. Atkinson, *Journal of Public Economics*, 1, March 1972, pp. 97-119.

“Taxation, Risk Taking, and the Allocation of Investment in a Competitive Economy,” *Studies in the Theory of Capital Markets*, M. Jensen (ed.), New York: Praeger, 1972, pp. 294-361. (Proceedings of a conference at the University of Rochester, August 1969.)

1973

“Approaches to the Economics of Discrimination,” *American Economic Review*, 62(2), May 1973, pp. 287-295. Reprinted in *Economics and Discrimination*, W. Darity and C. Boshamer (eds.), Edward Elgar Publishing, 1993.

“The Badly Behaved Economy with the Well Behaved Production Function,” *Models of Economic Growth*, J. Mirrlees (ed.), MacMillan Publishing Company, 1973, pp. 118-137. (Presented at the International Economic Association Conference on Growth Theory, Jerusalem, 1970.)

“Education and Inequality,” *Annals of the American Academy of Political and Social Sciences*, 409, September 1973, pp. 135-145.

“Recurrence of Techniques in a Dynamic Economy,” *Models of Economic Growth*, J. Mirrlees (ed.), MacMillan, 1973, pp. 138-161.

“Some Further Results on the Measurement of Inequality,” with M. Rothschild, *Journal of Economic Theory*, 6(2), April 1973, pp.188-204.

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“Trade Imbalances,” *The Guardian*, August 15, 2003

“Terrorism: There's No Futures in It,” *The LA Times*, July 31, 2003

“Don't Trust Technocrats,” *The Guardian*, July 16, 2003

“Biting the Budget Bullet: Why Raising Taxes is the Least Painful Way Out of the State's Fiscal Crisis,” with Peter Orszag, *The Boston Globe*, April 27, 2003

“The Ruin of Russia,” *The Guardian*, April 9, 2003

“Bush's Tax Plan - The Dangers,” *The New York Review of Books*, March 13, 2003.

“Fair Play? Not Always In Fair-Trade Treaties,” *The Nation*, February 18, 2003.

“Economists' Statement Opposing the Bush Tax Cuts,” *Economic Policy Institute*, February 2003.

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“There Is No Invisible Hand,” *The Guardian*, December 20, 2002

“Rewriting History,” *The Moscow Times*, November 27, 2002

“White House Economic Policies Are Bankrupt,” *The Los Angeles Times*, October 2, 2002

“The Disastrous Consequences of a World Without Balance,” *Financial Times*, September 23, 2002

“A Second Chance for Brazil and the IMF,” *New York Times*, August 14, 2002

“Argentina, Shortchanged: Why the Nation that Followed the Rules Fell to Pieces,” *Washington Post*, May 12, 2002

“Accounting for Options,” *Wall Street Journal*, May 3, 2002

“Overseas Aid is Money Well Spent,” *Financial Times*, April 14, 2002

“Global Greenbacks,” *Economic Times*, March 22, 2002

“Globalism's Discontents,” *The American Prospect*, January 14, 2002.

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“Thanks for Nothing,” *Atlantic Monthly*, October, 2001

2000

“What I Learned at the World Economic Crisis,” *New Republic*, April 17, 2000

1998

“Virtue Should be Granted its Reward; Instead of Reducing Foreign Aid to an All-time Low, Donors Should Target it at Developing World's Well-Governed Countries,” *The Guardian* (London), November 16, 1998.

Online publications, testimonies etc.

- “Brief of Joseph E. Stiglitz as *Amicus Curiae* in Support of Petitioners,” for *Esther Kiobel, et al. v. Royal Dutch Petroleum Co., et al.*, in the Supreme Court of the United States, December, 2011.
- “Brief of Joseph E. Stiglitz as *Amicus Curiae* in Support of Petitioners,” for *Republic of Argentina, Petitioner, v. NML Capital Ltd., et al., Respondents*, in the Supreme Court of the United States, March 24, 2014.
- “Budget Cuts vs. Tax Increases at the State Level: Is One More Counter-Productive than the Other During a Recession?” with Peter Orszag, Center on Budget and Policy Priorities Report, Nov. 6, 2001. <http://www.cbpp.org/10-30-01sfp.htm>.
- “Declaration of Joseph E. Stiglitz, Ph.D”, for ACLU regarding BRCA patents, Case 1:09-cv-04515-RWS, Document 224, Filed 01/20/2010, the United States District Court for the Southern District of New York.
- “I Dissent: Unconventional Economic Wisdom,” monthly column for Project Syndicate, an association of over 150 newspapers around the world. http://www.project-syndicate.org/series/series_list.php4?id=11.
- “The Impact of Paying for College on Family Finances,” with Laura Tyson, Peter Orszag, and Jonathan Orszag, commissioned by UPromise, Inc., November 2000. <http://www.upromise.com/pdfs/tysonStiglitzResearch.pdf>.
- “Implications of the New Fannie Mae and Freddie Mac Risk-based Capital Standard,” with Jonathan M. Orszag and Peter R. Orszag, *Fannie Mae Papers*, I(2), March 2002. <http://www.sbgo.com/Papers/fmp-v1i2.pdf>.
- “Incentives and the Performance of America’s Financial Sector, House Committee on Financial Services, Hearing on Compensation in the Financial Industry,” testimony by Joseph E. Stiglitz, January 22, 2010. <http://financialservices.house.gov/media/file/hearings/111/stiglitz.pdf>.
- “On the Need for Increased Capital Requirements for Banks and Further Actions to Improve the Safety and Soundness of America's Banking System,” testimony before the Senate Banking Committee, August 3, 2011. http://www.banking.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=97cec3e1-2d1d-44fa-acd9-a0a1bc640bc4.
- “Optimal Fire Departments: Evaluating Public Policy in the Face of Externalities,” with Peter R. Orszag, The Brookings Institution, Jan. 4, 2002. http://www2.gsb.columbia.edu/faculty/jstiglitz/download/papers/2002_Optimal_Fire_Depts.pdf.
- “The Role of Government in a Digital Age,” with Peter Orszag and Jonathan Orszag, study commissioned by the Computer & Communications Industry Association, October 2000.

- “Statement of Joseph Stiglitz at Center on Budget and Policy Priorities Press Conference,” Center on Budget and Policy Priorities Report, Oct. 26, 2001.
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- “Too Big to Fail or Too Big to Save? Examining the Systemic Threats of Large Financial Institutions,” testimony at a hearing of the United States Congress's Joint Economic Committee, April 21, 2009.
http://www.jec.senate.gov/public/?a=Files.Serve&File_id=6b50b609-89fa-4ddf-a799-2963b31d6f86.
- “Tax Cuts are not Automatically the Best Stimulus: A Response to Glenn Hubbard,” with Peter Orszag, Center on Budget and Policy Priorities Report, Nov. 27, 2001.
<http://www.cbpp.org/11-27-01tax.pdf>
- “The True Cost of the War,” testimony with Linda J. Bilmes at the House Committee on Veterans’ Affairs, September 30, 2010,
http://veterans.house.gov/hearings/Testimony_Print.aspx?newsid=632&Name=_Linda_J._Bilmes
- “U.S. versus Microsoft, Declaration as Part of The Tunney Act Proceeding,” with Jason Furman, commissioned by the Computer & Communications Industry Association, Jan. 28, 2002.
http://www.sbgo.com/Papers/tunney_jesjf.pdf
- “Witness Testimony of Joseph E. Stiglitz,” Congressional Oversight Panel, Hearing on Impact of the TARP on Financial Stability, March 4, 2011.
<http://cybercemetery.unt.edu/archive/cop/20110401230935/http://cop.senate.gov/documents/testimony-030411-stiglitz.pdf>.

Other outside activities

Speaking engagements at some point during the past five years

List includes lectures, speeches, and participation in panels. To view a select chronological list of Professor Stiglitz's speeches and links to powerpoints, videos, and speech texts, please visit his website, www.josephstiglitz.com. For more information on this list or an item on it, please write to stiglitzpress@gmail.com.

92nd Street Y, Abraaj Capital, Absa Capital African Central Banks Conference, Academy of Achievement, Academy of Behavioral Finance & Economics, Acumen Fund, Adana Young Businessmen Association (Turkey), ADC Forum (Australia), Advanced Graduate Workshop on Poverty, Development and Globalization (Bangalore), Affordable World Security Conference, AFL-CIO, African Export-Import Bank Advisory Group on Trade Finance and Export Development in Africa, All Party Parliamentary Group on Inclusive Growth of the UK, American Academy of Political and Social Science, American Bar Association, American Civil Liberties Union, American Economic Association (AEA) / Allied Social Science Association, American Federation of Labor and Congress of Industrial Organizations, Amundi, Annual India Business Conference (Columbia), Ansonia Independent Democratic Club, Asia Society, Asia Society (Hong Kong), Asian Development Research Institute, Associação Portuguesa de Empresas de Distribuição, Association for Evolutionary Economics, Atlanta Fed, Atlantic Council, Australia and New Zealand Banking Group Limited, Australia Institute, Australian Conference of Economists, Australian Institute of Superannuation Trustees (AIST), Azim Premji University, B&C Industrieholding, Bachelet Commission on Pension Re-reform, Bank of Singapore, Bank of Uganda, Barcelona Graduate School of Economics, Barclays, Barnes & Noble, Berggruen Institute, Bertelsmann Foundation, Blackwood Capital, BNDES - Brazilian Development Bank, Bohemian Club (Sonoma, California), BRICS International Competition Conference, British Academy, Brooklyn Public Library, B-Team, Calouste Gulbenkian Foundation, Camera dei Deputati (Italy), Carbon Commission, Carbon Pricing Leadership Coalition (CPLC), Catholic University of the Sacred Heart, Center for a New Economy (CNE), Center for Economic Development (Australia), Center for Popular Democracy, Center for Public Integrity, Center for Public Policy Debate (Brazil), Center of Studies of the University of Alcalá, Center on Global Economic Governance, Center on Japanese Economy and Business, Centre for International Governance Innovation, Centre of Excellence in Population Aging Research (Australia), Charles Krause Gallery, Chatham House, Chicago Council on Global Affairs, Chifley Research Centre (Australia), China Development Research Foundation, China Development Research Foundation (CDRF), China Entrepreneur Club, China Finance 40 Forum, China Machinery Press, Citi, City of Sydney, City University of New York, Clinton Global Initiative, CLSA Investors' Forum, Columbia Club of New York, Columbia European Society, Columbia Global Center (Turkey), Columbia Real Estate Forum, Columbia University Alumni Association (Bangalore), Columbia University Club, Comisiones Obreras (CCOO), Committee for Economic Development of Australia, Committee of 100, Committee on Global Thought, Committee on Japan's Long-term Low Carbon Vision, Commonwealth Club, Conference on Development Policy Options in Myanmar, Cornell Club, Council of Eminent Persons, Council on Foreign Relations, Coursera, Crawford School of Economics, Credit Suisse, Cultural Services of the French Embassy (New York), Deakin University (Australia), DeGroote School at McMasters University, Democratic Party of Japan, Dhurakij Pundit University, Discovery Leadership Conference (South Africa),

Doosan Global Business Forum, Dubai World Government Summit, Economic and Social Research Institute, Economic Commission for Latin America and the Caribbean (ECLAC), Economic Society of Australia, ECOSOC, Edinburgh Book Festival, Employment and Social Affairs Committee (EU Parliament), Ernst and Young, ETH Zurich, European Parliament Members Inquiry Committee (PANA), European Pensions & Investments Summit, European Petrochemical Association, Federal Department of Foreign Affairs (Switzerland), Federal Reserve System, Feltrinelli Foundation, Financial Conduct Authority, Fondation Jean Jaurès, Ford Foundation, Fordham University, Foundation for European Progressive Studies (FEPS), Free Library of Philadelphia, Friedrich-Ebert-Stiftung, Frontiers of Thought, Fundación RAP, George Washington University Law School, German Council on Foreign Relations, Gerson Lehrman Group, Global Alliance for Tax Justice, Global Development Institute, Global Economic Symposium, Global Relations Forum, Government of Chile, Government of China, Government of Colombia, Government of Cuba, Government of Japan, Government of Mexico, Government of Namibia, Government of Panama, Government of Scotland, Government of South Africa, Government of Sri Lanka, Government of Tunisia, Government of United Arab Emirates, Greenpeace, Hans Boecker Foundation, Harvard Business School, Harvard Club, Harvard University, HEC Paris, Hessian State Centre for Civic Education, Hitachi Innovation Forum, Hong Kong Trade Development Council (Asia Financial Forum), House Democratic Caucus Issues Conference, How To Academy, Icahn School of Medicine at Mt. Sinai, IHEC School of Business (Tunisia), Independent Commission for the Reform of International Corporate Taxation, Independent Commission for the Reform of International Corporate Taxation, Initiative for Policy Dialogue (IPD), Innovasjon Norge, Institute for Human Rights and Business, Institute for New Economic Thinking (INET), Institute for Science, Engineering and Public Policy, Institute of Development Studies Kolkata, Institute of Latin American Studies at Columbia University, Intergovernmental Group of 24, International Bar Association, International Economics Association, International Federation of Accountants, International Institute for Journalism, International Institute of Information Technology (Bangalore), International Labour Organization, International Monetary Fund, International Political Science Association World Congress, International Summit of Cooperatives, Istituto di Studi Economici e per l'Occupazione (I.S.E.O.), Italian Cultural Institute, Japan Broadcasting Corporation (NHK), Japan International Cooperation Agency, Jewish Community Center, Joseph Crowley, Joseph Fisher Lecture, Julius Baer, Kairos, Kentucky Author Forum, Khazanah (Malaysia), Kiel Institute, Koç Holding, Korea Business News, Labour Party of the UK, Lanxess, Le Havre Forum, Les Entretiens du Tresor, Libera Università Internazionale degli Studi Sociali (LUISS), Lindau Nobel Laureate Meetings, lit.COLOGNE, Living Liberally, London School of Economics, Lotos Club, Lugano Fund Forum, LUISS University, Luxembourg Income Study, Lycee Francaise (New York), Macao International Environmental Co-operation Forum & Exhibition, Marche Polytechnic University, Martha's Vineyard Hebrew Center Summer Institute, Masic Investment Forum, Massachusetts Institute of Technology, Mexican Association of Insurance Companies, Milestones Conference, Ministry of Finance (Ethiopia), Ministry of Finance (Indonesia), Monetary Authority of Macau, Morgan Stanley Investment Management, MS Europa, Museum of American Finance, Myanmar Federation of Chambers of Commerce and Industry (sponsored by UNDP and

Myanmar Development Research Institute), Nasscom, National Assembly (France), National Association for Business Economics (NABE), National Association of Economists and Accountants of Cuba (ANEC), National Press Club, National Tax Association, Negotiators of the Trans-Pacific Partnership, New Democratic Party of Canada, New York City Bar Association, New York Hedge Fund Roundtable, New York Historical Society, New York Public Library, New York University, NMS Management, North Jersey Public Policy Network , OECD, Open Society Institute, Organisation for Economic Co-operation and Development, Otis University, Oxfam, Oxford Blavatnik School, Oxford Fulbright Distinguished Lecture in International Relations, Oxford Martin School, Paris School of Economics, Parliament of Scotland, Pew Charitable Trusts, Phoenix Group, Polish Chamber of Commerce, Pontifical Academy of Social Sciences, Princeton University Press, Princeton University's Griswold Center for Economic Policy Studies, Productivity Commission (Australia), Program for Economic Research, Progressive Alliance of Socialists and Democrats (European Parliament), Progressive Economy Annual Forum (Belgium), Public Eye Awards, Public Pension Funding Forum (Columbia), Public Theater, Rabobank, Raising the Bar, Ramapo College, Real Academia de Ciencias Económicas y Financieras, Reinventing Bretton Woods Committee, Renmin University, Research Institute for Development, Growth and Economics (RIDGE), Reserve Bank of India, Resources for the Future, Responsible Endowments Coalition, Rockefeller Brothers Fund, Roosevelt Institute, Rosa DeLauro, Royal Bank of Canada, Royal Geographical Society , Royal Society for the Encouragement of Arts, Manufactures and Commerce, Russell Sage Foundation, Rutgers University, Sacred Heart school (New York), Sapienza University of Rome, Scientific Council for Government Policy (Netherlands), School of International and Public Affairs at Columbia University, Sciences Po, Scuola Superiore Sant'Anna, SEC, Securities & Exchange Commission, Shanghai Jiaotong University, Shearman and Sterling, LLP, Social Business Awards (France), Society for Progress, Society of Corporate Secretaries and Governance Professionals, Spanish Royal Academy, Standard Chartered, Starmus Festival, Statoil, Stuyvesant High School, Sun Hung Kai Properties, Swedish International Development Cooperation Agency (SIDA), Swiss International Finance Forum, Tamer Center, Tannenbaum Lecture (Columbia), The Chinese University of Hong Kong, The Commonwealth, The Economist, The Greens/European Free Alliance (European Parliament), The New Republic, The New School, The Overseas Development Institute, Tiger Forum (France), Tokyo International Conference on African Development, Town Hall Seattle , Trento Festival of Economics , Trinity College, Tsinghua University, Turkish Economic Association, UBS, UK Treasury, UNDESA, UNDP, UNESCO, UNFPA, UNICEF, Union Investment, United Nations, United Nations Conference on Trade and Development, United Nations Development Programme, United Nations Economic and Social Commission for Asia and the Pacific, United Nations High-Level Panel on Innovation and Access to Medicines, United Nations Industrial Development Organization, United Nations Office of the High Commissioner for Human Rights, United Nations Panel Sovereign Debt Vulnerabilities and the Opportunity for a New Debt Workout Mechanism Building on the UNGA process, United Nations University World Institute for Development Economics Research (UNU-WIDER), United States Congress, United States Senate, United States Senate Budget Committee, United States State Department, Universidad del Rosario, Universidad

Nacional de Cordoba (Argentina), Universite Paris-Dauphine, University of Adelaide, University of British Columbia, University of California at Berkeley, University of Chicago Booth School of Business, University of Fribourg (Switzerland), University of Goettingen, University of Havana, University of Hawaii, University of Heidelberg, University of Hyderabad, University of Macao, University of New South Wales, University of Oslo, University of Ottawa, University of Split (Croatia), University of Trento, University of Zurich, Vector Casa de Bolsa, Victoria University, Vienna University of Economics and Business, Virginia Festival of the Book, Washington Center for Equitable Growth, Ways With Words Festival (Totnes, UK), Winton Capital Management, Women's Alternative Investment Summit, World Affairs Council, World Bank, World Economic Forum, World Health Organization, World Leaders Forum, World Technology Network, World Urban Forum, Yale Institution for Social and Policy Studies, Youth Forum on Foreign Policy (India), ZFU International Business School.

Additional outside activities (including consulting, advising, paid and unpaid) at some point during last five years:

CFTC-SEC Advisory Committee on Emerging Regulatory Issues (Member), Acumen Fund (member of the board), Amherst College (member of board of trustees), Resources for the Future (member of board of trustees), Alliance for Climate Projection, Center for Global Development, Economic Research Forum (Cairo), Barcelona Graduate School of Economics Advisory Scientific Council, International Advisory Board, Statoil and Docomo, Scientific Advisory Board, Institute for New Economic Thinking, International Economics Association (President, 2011-2013), World Bank (CEAC, Chief Economist's Advisory Council, Eminent Persons), OECD (High Level Expert Group on the Measurement of Economic Performance and Social Progress, co-chair), Commission of Experts on Reforms of the International Monetary and Financial System, appointed by the President of the General Assembly of the United Nations (2009, chair), Economic Advisory Council (South Africa), South African Competitive Council (Expert), Government of South Africa, Fiscal Commission Working Group (Scotland), Roosevelt Institute (Chief Economist), Oxfam, Advisory Board of the Martin School of Oxford, Independent Commission for the Reform of International Corporate Taxation (Commissioner), World Economic Forum (on Latin America, Co-chair and other advisory work), China Development Research Foundation, Research Institute for Development, Growth and Economics (Chairman), Brennan Center for Justice (Member, Economic Advisory Board), Carbon Pricing Leadership Coalition's High-level Commission on Carbon Prices (Co-Chair), Center for a New Economy's Growth Commission for Puerto Rico (Member).

Litigation support/expert witness for plaintiffs in anti-trust litigation concerning alleged anti-competitive restraints imposed by Visa, Mastercard, and American Express and for US Air concerning alleged anti-competitive restraints imposed by Sabre GDS; for plaintiffs in Canada concerning alleged anti-competitive practices of Microsoft and their impacts on consumers and innovation; for plaintiffs involved in litigation involving alleged

misconduct by credit rating agency; pro-bono expert for Argentina in litigation involving debt restructuring; expert witness on welfare costs associated with exclusionary actions against Intel, Apple, and Hewlett Packard before ITC in case involving alleged patent infringement; pro-bono amicus filings in cases concerning Alien Torts Act, patentability of human genes (BRAC genes), and debt restructuring (interpretation of pari passu clause), Brattle (work involving financial sector misconduct and anti-trust issues).

Informal and unpaid consultations and advice to a variety of governments and government officials, including those in Greece, Namibia, Panama, South Africa, Spain, Scotland, and France; congressional testimony and to the congressional oversight panel on matters relating to reforming the financial sector, the cost of Iraq and Afghanistan wars, and inequality.

Working papers and unpublished papers (in categories)

1. Economics of Information

- “Characterization, Existence, and Pareto Optimality in Insurance Markets with Asymmetric Information with Endogenous and Asymmetric Disclosures: Revisiting Rothschild-Stiglitz,” (update and revision of “Equilibrium in a Competitive Insurance Market Under Adverse Selection with Endogenous Information”), February 2018.
- “Contests and Cooperation: Toward a General Theory of Compensation and Competition,” presented at a Conference on the Internal Organization of Firms, International Institute of the Internal Organization of Firms, International Institute of Management, Berlin, July 1980; and at a Conference on the Economics of Information, University of Pennsylvania, May 1981.
- “Cutting off Credit: An Application of Constraints on Incentive Devices,” with A. Weiss, April 1982.
- “Equilibrium in a Competitive Insurance Market Under Adverse Selection with Endogenous Information,” with Jungyoll Yun and Andrew Kosenko, NBER Working Paper No. 23556, June 2017.
- “Equilibrium Unemployment as a Worker Screening Device,” with B. Nalebuff and A. Rodriguez, NBER Working Paper 4357, May 1993. (Paper presented as “Equilibrium Unemployment, Testing, and the Pure Theory of Selection” at the NBER/CEPR Conference on Unemployment and Wage Determination, Boston, October 1991.)
- “Equilibrium Unemployment, Testing, and the Pure Theory of Selection,” with A. Rodriguez, presented at NBER/CEPR Conference on Unemployment and Wage Determination, Boston, October 1991.
- “The Existence and Characteristics of Competitive Equilibrium,” with R. Arnott, revised 1985.

- “Existence and Equilibrium in Markets with Imperfect Information,” with M. Rothschild, presented to World Congress of Econometric Society, Toronto, 1975.
- “Incentives Schemes Under Differential Information Structures: An Application to Trade Policy,” with P. Dasgupta, IMSSS Technical Report No. 172, Stanford University, July 1972.
- “Information and Exploration Externalities,” SEER Technical Report, Stanford University, 1976.
- “Information in a Decentralized (Market) Economy,” presented at Spoleto Conference on Post Industrial Society, July 1986.
- “Information, Planning and Incentives,” presented at the CSCCRP Sino-American Conference on Alternative Development Strategies in Wingspread, Racine, WI, November 1980. (Chinese edition published 1982.)
- “Knowledge of Technology and the Technology of Knowledge: New Strategies for Development,” Background paper for *UNDP Human Report 2001*.
- “Moral Hazard and Unemployment in Competitive Equilibrium,” with P. Rey. October 1993. (Revised July 1996.)
- “Prices and Queues in Screening Services in Competitive Markets,” IMSSS Technical Report 212, Stanford University, August 1976.
- “Remarks on Inequality, Agency Costs, and Economic Efficiency,” prepared for a workshop in “Economic Theories of Inequality,” Stanford Institute for Theoretical Economics, Stanford University, March 11-13, 1993.
- “Unemployment and Efficiency Wages: The Adverse Selection Model,” with A. Rodriguez, presented at NBER/CEPR Conference on Unemployment and Wage Determination, Boston, October 17-19 1991.
- “Unemployment As a Worker Selection Device,” with B. Nalebuff, Princeton University, 1985, (Revision of “Quality and Prices,” Princeton University Econometric Research Memorandum No. 297, May 1982.)

2. Economics of Uncertainty

- “Risk and Trade Policy,” with D. Newbery, World Bank Working Paper No. 53, January 1983. (Revised 1985.)

3. Risk and Agriculture

- “Alternate Stabilization Schemes for Supply Uncertainty,” with D. Newbery, Economic Theory Discussion Paper No. 4, University of Cambridge, January 1978.
- “Determinants of the Distributional Impact of Commodity Price,” with D. Newbery, Economic Theory Discussion Paper 17, University of Cambridge, July 1979.

4. Financial Markets

- “Bail-ins and Bail-outs: Incentives, Connectivity, and Systemic Stability”, with B. Benjamin and A. Capponi, NBER Working Paper No. 23747, August 2017. (Presented to the World Congress of the International Economic Association, Mexico City, June, 2017.)
- “Economics of Small Business Lending,” at “Bank Lending to Small Businesses: A Conference,” Office of the Comptroller, November 15, 1991.
- “The Effect of Financial Repression in an Economy with Positive Real Interest Rates: Theory and Evidence,” with K. Murdock, August 1993.
- “Equity Financing for New Firms,” with I. Gale, May 1986.
- “The Fall: A Chronicle of the Financial Crisis,” lecture at IMCA 2010 Annual Conference in Orlando, Florida, May 17, 2010.
- “Financial Restraint: Toward a New Paradigm,” with Thomas Hellmann and Kevin Murdock, Stanford Graduate School of Business Research Paper: 1355, April 1995. (Prepared for World Bank’s EDI Workshop on “Role of Government in Economic Development: Analysis of East Asian Experiences,” Kyoto, Japan, September 16-17, 1994.)
- “Futures Markets and Risk: A General Equilibrium Approach,” Princeton University Financial Research Center Memorandum 47, April 1984.
- “Futures Markets Are Almost Always Informationally Inefficient,” with I. Gale, Princeton University Financial Research Center Memorandum No. 57, February 1985. (Revised as “A Simple Proof that Futures Markets Are Almost Always Informationally Inefficient,” Working Paper, 1989.)
- “Multiple Stock Offering and the Financing of New Firms,” with I. Gale, Princeton University Financial Research Center Memorandum 73, November 1986.
- “Perfect and Imperfect Capital Markets,” presented to the Econometric Society Meetings, New Orleans, 1971.
- “Restoring Stability and Confidence in European Sovereign Debt Markets,” lecture given at Global ARC in London, May 18, 2010.
- “Theory of Liquidity Preference and the Term Structure of Interest Rates,” Cowles Foundation Discussion Paper No. 252, August 1968.

5. Growth and Capital Theory

- “Capital Constraints and Economic Growth,” revised version of a paper prepared for a conference at Buffalo, May 1990.
- “Imperfect Capital Markets and Productivity Growth,” with B. Greenwald and M. Salinger. Paper presented at NBER Conference in Vail, CO, April 1990, revised March 1991 and April 1992.

“Notes on Learning, Capital Constraints, Growth and Efficiency,” presented at Conference held by Institute for the Study of Free Enterprise Systems, Buffalo, NY, May 1990.

6. Natural Resources

“Climate Change: An Agenda for Global Collective Action,” with Joseph E. Aldy and Peter R. Orszag, prepared for the conference on “The Timing of Climate Change Policies,” Pew Center on Global Climate Change, October 2001.

“Stepping Toward Balance: Addressing Global Climate Change,” presented at the Conference on Environmentally and Socially Sustainable Development. Washington, D.C., October 6, 1997.

“Sharing the Burden of Saving the Planet: Global Social Justice for Sustainable Development,” Keynote speech at the meeting of the International Economic Association, Istanbul, June 2008.

7. Theory of Market Structure, R&D

“Analysis of Factors Affecting the R&D Choices of Firms,” with P. David, Center for Research in Economic Growth Memorandum 232, Stanford University, 1979.

“Creating Competition in Telecommunications,” presented at the Conference on Managing the Telecommunications Sector Post-Privatization, George Washington University, Washington, D.C., April 27, 1998.

“Entry, Equilibrium, and Welfare,” with R. Gilbert.

“Exercises in the Economics of Learning-By-Doing,” with P. Dasgupta, Cambridge University, May 1985. (Presented at GTE Conference on Industrial Organization, Cambridge, August 1985.)

“Intellectual Property Rights, the Pool of Knowledge, and Innovation,” NBER working paper 20014, March 2014, available at http://www.nber.org/papers/w20014.pdf?new_window=1.

“Some Rough Notes on Diversity of Tastes and Diversity of Commodities,” Oxford University, paper presented at Bell Labs Conference on Monopolistic Competition, February 1977.

“Sunk Costs, Competition, and Welfare,” with P. Dasgupta, August 1985.

“Unemployment and Innovation,” NBER Working Paper 20670, November 2014.

“Welfare and Competition with Sunk Costs,” with P. Dasgupta, November 1985.

8. Macroeconomics

“An Agenda for Reforming Economic Theory,” lecture at Institute for New Economic Thinking Conference in Cambridge, April 10, 2010.

“Bankruptcy protection against macroeconomic shocks: the case for a ‘super chapter 11’,” with M. Miller, World Bank Conference on Capital Flows, Financial Crises, and Policies, April 15, 1999.

- “Capital Market Imperfections and Labor Market Adjustments,” with B. Greenwald, presented to NBER/CEPR Conference on Labor Market Dynamics, Cambridge, October, 1991.
- “An Economic Analysis of Labor Turnover,” Institute for Mathematical Studies in the Social Sciences (ISMMM) Working Paper No. 53, Stanford University, February 1976.
- “Evolutionary Theory and the Current Economic Crisis,” presented at the American Economic Association annual meeting, January, 2010.
- “Expectations, Asset Accumulation and the Real-Balance Effect,” with P. Neary, presented at Dublin Meetings of the Econometric Society, September 1982, Working Paper 1990.
- “Financially Constrained Fluctuations in an Evolving Network Economy,” with D. Delli Gatti, M. Gallegati, B. Greenwald and A. Russo, NBER working paper No. 14112, June 2008.
- “From Measuring Production to Measuring Wellbeing,” lecture co-hosted by the Economic Society of Australia Victorian Branch and the Productivity Commission in Melbourne, Australia, July 29, 2010.
- “Growth and Equity in a World of Deficits: An Alternative to Austerity,” lecture given in Copenhagen, Denmark, May 13, 2011.
- “Household Labor Supply, Unemployment, and Minimum Wage Legislation”, with Kaushik Basu and Garance Genicot, Policy Research Working Paper 2049, Washington, D.C.: World Bank, 1999.
- “Imperfect Information and Macroeconomic Analyses,” with B. Greenwald.
- “The Long Boom? Business Cycles in the 1980s and 1990s,” given to CEPR conference “The Long Boom”, Stanford University, September 5, 1997.
- “Macro-economic Management in an Electronic Credit/Financial System, “ NBER Working Paper 23032, January 2017.
- “Macroeconomic Dynamics, Heterogeneous Interacting Agents and Network: A Solvable Agent Based Model of a Monetary Economics,” with M. Gallegati and S. Landini, 2010.
- “Macroeconomic Equilibrium and Credit Rationing,” with A. Weiss, NBER Working Paper 2164, 1987.
- “The New Keynesian Economics: Money and Credit,” Fisher-Schultz Lecture presented at the Meetings of Econometric Society, Copenhagen, August 1987.
- “Principles and Guidelines for Deficit Reduction,” The Roosevelt Institute, December 2, 2010, Working Paper No. 6.
- “Pseudo-Wealth and Consumption Fluctuations,” with Martin Guzman, NBER Working Paper No. 22838, November 2016 and presented at the American Economic Association Meetings, January, 2015.

"Rethinking Macroeconomics: What Went Wrong and How to Fix It," Adam Smith Lecture, European Economic Association, Glasgow, August 24, 2010. Also presented at DIME conference, Budapest, September 8, 2010.

"A Theorist's View of Policymaking and a Policymaker's View of Theory Perspectives on Modern Macro-economics," Marshall Lectures presented at Cambridge University. April 29-30, 1996.

9. Monetary Economics

"Adverse Selection, Credit Rationing and Central Bank Policy," Working Paper, 1989.

"Capital Market Imperfections and Regional Economic Development," with B. Greenwald and A. Levinson, prepared for CEPR conference on Finance and Development in Europe, Santiago, Spain, December 1991.

"Consumer and Producer Price-Neutral Tax Reform with an Informal Economy," with M. Shahe Emran, Working Paper, September, 2002.

"Money Neutrality in a Model of Firm Adjustment," with B. Greenwald and K. Clay, Working Paper, Stanford University, 1990.

"Monetary and Exchange Rate Policy in Small Open Economies: The Case of Iceland," Central Bank of Iceland Working Paper Nr. 15.
<http://www.sedlabanki.is/uploads/files/WP-15.pdf>

"Monetary Policy and the Institutional Structure of Banking," with B. Greenwald, June 1991.

"Monetary Policy and the Theory of the Risk-Averse Bank," with B. Greenwald, prepared for the conference "Macroeconomic Stabilization Policy: Lessons for the Future," CEPR, Stanford University and the Federal Reserve Bank of San Francisco, March 5, 1993.

"Net Worth, Exchange Rates, and Monetary Policy: The Effects of a Devaluation in a Financially Fragile Environment," with D. Delli Gatti, M. Gallegati, and B. Greenwald, Stiglitz, NBER working paper No. 13244, July 2007.

"Real Exchange Rate Policies for Economic Development," with M. Guzman and J.A. Ocampo, NBER working paper No. 23868, September 2017.

10. International Economics

"Asia and the Emerging Global Economic System," lecture presented at Institute for New Economic Thinking conference, Bretton Woods, April 10, 2011.

"Back to Basics: Policies and Strategies for Enhanced Growth and Equity in Post-Crisis East Asia," Bangkok, Thailand. July 29, 1999.

"Can We Prevent Another Global Financial Crisis?" public lecture at the University of Hobart in Hobart, Australia, August 2, 2010.

"The Economic Crisis: Towards a New World Order? Towards Sustainable Growth?" lecture given in Mumbai, May 26, 2010.

- “Farewell to the Invisible Hand? A Global Financial System for the Twenty-first Century,” 2010 David Finch Lecture at the University of Melbourne in Melbourne, Australia, July 28, 2010.
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- “Two Principles for the Next Round or, How to Bring Developing Countries in from the Cold,” Stockholm, Sweden, April 12, 1999. Revised and presented to WTO, Geneva, Switzerland, September 21, 1999.
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- “Development Under Adversity? The Palestinian Economy in Transition,” address to the Conference on Development Under Adversity, Gaza, November 22, 1997.

- “The East Asian Crisis and Its Implications for India,” Commemorative Lecture for the Golden Jubilee Year Celebration of Industrial Finance Corporation of India, New Delhi, India, May 19, 1998.
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- “The Indian Microfinance Crisis,” with Antara Haldar, February 2013.
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- “An Issues Paper on Financial Markets and Policies in East Asian Economies,” June 1992.
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- “Microfinance and Missing Markets,” with Shahe Emran and Mahbub Morshed, October 2006.
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- “A Social Democratic Agenda for a More Dynamic Indian Economy: Creating an Innovative and Learning Society,” The 2010 Jawaharlal Nehru Memorial Lecture, November 18.
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15. Political Economy

“Gender and Development: The Role of the State,” World Bank Gender and Development Workshop, Washington, D.C., April 2, 1998.

“Political Economy in a Contestable Democracy: The Case of Dividend Taxation,” with A. Korinek, *2008 Meeting Papers*, Society for Economic Dynamics.

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“Rethinking the Economic Role of the State: Publicly Provided Private Goods,” lecture delivered at Universitat Pompeu Fabra, Barcelona, November 15, 1992.

16. Theory of Taxation / Public Finance

“Financial Structure and the Incidence of the Corporate Income Tax,” with B. Greenwald, March 1987.

“Information and Multi-Period Optimal Income Taxation with Government Commitment,” with D. Brito, J. Hamilton, and S. Slutsky, NBER Working Paper 2458, December 1987.

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“Taxation and Agricultural Pricing Policies, Cost Benefit Analysis, and the Foreign Exchange Constraint,” Paper prepared for the World Bank, September 1982.

“The Town-Versus-Country Problem: Optimal Pricing in an Agrarian Economy,” with A. Braverman and R. Sah, presented to a Conference at the World Bank, June 1982.

17. Theory of Public Expenditures

“Project Appraisal and Foreign Exchange Constraints: A Simple Exposition,” with C.R. Blitzer and P. Dasgupta, NBER Working Paper 2165, 1987.

“The Theory of International Public Goods and the Architecture of International Organizations,” Background Paper No. 7, Third Meeting, High Level Group on Development Strategy and Management of the Market Economy, UNU/WIDER, Helsinki, Finland, July 8-10, 1995.

18. Miscellaneous

“Bailouts, Regulation or Free Markets? Business and Government in a Small Regional Economy,” lecture given to Economic Society of Australia Tasmania Branch and the Tasmanian Chamber of Commerce and Industry in Hobart, Australia, August 2, 2010.

“China: Forging a Third Generation of Reforms,” Speech given on July 23, 1999.

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“Inequality and Capital Taxation,” IMSSS Technical Report 457, Stanford University, July 1985.

“Incentives and Institutions in the Provision of Health Care in Developing Countries: Toward an Efficient and Equitable Health Care Strategy,” Keynote Address, International Conference in Health and Economic Development, National Institutes of Health, November 15, 1999.

“Optimal Leverage: The Role of Externalities,” with S. Battiston, D. Delli Gatti, M. Gallegati, and B. Greenwald.

“Optimal Provision of Loans and Insurance against Unemployment from a Lifetime Perspective,” with Jungyoll Yun, National Bureau of Economic Research Working Paper 19064, May 2013.

“Optimality and Equilibrium in a Competitive Insurance Market under Adverse Selection and Moral Hazard,” with Jungyoll Yun, NBER Working Paper 19317, August, 2013.

**EXHIBIT B:
PREVIOUS EXPERT TESTIMONY**

The list below indicates all matters in which I have provided expert reports, affidavits, declarations, witness statements, deposition testimony, or trial testimony in the past five years. While I have in my possession copies of all such reports, affidavits, declarations, and witness statements, many of these cases are subject to protective orders or confidentiality agreements that prevent me from providing copies in this matter.

Case: Ambac Assurance Corporation and The Segregated Account of Ambac Assurance Corporation, vs. Countrywide Home Loans, Inc., Countrywide Securities Corp., Countrywide Financial Corp., and Bank of America Corp., Index No.: 653979/2014

Forum: Supreme Court of the State of New York, New York County

Testimony: Report

This case is subject to a protective order that prevents disclosure of materials.

Case: American International Group, Inc. and Subsidiaries vs. United States of America, ECF Case No.: 09 Civ. 1871 (LLS)

Forum: United States District Court for the Southern District of New York

Testimony: Report, Rebuttal Report, Deposition

This case is subject to a protective order that prevents disclosure of materials.

Case: MBIA Insurance Corporation vs. Credit Suisse Securities (USA) LLC, DLJ Mortgage Capital Inc., and Select Portfolio Servicing, Inc., Index No.: 603751/2009

Forum: Supreme Court of the State of New York, New York County

Testimony: Report, Rebuttal and Reply Report, Deposition

This case is subject to a protective order that prevents disclosure of materials.

Case: Ambac Assurance Corporation vs. EMC Mortgage LLC (f/k/a EMC Mortgage Corporation), J.P. Morgan Securities LLC (f/k/a Bear, Stearns & Co. Inc.), and JPMorgan Chase Bank, N.A., Index No.: 650421/2011

Forum: Supreme Court of the State of New York, New York County

Testimony: Report, Rebuttal Report

This case is subject to a protective order that prevents disclosure of materials.

Case: Ambac Assurance Corporation and The Segregated Account of Ambac Assurance Corporation, vs. Countrywide Home Loans, Inc., Countrywide Securities Corp., Countrywide Financial Corp., and Bank of America Corp., Index No.: 651612/2010

Forum: Supreme Court of the State of New York, New York County

Testimony: Report, Rebuttal Report, Deposition

This case is subject to a protective order that prevents disclosure of materials.

Case: US Airways, Inc., vs. Sabre Holdings Corporation, Sabre, Inc., Sabre Travel International Limited, Civil Action No.: 1:11-cv-02725-LGS

Forum: United States District Court for the Southern District of New York

Testimony: Report, Reply Report, Deposition, Declaration, Trial Testimony, Rebuttal Trial Testimony

This case is subject to a protective order that prevents disclosure of materials.

Case: In re: American Express Anti-Steering Rules Antitrust Litigation, 11-MD-02221

Forum: United States District Court for the Eastern District of New York

Testimony: Declaration

This case is subject to a protective order that prevents disclosure of materials.

Case: Abaclat and Others vs. The Argentine Republic, Case No.: ARB/07/5

Forum: International Centre for Settlement of Investment Disputes

Testimony: Reports, Rebuttal Reports

This case is subject to a confidentiality agreement that I believe prevents disclosure of materials.

**EXHIBIT C:
MATERIALS CONSIDERED**

MATERIALS CONSIDERED

CASE FILINGS AND EXPERT REPORTS

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2. H. Wanless, “Declaration of Dr. Harold R. Wanless in Support of Answer of Real Parties in Interest to Petition for Writ of Mandamus”, in *United States of America et al. v. United States District Court for the District of Oregon et al.*, Case No. 17-71692, Doc. No. 14-3.

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