The Fiscal Costs of Climate Change in the United States

Lint Barrage*
ETH Zurich

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Abstract

This paper explores the fiscal impacts of climate change and their policy implications for the United States. We develop and empirically quantify a model where climate change can affect both public expenditures (e.g., on Medicare) and tax revenues. First, the paper presents a novel quantification of fiscal impacts, including an empirical analysis documenting substantial public healthcare costs from extreme heat. Second, we show theoretically that the social cost of carbon (SCC) must account for climate impacts on both government consumption and, if the marginal cost of public funds exceeds unity, household transfers. Finally, the numerical results demonstrate the importance of fiscal impacts for policy: Climate impacts on public program costs induce U.S. welfare losses of $6-7 trillion and increase the U.S. SCC by 20-40%.

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1 Introduction

Climate change is increasingly recognized as a risk to public finances (e.g., EU 2024; CBO 2021a). Public budgets may be exposed to climate change in numerous ways, including through existing program costs (e.g., disaster relief), the need for publicly funded adaptation, and changes in revenue yields due to climate impacts on tax bases. Despite their intuitive relevance, these fiscal impacts and their general equilibrium effects have received little attention to date by integrated assessment models used to quantify the social cost of carbon (e.g., DICE, Barrage and Nordhaus 2024; GIVE, Rennert et al. 2022) and by leading empirical climate change impact projections (e.g., Hsiang et al. 2017; CIL in EPA 2023).

This paper presents what is to the best of our knowledge a first attempt to both quantify aggregate fiscal climate change impacts for the United States and to analyze their policy implications. First, we present a novel bottom-up quantification of climate change impacts on existing public program costs by synthesizing prior estimates and by empirically analyzing public healthcare expenditure impacts of temperature extremes. The empirical results indicate that even just one additional day with very hot temperatures increases total (federal, state, and local) annual public health expenditures by around +0.18% on average. Even when accounting for adaptation to future climate change in line with leading empirical methods (Carleton et al. 2022), forward projections indicate that public healthcare costs could increase meaningfully from changes in future temperature extremes alone. Accounting for other impacts based on prior literature (e.g., hurricane-related healthcare costs as in Deryugina 2017) we obtain central public program cost change estimates of +3.8% for public healthcare, +1.3% for government consumption, and +0.5% for public transfers in a high-warming scenario.

Second, this paper develops a climate-macroeconomic model with several novel fiscal impact channels in order to analyze their theoretical and quantitative implications for the U.S. economy. Building on the global dynamic general equilibrium climate-economy model with distortionary income taxes of Barrage (2020a), we create a model of the U.S. economy where climate change can affect not only (i) aggregate production and (ii) household utility, but also (iii) government consumption requirements, (iv) government transfers to households, (v) public health expenditures, (vi) endogenous public adaptation expenditures, (vii) tax revenues via production impacts and (vii) capital depreciation from sea level rise. Though very different in focus, this approach is similar in spirit to a new generation of studies that integrate more detailed empirically based representations of climate change impacts into multi-sector models (e.g., Nath 2025; Conte et al. 2022; Rudik et al. 2022; Casey et al. 2024; Fried 2022), whereas the broader integrated assessment climate-macro literature traditionally represents all climate impacts simply as an aggregate productivity or utility loss (e.g., Barrage and Nordhaus 2024; Golosov et al. 2014; Acemoglu et al. 2012; etc.).

Theoretically, we show that the social cost of carbon (SCC) must account for fiscal impacts. Public healthcare costs and government consumption requirement increases ought to be internalized analogously to private output losses. In addition, if revenues are raised with distortionary taxes for which the marginal cost of public funds exceeds unity, the SCC should further account for climate impacts on *transfers* to households.[1]

Finally, the numerical results highlight the quantitative importance of fiscal impacts for U.S. policy and welfare. Public expenditure impacts of climate change increases the U.S. social cost of carbon (SCC) by +20-40% and lead to an estimated \$6-7 trillion in welfare costs (\$2025 initial period equivalent variation), or around 0.6% in consumption-equivalent terms. The results also indicate that the domestic welfare benefits of optimizing carbon prices and energy taxes in the United States are substantially larger once fiscal interactions are taken into account. Intuitively, this is because the revenue and climate benefits of carbon and energy taxes are valued more highly when public funds are scarce.[2]

Of course these results are subject to important caveats. Climate change impact quantification is always subject to significant uncertainties. Here, the fiscal cost estimates are moreover based on a first generation of studies of select programs. The model also abstracts from other frontiers that have recently been shown to be important for climate impacts, such as migration and uncertainty. The results nonetheless demonstrate that fiscal costs are both conceptually relevant and quantitatively important for U.S. policy. As a growing number of governments and scholars seek to understand fiscal climate risks, we also highlight public healthcare costs as an especially underappreciated mechanism to date.

Our analysis relates to several strands of the literature. First, it builds on the rich tradition of climate-economic integrated assessment models (IAMs, recently reviewed by Dietz 2024). This literature has advanced on numerous fronts in recent years such as uncertainty (e.g., van den Bremer and van der Ploeg 2021; Cai and Lontzek 2019), migration and spatial detail (e.g., Cruz and Rossi-Hansberg 2024; Conte et al. 2022), and innovation (e.g., Casey 2024), to name a few. Most of this literature abstracts from public finances and income taxation, however, and even those that model fiscal policy have generally not considered climate change impacts on public spending to the best of our knowledge (e.g., Barrage 2020a;

[1] Formally, this is because changes in transfers alter the set of equilibria that can be decentralized as a competitive equilibrium.

[2] The range of estimated impacts is large because the magnitude of these effects depends critically on the assumed counterfactual revenue-raising scenario, that is, what kinds of income tax increases can be avoided through carbon and energy taxes.

Douenne et al. 2026).[3] Importantly, this literature typically also ignores healthcare costs,[4] which this study reveals to be a first-order contributor to the SCC.

Second, a large literature has studied interactions of pre-existing taxes and environmental policy (reviewed by, e.g., Bovenberg and Goulder 2002). This literature has, however, again generally abstracted from pollution impacts on government expenditures. One important finding of this literature in recent years has been that the environmental policy implications of distortionary taxes depend very much on whether they are levied in order to raise revenues (in a world where lump-sum levies are infeasible) or in order to redistribute among heterogeneous agents (in a world where targeted transfers are infeasible) (e.g., Douenne et al. 2022; Jacobs and van der Ploeg 2019). This paper focuses on the former case. A common finding in this literature is that the second-best pollution tax is generally lower when levied alongside distortionary taxes. Our theoretical analysis reveals that climate impacts on public expenditures can potentially overturn this result. Specifically, when the marginal cost of public funds exceeds unity, a term is added to the optimal carbon price expression to reflect climate impacts on public transfer payments (and their associated general equilibrium effects). Numerous studies have also used sophisticated computable general equilibrium models of the U.S. economy to quantify carbon pricing and tax system interactions, but they generally again do not consider climate change impacts on public expenditures or healthcare (e.g., Goulder and Hafstead 2018; Fried et al. 2018; Goulder et al. 2016; see also models reviewed in Barron et al. 2018; Bovenberg and Goulder 1996; etc.) This literature typically also abstracts from climate change impacts on tax bases.[5] While this paper's representation of the economy is vastly simplified compared to these studies, it endogenizes physical climate and its macroeconomic effects including on public budgets.

[3] Barrage (2020b) introduces climate change impacts on government consumption and endogenous publicly financed adaptation against general production and utility damages in a stylized global extension of Barrage (2020a). However, the quantification of expenditure impacts is based on an early version of this paper, neither transfer payments nor sea level rise impacts are considered, there are no theoretical results nor empirical estimates, and no results specific to U.S. policy.

[4] The valuation of climate "health" impacts in IAMs is typically limited to mortality (e.g., Rennert et al. 2022) and sometimes also morbidity (e.g., FUND 2014) valued by disability-adjusted life years, whereas healthcare expenditures are rarely considered (see Online Appendix Section A2.1).

[5] An emerging international literature moves in this direction. Bachner and Bednar-Friedl (2019) integrate several climate impacts including on public disaster relief in a CGE model of Austria. Several studies also model climatic disaster risks in small open emerging markets with publicly financed adaptation (Catalano et al. 2020; Cantelmo et al. 2023; Corugendo et al. 2023). This paper differs by (i) empirically quantifying healthcare and other broader public expenditure impacts, (ii) endogenizing physical climate, (iii) consideration of the U.S. and (iv) endogenizing capital dynamics (whereas the above assume static decision-making or that interest rates are globally given). These differences are important because this paper (i) reveals the first-order importance of healthcare costs for the SCC, a previously largely ignored impact, (ii) derives novel climate policy implications of fiscal costs, and (iii) offers different conclusions on the effects of dynamic taxes (see Barrage 2025).

Third, as noted above, this paper relates to a new literature that integrates detailed and empirically based representations of climate change's impacts into multi-sector models to quantify its general equilibrium effects. This literature ranges from global trade models (e.g., Nath 2025) to U.S. models of migration and production (e.g., Rudik et al. 2022) and models of capital production (Casey et al. 2024). Fried (2022) builds and empirically quantifies a detailed heterogeneous agent model of adaptation to storm events and climate change in the United States, but does not distinguish public and private investments. Phan and Schwartzman (2023) study the interplay between natural disasters, sovereign default, investment, and growth in a model with a quantification for hurricanes in Mexico; Mallucci (2022) presents a similar investigation in the context of the Caribbean. While their modeling and focus are clearly different, these papers ultimately also show how climate change can affect macroeconomic outcomes via adverse impacts on public finances.

Finally, this paper relates to the empirical literature that quantifies the economic impacts of climatic risks. We build on the climate adaptive response estimation approach from Auffhammer (2022) and the Climate Impacts Lab (Carleton et al. 2022) to quantify climate change impacts on public health expenditures via changes in daily temperature realizations. This approach uses historical plausibly exogenous variation in temperatures within a location over time to identify impacts, but accounts for adaptation to future climatic change by allowing these effects to vary with the local climate. The literature has used this approach to quantify climate change impacts on outcomes such as energy consumption (Auffhammer 2022), mortality (Carleton et al. 2022), and manufacturing productivity (Nath 2025). To the best of our knowledge, this paper's estimates of public healthcare costs associated with changes in extreme temperature events add to this literature. While numerous studies investigate the impacts of temperatures on mortality in the United States (e.g., Heutel et al. 2021; Barreca et al. 2016; Deschenes and Greenstone 2011; etc.), less is known about their impacts on public healthcare costs. A growing empirical literature demonstrates significant temperature impacts on specific healthcare utilization services, including hospital and emergency department visits in California (Gould et al. 2025; White 2017), mental health-related outcomes (e.g., Mullins and White 2019), and hospital utilization in other countries (e.g., Liao et al. 2025; Rizmie et al. 2022; Karlsson and Ziebarth 2018). Finally, this paper contributes to an emerging empirical literature on the fiscal impacts of severe weather events in the United States. While estimates of aggregate or national-level impacts are incorporated into the fiscal damage function and described in Section 2.2, several recent studies also demonstrate municipal effects. Jerch et al. (2023) show that hurricane strikes decrease local tax revenues, increase borrowing costs, and decrease public works expenditures significantly for several years after exposure. Liao and Kousky (2022) show that wildfires in California increase the probability of a municipal budget deficit by 25 percentage points. Both Painter (2020) and Goldsmith-Pinkham et al. (2023) show that municipal bond markets are capitalizing sea level rise risk, raising long-term borrowing costs for vulnerable municipalities. Jeon et al. (2026) report similar results for future wildfire risks. By incorporating prior empirical estimates into a macroeconomic climate-economy model, we highlight their welfare and policy consequences in a general equilibrium framework.

The remainder of this paper proceeds as follows. Section 2 presents the quantification of climate change impacts on existing public program costs. Section 3 describes the model setup and the theoretical results. Section 4 presents the quantification of the model, including for the other fiscal impact channels of publicly provided adaptation to sea level rise and macroeconomic impacts that affect revenue collection. Section 5 showcases the numerical results, and Section 6 concludes.

2 Existing Program Costs

This section investigates climate change impacts on the costs of existing public programs. Given that public health programs such as Medicare and Medicaid account for more than a quarter of U.S. government expenditures,[6] and given the substantial body of evidence linking extreme temperatures to U.S. mortality, morbidity, and emergency department visits, we first empirically analyze the potential public healthcare cost impacts of changes in daily temperature distributions. We then synthesize prior literature estimates of other channels to construct "fiscal damage functions" relating global temperature change to U.S. government consumption and transfer payment obligations.

2.1 Public Healthcare Costs of Temperature Extremes

We obtain total public medical benefit transfers at the county-year level from the Bureau of Economic Analysis' (BEA) Regional Economic Accounts ("REA", following Deryugina 2017). This measure includes payments made through federal, state, and local governments through intermediaries to beneficiaries for care provided under programs including Medicare, Medicaid, Children's Health Insurance Program, military medical insurance benefits, and

[6] Calculated using National Health Expenditure data (CMS, 2022) for the base year 2016 by summing reported expenditures on Medicare, Medicaid, CHIP, Dep. of Defense, Dep. of Veterans Affairs, Indian Health Services, federal, state, and local maternity/child health and vocational rehabilitation programs, SAMHSA, plus other federal, state, and local program expenditures and public health activity, yielding \$1.509 trillion (\$2016). Dividing by total U.S. government expenditures net of interest payments for 2016 from the National Income and Product Accounts (\$5.523 trillion) yields 0.27.

local general assistance medical programs.[7] The REA data also provide information on populations and incomes. Next, we combine gridded daily weather data from PRISM with 2010 U.S. Census population data to compute the weighted average exposure to days in different temperature bins at the county-year level.[8] Following prior literature, the benchmark specification divides temperatures into cold, moderate, and high heat bins (e.g., Barreca et al. 2016), where moderate days are the omitted variable. We consider several definitions of "hot" days. The benchmark considers daily average temperatures above 32°C (90° F), and "freezing" days as having a daily average temperature below freezing (0°C). Importantly, these temperatures are calculated over 24-hour periods (including nighttime temperatures) so that a 32°C *average* day is a rare event, with the average county experiencing only 0.71 such days per year. Alternative specifications with finer bins confirm that the main effects of heat occur above $32°C$ and that further disaggregating effects of different higher degree days becomes statistically difficult due to the rarity of such events in the data (see Online Appendix ("OA") Section A1.1.3). Alternatively, we also consider daily maximum (minimum) temperatures above $35°C$ (below $0°C$), and days above (below) each county's 97.5th (2.5th) percentile of daily temperatures. Daily data are aggregated into annual measures by calculating the total number of hot and freezing days in each grid cell-year, which are aggregated to the county-year level using population weights derived from 2010 U.S. Census block data. In line with the literature, we also add second-order polynomial controls for precipitation (Carleton et al. 2022). As the healthcare cost impacts of hurricane strikes are quantified separately in Section 2.2, here we also control for the number of hurricane days in the county-year (based on the National Oceanic and Atmospheric Administration's (NOAA) Storm Events Database[9]). All benchmark specifications also include demographic and economic controls (described below), where data on population age and race profiles are from the National Center for Health Statistics. The estimating equation is:

$$\ln y_{j,t} = +\sum_{m}[\beta_m + \gamma_m \overline{T}_{m,j}] \times TD_{m,j,t} \qquad (1)$$
$$+ \delta_j + \delta_t + (\theta_s \cdot t) + \mathbf{X_{j,t}}'\beta + \epsilon_{j,t}$$

[7] Some U.S. government health expenditures are not covered in these data, such as healthcare services produced directly in Veterans Administration hospitals. For 2016 our BEA data capture $1.250 trillion in health expenditures compared to a $1.509 trillion total estimate from CMS data. The quantitative model applies our estimated impact function to all U.S. public healthcare expenditures.

[8] The analysis focuses on the continental U.S. and excludes counties for which BEA data provide only combined estimates, notably in Virginia.

[9] The Storm Events Database maps events into counties or "zones". I translate zone events into underlying counties based on the National Weather Service's zone-county correlation file, URL (accessed February 2021): [https://www.weather.gov/gis/ZoneCounty]

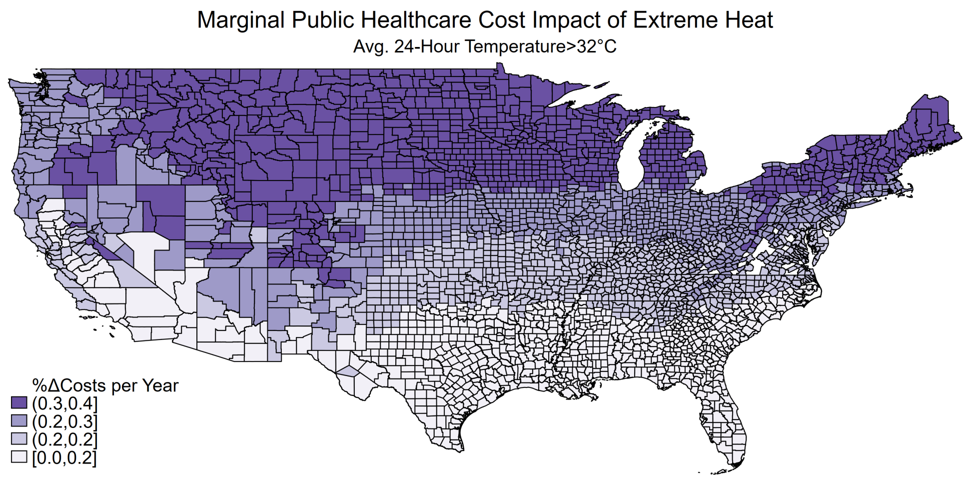
Here, $\ln y_{j,t}$ denotes the logarithm of public medical expenditures per capita in county j in year t. County fixed-effects δ_j absorb cross-sectional differences in public health spending across counties. Year fixed-effects δ_t capture national shocks to public medical spending in a given year. State-specific trends $(\theta_s \cdot t)$ further allow public health spending to follow different trends in different states. The $TD_{m,j,t}$ terms represent 'temperature days," that is, the population-weighted number of days that county j experienced temperatures in bin m in year t. We account for adaptation to climatic risks by allowing the effects of temperature realizations $TD_{m,j,t}$ to depend on a county's long-run climate $\overline{T}_{m,j}$, measured by a 30-year average temperature in the preferred specification. Alternatively, we also consider the average number of "hot" or "freezing" days in the county over the past 30 years. Finally, the vector $X_{j,t}$ represents other controls. In addition to the aforementioned precipitation and hurricane controls, $X_{j,t}$ includes the log of counties' populations, of the population 65 years and older, and of real per capita income, controls for prior year to current population and per capita income growth, and the fraction of non-hispanic whites in the county population. For robustness, we also consider interactions between precipitation and temperature, and interactions with demographic variables (discussed below). While the data are available through 2022,[10] our preferred specification excludes the Covid pandemic and focuses on the years 1996-2019. Including the Covid years yields slightly larger estimates (see OA Table A1). Standard errors $\epsilon_{j,t}$ are heteroskedasticity-robust and clustered at the county level, and observations are weighted by county populations. Robustness to alternative specifications is discussed below.

Results: Table 1 showcases the results. The key findings are that (i) even just a single extreme heat day can significantly increase public health spending in a given county-year, but that (ii) this effect is significantly smaller in areas with warmer climates. In contrast, for freezing days the results are small and imprecise in line with related studies as discussed further below. Column (1) shows the benchmark specification defining extreme heat (freezing) days based on daily average temperatures. Column (2) adds interaction terms between temperatures and precipitation. Column (3) showcases the specification using the average number of heat and freezing days as respective measures of local climate ($\overline{T}_{m,j}$). Column (4) uses daily maximum and minimum temperatures, and Column (5) percentile realizations to define heat and cold events, respectively. While Table 1 also shows highly significant increases in health expenditures due to hurricanes in line with Deryugina (2017), her estimates are preferred for damage function construction given her dedicated focus on cyclone impact estimation.[11]

[10] The REA data delineating medical transfers at the county level ("CAINC35") was discontinued after 2022 due to budget cuts.

[11] Quantitatively, the estimates of Table 1 align well with Deryugina's: a 0.4% increase per hurricane-day

Figure 1 illustrates the estimated marginal public health expenditure impacts of an additional hot day across the continental United States under current climatic conditions (based on the results of Column (1) in Table 1). The results suggest that the impacts of one additional hot day on annual public health expenditures range from zero to +0.3%, with the largest estimated impacts in northern regions which are less adapted to extreme heat.[12] OA Sections A1.2-A1.3 contextualize these results with additional Medicare analysis and literature review to gauge the plausibility of magnitudes and so-called "harvesting" effects.



Estimated marginal effects of extreme heat days (average 24-hour temperature above 32°C) on annual public healthcare costs (from Table 1 Col. 1) evaluated at current climate

While the results consistently suggest a significant positive impact of extreme heat days on annual public health expenditures, the results for freezing days are small, imprecise, and vary with the specification. This pattern is in line with findings from related prior studies

times the average number of hurricane-days per storm (3.33) implies a 1.3% increase in annual per capita health expenditures per storm, whereas Deryugina's short-run estimates (0-4 years) suggest effects of 0.019 log points for per capita medical net of Medicare and -0.006 log points for per capita Medicare expenditures. Importantly, however, Deryguina finds that medical expenditure impacts increase over the 10 years after a storm, leading to larger cumulative impact estimates. Deryugina (2017) also limits her sample to cyclone-vulnerable coastal counties (as inland counties are not an ideal control group for the evaluation of cyclone impacts), and carefully deals with wind fields and other nuances Table 1 does not consider, making her estimates preferred for hurricane impacts.

12 The results of Column (1) in Table 1 would mathematically imply negative marginal effects for annual average temperatures above 26.5°C. In our data, the maximum long-run temperature is Monroe County, FL, with 25.3°C. For this reason, all marginal expenditure impact estimates at the baseline climate in Figure 1 are positive. In future warming simulations, we set marginal effects to zero for counties whose long-run average temperatures exceed this inflection point.

Table 1: Public Health Expenditure Impacts of Temperature Extremes

Dep. Var.:	ln(Public Medical Expenditures/Pop.)				
	(1)	(2)	(3)	(4)	(5)
Extreme Heat Days$_{j,t}$	0.00394***	0.00476***	0.00134***	0.00013	0.00021**
	(0.00120)	(0.00184)	(0.00018)	(0.00011)	(0.00009)
Extreme Heat Days$_{j,t}$ $\times$ $\overline{T}_{m,j}$	-0.00015**	-0.00018**	-0.00002**	0.00000	
	(0.00007)	(0.00009)	(0.00001)	(0.00000)	
Pop-weighted Avg. MFX$_{\text{Extreme Heat}}$	0.0018	.0018	.0013	.0002	0.00021
Freezing Days$_{j,t}$	0.00029	0.00013	-0.00037***	0.00001	-0.00029***
	(0.00019)	(0.00020)	(0.00010)	(0.00014)	(0.00010)
Freezing Days$_{j,t}$ $\times$ $\overline{T}_{m,j}$	-0.00003**	-0.00004***	0.00001***	0.00000	
	(0.00001)	(0.00001)	(0.00000)	(0.00000)	
Pop-weighted Avg. MFX$_{\text{Freezing}}$	-.00005	-.00007	-.00011	.00013	-0.00029
Hurricane Days$_{j,t}$	0.00389***	0.00395***	0.00388***	0.00395***	0.00390***
	(0.00123)	(0.00122)	(0.00122)	(0.00123)	(0.00123)
Obs.	70,239	70,239	70,239	70,239	70,239
Adj. R-Sq.	0.972	0.972	0.972	0.972	0.972
#Counties (Clusters)	3,055	3,055	3,055	3,055	3,055
"Heat" Measure	Avg.>32C	Avg.>32C	Avg.>32C	Max.>35C	Avg.>97.5th Pct.
"Freezing" Measure	Avg.<0C	Avg.<0C	Avg.<0C	Min.<0C	Avg.<2.5th Pct.
$\overline{T}_{m,j}$ is average of:	Temp.	Temp.	#H/F Days	#H/F Days	-
Demo./Inc./Precip./Hurricane Cntrs.	Yes	Yes	Yes	Yes	Yes
Precip. $\times$ Hot, Cold	No	Yes	No	No	No
County F.E.s:	Yes	Yes	Yes	Yes	Yes
Year F.E.s:	Yes	Yes	Yes	Yes	Yes
State-Trends:	Yes	Yes	Yes	Yes	Yes

Table shows results of linear regression of log of county-year public medical expenditures per capita (1996-2019, from BEA) on the number of "heat" days (defined as avg. daily temp.>32C in Cols 1-3, max. daily temp.>35C in Col. 4, avg. daily temp.>97.5th county pctl. in Col 5), "freezing" days (defined as avg. daily temp.<0C in Cols 1-3 and min. daily temp.<0C in Col. 4, avg. daily temp.<2.5th pctl. in Col 5.) both in levels and interacted with climate measures $\overline{T}_{m,j}$ (avg. temp. in Cols. 1-2 and avg. number hot/cold days in Cols. 3-4) (based on data from PRISM) along with county fixed effects, linear state-level trends, year fixed effects and controls for log of county pop., log of the population 65 years and older, prior to current year population growth, percent non-hispanic whites (from the National Center for Health Statistics), log and growth of real per capita income (from BEA), precipitation (2nd order polynominal) plus interaction of precipitation and "heat"/"freezing" days in Col. 2 (based on data from PRISM), and the number of hurricane days in the county-year (NOAA Storm Events Database). Regressions are weighted by county populations. Standard errors are heteroskedasticity-robust and clustered at the county level. P-values are labeled: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

such as Karlsson and Ziebarth (2018), who find for hospital admissions in Germany that the estimated effects of freezing temperatures differ qualitatively depending on the specification and weather controls. In projecting future warming impacts, our preferred specification thus focuses on heat day impacts. However, we also show results using Table 1 Column 3 results which include precisely estimated cost savings from freezing days in OA Section A1.6.

Robustness: OA Section A1.1 showcases the robustness of the results to inclusion of Covid years, finer temperature bins, state-level clustering of standard errors, inclusion of quadratic or county-level time trends, exclusion of socio-economic control variables, and interactions of temperature with income and age indicators, and describes the motivation for excluding these additional factors from the benchmark estimation of future fiscal climate impacts. For example, although we find that higher incomes are associated with larger responsiveness of public health expenditures to temperature extremes, to the extent that this reflects income-driven expansions in the availability and generosity of public health programs, including this association in our projections would be inconsistent with the baseline model assumption of constant government services provision.

Climate Change Impact Projections Mapping these estimates to climate impacts requires daily future local temperature projections. We use two suites of climate model output: one from the latest Coupled Model Intercomparison Project (CMIP6) as bias-corrected and downscaled by Gergel et al. (2024). We combine these gridded temperature projections with 2020 Census data to compute population-weighted hot day counts analogous to the empirical analysis. The other suite is from Rasmussen et al. (2016), which relies on earlier simulations (CMIP5) but adds surrogate models to construct probabilistic estimates with coverage of tail probabilities which standard CMIP output fails to capture.

All projections show large potential increases in extreme heat days across the United States (see OA Figure A5). In order to account for adaptation when translating these extra heat days into future healthcare costs, we evaluate marginal impacts at future climates (based on the **30**-year prior population-weighted average temperature).[13] Both statistical and climate uncertainty are assessed through a Monte Carlo analysis using the **covariance matrix** underlying Table 1 (Col. 1) and the distribution of future temperature projections across climate models for each of three warming scenarios: SSP2-4.5, SSP3-7.0, and RCP 8.5 with surrogate models to capture tail risks. For each future scenario-year, we take 1,000 draws from the distributions of the impact coefficients and the number of extreme heat days and associated long-run temperatures in each county. Impacts are aggregated within each draw using base year county shares of national public health expenditures.[14] Figure 2 shows the resulting distribution over time for SSP3-7.0 as an example. Figure 3 plots the means

[13] We set marginal damages to zero when average temperatures rise sufficiently to imply negative costs. Without this assumption, damages would be only slightly smaller.

[14] Assuming a constant population distribution across space may bias our estimates upwards or downwards. Several studies find that projected future U.S. population patterns will significantly add toaggregate climate change vulnerability (Jones et al. 2015; Wing et al. 2022). On the other hand, optimized migration could reduce climate change damages substantially (Desmet et al. 2021).

of each scenario-ensemble-year's aggregate healthcare cost estimates against the associated mean global temperature change (from the MAGICC model, Meinshausen et al. 2011).

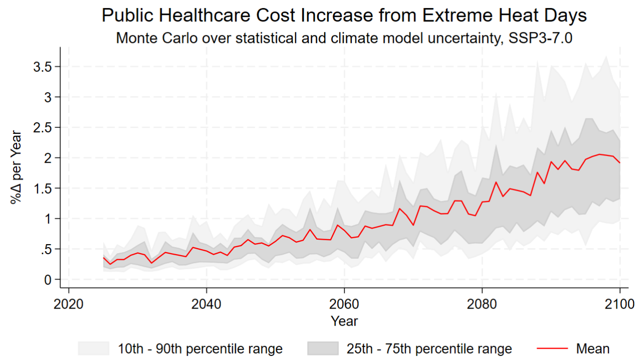


Figure 2: Monte Carlo results in SSP3-7.0

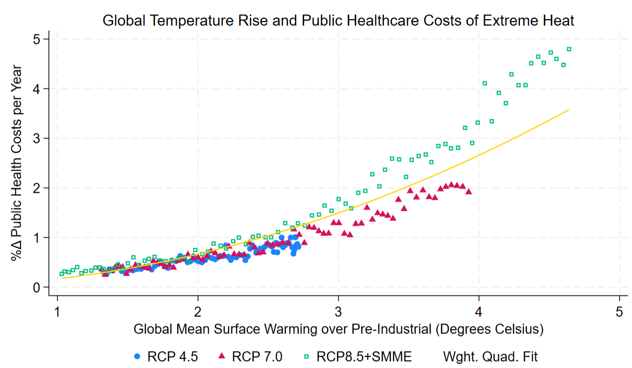


Figure 3: Heat healthcare damage function

Finally, we fit a quadratic heat-days healthcare cost damage function to the estimates displayed in Figure 3,[15] which yields $\%\Delta\text{PublicHealthCosts}_t = (0.166)T_t^2$. Estimation details and a discussion of the treatment of the intercept are in Appendix 7.1; alternatives to the quadratic specification are shown in OA Figure A6.

2.2 Overall Public Program Cost Impacts

Table 2 summarizes estimates of the broader potential public program cost impacts of climate change based on a synthesis and supplementary calculations of prior literature. For healthcare, we combine empirical estimates of hurricanes' public healthcare costs based on

[15] We weight CMIP5-based (RCP 8.5) estimates at half the rate of the more recent CMIP6-based ones.

Deryugina (2017) with future U.S. cyclone risks from Bakkensen and Barrage (2026) and find substantial potential future healthcare costs from rising storm activity. We add modeling-based estimates of healthcare costs from climate-induced changes in air quality (based on Garcia-Menendez et al. (2015) and OMB (2016)), though with the caveat that these does not account for changes in wildfire risks, likely leading to a substantial underestimate.[16] Beyond health, Table 2 considers estimates of the effects of warming on the costs of the Federal Crop Insurance Program (which pays for the majority of farmer' premium costs), of wildfire suppression on federal lands, of hurricane disaster relief provided by several agencies (the Federal Emergency Management Agency, the Department of Housing and Urban Development, repair activities by the Army Corps of Engineers, the Department of Transportation, and the Department of Defense), of the Endangered Species Act via costs at agencies such as the U.S. Fish and Wildlife Service (based on Moore et al. 2022), and, finally, of maintaining current levels of service in urban infrastructure drainage systems and roadways (based on EPA 2017). Appendix 7.2 provides further details on these studies and Table 2 calculations.[17]

The headline results are twofold. First, U.S. government expenditure requirements are projected to be increased by future warming. In a high warming scenario, estimated cost changes range from around +0.5% for transfer payments to +1.3% for government consumption and +3.8% for healthcare costs.[18] Second, increases in public healthcare costs account for the majority of the projected impacts. This finding is especially notable as prior literature typically gives limited consideration to healthcare costs when estimating the social costs of carbon, quantifying "health" impacts mainly through mortality effects monetized at the value of statistical life (e.g., Rennert et al. 2022; Hsiang et al. 2017; see OA Section A2.1).

Before proceeding, important caveats must be noted**.** First, a range of potentially relevant programs are excluded from Table 2. For some, a reliable impact quantification simply did not seem possible within the scope of this study. For example, Department of Defense outlays could be affected in ways ranging from damages to military bases to new international conflicts, but these are challenging to project. For others, fiscal exposure may not

[16] Growing evidence links wildfires to U.S. particulate pollution and associated adverse health impacts (Childs et al. 2022; Heft-Neal et al. 2022; Miller et al. 2017). Previous versions of this paper attempted to quantify wildfire healthcare expenditure impacts. These estimates were ultimately discarded due to their sensitivity to wildfire activity indicators and uncertainty in their mappings to climate. Our estimate for national costs based on Western U.S. impcats was around 25% of heat health impacts. However, new work on mortality suggests that wildfire smoke may contribute almost as much to the U.S. SCC as temperature mortality (Qiu et al. 2026).

[17] **Section A2.4 provides additional discussion of the treatments of uncertainty and adaptation in the grey literature estimates of Table 2.**

[18] The denominator for transfers is adjusted to exclude healthcare transfers. In NIPA most healthcare spending is counted as "transfers," but in our model transfers represent income given to households, not purchases of healthcare services.

Table 2: Summary of Public Program Cost Impact Estimates

	%Δ Annual costs by 2100			Calculations based
	Gov. Cost Base	RCP 4.5	RCP 8.5	on estimates in:
Healthcare - Heat	Healthcare	+1.03%	+3.07%	Section 2.1
Healthcare - Hurricanes	Healthcare	+0.34%	+0.66%	Deryugina (2017), Bakkensen Barrage (2026)
Healthcare - Air quality	Healthcare	+0.04%	+0.07%	Garcia-Menendez et al. (2015)
Crop-insurance subsidies	Consumption	+0.17%	+0.30%	Diffenbaugh et al. (2021), OMB (2016)
Forest Service fire suppr.	Consumption	+0.09%	+0.15%	OMB (2016), Forest Service (2016)
Dep. of Interior fire suppr.	Consumption	+0.09%	+0.15%	OMB (2016), Forest Service (2016)
Hurricane direct response	Consumption	+0.08%	+0.14%	CBO (2016)
Urban drainage	Consumption	+0.20%	+0.33%	EPA (2017)
Road maintenance	Consumption	+0.14%	+0.23%	EPA (2017)
Endangered Species Act	Consumption	+0.01%	+0.02%	Moore et al. (2022)
Hurricanes - Transfers	Transfers	+0.28%	+0.48%	Deryugina (2017), Bakkensen Barrage (2026)

Table shows projected percent change in U.S. government healthcare expenditures, non-health consumption expenditures, and non-health transfer payments, due to warming by 2100 in a moderate (RCP 4.5) and high (RCP 8.5) scenario. Associated warming levels are around 2.5°C and 4.3°C over pre-industrial by 2100 in the MAGICC model (Meinhausen et al. 2011). "Hurricane direct response" includes aid through several programs such as Federal Emergency Management Agency grants and the Army Corps of Engineers (CBO, 2016). Estimation details are provided in the Appendix.

(yet) be codified into the law, making future outlays speculative to project. An important example is property insurance markets, where state and federal programs are typically designed to recover costs of debt, reinsurance, etc. from insurers and ratepayers, but where government has occasionally stepped in and may increasingly need to do so in the future (see OA Section A2.3). While the omission of these costs and the conservative assumptions made throughout suggest that Table 2's estimates likely understate total impacts, some potential cost reductions are also omitted, such as if projected energy cost savings (Rode et al. 2021) also benefit government. While decreased participation in Social Security from increased elderly mortality has also been hypothesized as potential cost reduction (CBO 2021a), we note that more recent empirical studies project reductions in U.S. elderly mortality as a result of warming as decreases in cold deaths are projected to outweigh increases in heat deaths (e.g., Gould et al. 2025; Carleton et al. 2022; Heutel et al. 2021), suggesting that Social Security liabilities may actually increase from warming (see OA Section A2.2). Second, it is not possible to formally extend the quantification of uncertainty from Section 2.1 to the broader set of fiscal impacts considered in Table 2 as these cover distinct climatic risks (hurricanes, wildfires, extreme precipitation, etc.) that were quantified using different climate model ensembles and scenarios.[19] Finally, the above estimates inevitably make

[19] That is, impacts for most of the models underlying our health impact Monte Carlo estimation are simply

simplifying assumptions, such as that government service provision will be held constant at baseline levels (discussed again below). Related caveats apply to any climate change impact projections as future technological and societal changes may alter climate vulnerability in unforeseen ways. In spite of these caveats, we use Table 2 as a benchmark based on the best available evidence to gauge the plausible order of magnitude of climate change's fiscal costs via existing program costs. Given potential concerns one may have about inconsistency in methods between our empirical health estimates and the other cost quantifications, we show results for different subsets of Table 2 impacts as well, such as healthcare cost-only effects. The quantifications of the associated damage functions other fiscal impact channels in the model are described in Section 4 below.

3 Model

This section presents the model. We build on the COMET (Climate Optimization Model of the Economy and Taxation) model of Barrage (2020a), which, in turn, builds on the climate-economy models of Golosov et al. (2014) and Nordhaus (2017) by incorporating a classic dynamic optimal Ramsey taxation framework. Here, taxes are imposed for the purpose of raising revenues as lump-sum levies are assumed to be infeasible. We here extend the COMET in five ways. First, we introduce climate change impacts on the costs of providing government services and on requisite transfers to households. Second, we introduce endogenous public adaptation expenditures. Third, we introduce a sea level rise module. That is, while standard models commonly summarize climate change impacts as loss in aggregate output, we separate out capital losses from sea level rise so as to more accurately account for impacts on different tax bases. Fourth, while the COMET is a global model, here we present a model specific to the United States (US-COMET). Finally, we incorporate several updates such as to the carbon cycle in line with the latest DICE vintage (Barrage and Nordhaus 2024) which responds to concerns that certain recent climate science findings were not reflected in prior DICE vintages (Dietz et al. 2021b; Folini et al. 2024).

The analysis takes the *primal* approach. As is well-known, the (unique) optimal allocation in this setting can be decentralized by multiple policy combinations (Chari and Kehoe 1999). The model adopts a normalization that seems natural for the United States, specifically setting consumption as the untaxed good and allowing all other policies required for the planner to have a *complete* set of tax instruments.[20] While alternative normalizations could

not observed in the other fiscal impact estimates as they use fewer models (e.g., 5 in EPA 2017 vs. over 30 in Rasmussen et al. 2016) or different model vintages run over older scenarios (e.g., A1b for the synthetic cyclone tracks used by Bakkensen and Barrage 2025).

[20] Pigouvian carbon tax revenues are assumed to be insufficient to meet government revenue needs, and

imply different optimal tax levels, the net *wedges* implied by these policies and the resulting allocations would be the same.

Households A representative household has well-behaved preferences over consumption C_t, labor L_t, the climate T_t, and publicly provided adaptation to reduce climate change utility impacts $\Lambda_t^u \in [0,1]$. Lifetime utility U_0 is given by:

$$U_0 \equiv \sum_{t=0}^{\infty} \beta^t U(C_t, L_t; T_t, \Lambda_t^u) \tag{2}$$

Utility losses from climate change may reflect non-production impacts such as damages to national parks or the valuation of mortality effects (separate from labor effects). These impacts can be mitigated both by the availability of general government services G_t^c (e.g., public healthcare reducing mortality effects as in Mullins and White 2020) and dedicated adaptation expenditures γ_t^u (e.g., the National Park Service Climate Change Response Program):

$$\Lambda_t^u = f^u(G_t^c, \gamma_t^u) \tag{3}$$

We assume separability in preferences:

$$U(C_t, L_t, T_t) = v(C_t, L_t) + h[(1 - \Lambda_t^u)T_t] \tag{4}$$

Each period, the household allocates his income between consumption, the purchase of one-period government bonds B_{t+1} (at price ρ_t), and investment in the capital stock K_{t+1}. The household's income derives from net-of-tax (τ_{lt}) labor income $w_t(1-\tau_{lt})L_t$, net-of-tax (τ_{kt}) and depreciation ($\overline{\delta}+\delta(SLR_t)(1-\Lambda_t^{slr})$) capital income $\left\{1 + (r_t - \delta(SLR_t, \Lambda_t^{slr}))(1-\tau_{kt})\right\} K_t$, government bond repayments B_t, profits from the energy production sector Π_t, and government transfers $G_t^T(T_t)$, which are restricted to be non-negative and may be affected by climate change. Capital depreciation beyond the base rate $\overline{\delta}$ depends on sea level rise SLR_t and coastal protection level $\Lambda_t^{slr} \in [0,1]$. Households take the climate and Λ_t^{slr} as given. The final consumption good is normalized to be the untaxed good. The household's flow budget

the government is assumed to be able to commit to future taxes (see Barrage (2020a) for a discussion).

constraint each period is given by:[21]

$$C_t+\rho_t B_{t+1}+K_{t+1} \leq w_t(1-\tau_{lt})L_t+\left\{1+(r_t-\overline{\delta}-\delta(SLR_t)(1-\Lambda_t^{slr}))(1-\tau_{kt})\right\}K_t+B_t+\Pi_t+G_t^T(T_t) \tag{5}$$

As usual, the household's first order conditions imply that savings and labor supply are governed by the following decision rules:

$$\frac{U_{ct}}{U_{ct+1}}=\beta\left\{1+(r_{t+1}-\overline{\delta}-\delta(SLR_{t+1})(1-\Lambda_{t+1}^{slr}))(1-\tau_{kt+1})\right\} \tag{6}$$

$$\frac{-U_{lt}}{U_{ct}}=w_t(1-\tau_{lt}) \tag{7}$$

where U_{it} denotes the partial derivative of utility with respect to argument i at time t.

Production The final consumption-investment good is produced with a constant returns to scale technology using capital K_{1t}, labor L_{1t}, and energy E_t inputs which is assumed to satisfy the standard Inada conditions. Output further depends on an exogenous productivity term A_{1t}, climate change T_t, and publicly provided adaptation against production impacts $\Lambda_t^y \in [0,1]$:

$$Y_t=[1-D(T_t)(1-\Lambda_t^y)]F_1(A_{1t};,L_{1t},K_{1t},E_t) \tag{8}$$

As before adaptation Λ_t^y can result from both general government programs and dedicated new spending γ_t^y. Profit maximization and perfect competition imply that marginal products of factor inputs, denoted by Y_{it} for input i at time t, are equated to their prices in equilibrium. Letting p_{Et} denote the price of energy inputs, these conditions imply:

$$Y_{L1t}=w_t;\ Y_{Et}=p_{Et};\ Y_{K1t}=r_t$$

Energy inputs E_t are produced from capital K_{2t} and labor L_{2t} with constant returns to scale:

$$E_t=F_2(A_{2t},K_{2t},L_{2t}) \tag{9}$$

Energy is generally carbon-based, but producers can provide fraction μ_t of energy from clean or zero-emissions technologies at an additional cost $\Theta_t(\mu_t,E_t)$. Following Douenne et al. (2026), we assume that $\Theta_{\mu,t},\ \Theta_{\mu\mu,t},\ \Theta_{E,t}>0,\ \Theta_t(0,E_t)=0$ and specifically impose a

[21] As in Barrage (2020a), I assume that (i) capital holdings cannot be negative, (ii) consumer debt is bounded by some finite constant M via $B_{t+1}\geq -M$, (iii) purchases of government debt are bounded above and below by finite constants, and (iv) initial asset holdings B_0 are given.

specification that assumes convexity in the fraction of emissions avoided but abatement costs that otherwise scale with the size of the economy via $\Theta_t(\mu_t, E_t) = \Theta_t(\mu_t)E_t$. Energy sector profits are thus given by:

$$\Pi_t = (p_{Et} - \tau_{It})E_t - [(1-\mu_t)E_t]\tau_{Et} - w_t L_{2t} - r_t K_{2t} - \Theta_t(\mu_t)E_t \tag{10}$$

where p_{Et} represents the price of energy, τ_{It} is an excise intermediate goods tax,[22] and τ_{Et} is an excise tax on carbon *emissions* $E_t^M \equiv (1-\mu_t)E_t$. In line with prior literature (e.g., Douenne et al. 2026, Barrage 2020a), we implicitly assume that any positive energy sector profits could be taxed away at the optimal (100%) rate. Considering instead untaxable profits would lead to implications that are well-understood (e.g., Bento and Jacobsen 2007) but of limited interest in this setting.

Both capital and labor are assumed to be perfectly mobile across sectors, with associated market clearing conditions:

$$K_t = K_{1t} + K_{2t};\; L_t = L_{1t} + L_{2t} \tag{11}$$

Profit maximization thus implies that prices and marginal factors will be equated,

$$\begin{aligned} &[p_{Et} - \tau_{It} - \tau_{Et}(1-\mu_t) - \Theta_t(\mu_t)]F_{2Lt} = w_t; \\ &[p_{Et} - \tau_{It} - \tau_{Et}(1-\mu_t) - \Theta_t(\mu_t)]F_{2Kt} = r_t, \end{aligned} \tag{12}$$

and that energy producers abate μ_t until marginal cost equals the carbon price τ_{Et} :

$$\tau_{Et} = \Theta_t'(\mu_t). \tag{13}$$

Government The government has several responsibilities. First, it must fund existing government programs G_t^c, the costs of which, γ_t^c, depend on the climate,

$$\gamma_t^c = f^c(G_t^c, T_t), \tag{14}$$

and similarly so for transfer payment obligations $G_t^T(T_t)$.[23] This dependence is a central

[22] The intermediate goods tax τ_{It} is necessary to ensure the planner has a *complete* set of tax instruments as the consumption good is already normalized to be untaxed (Chari and Kehoe 1999). Intuitively, this is because increasing energy supply and carbon emissions are distinct decision margins since energy can come from both fossil and clean sources. Without an energy tax, a constraint would need to be added that the planner cannot distort these margins separately. If the planner can fully optimize, the intermediate goods tax is not used at the optimum. However, in additionally constrained fiscal scenarios it may be used (see Barrage 2020 for a discussion).

[23] We take the levels of G_t^T and G_t^c that must be provided as given, effectively treating existing public

innovation of our framework. Second, the government must decide on new public adaptation spending γ_t^u and γ_t^y, and on SLR adaptation investments γ_t^{slr} which add to a protective capital stock Γ_t depreciating at rate δ^Γ :[24]

$$\Lambda_t^{slr} = f^{slr}(\Gamma_t) \tag{15}$$

$$\Gamma_t = \Gamma_{t-1}(1-\delta^\Gamma) + \gamma_t^{slr} \tag{16}$$

In the quantitative model, adaptive capacity further depends on the stock of adaptive capital relative to the value of capital at risk in line with Fried (2022) (see Section 4). Finally, the government pay must eventually pay off inherited debt B_0^G.To raise revenues, the government can impose linear taxes on labor and capital income, levy excise taxes on energy inputs and on carbon emissions, and it can issue new, one-period bonds B_{t+1}^G. The public flow budget constraint is thus given by:

$$\gamma_t^c(G_t^c, T_t)+\gamma_t^u+\gamma_t^y+\gamma_t^{slr}+G_t^T(T_t)+B_t^G = \tau_{lt}w_tL_t+\tau_{It}E_t+\tau_{Et}E_t^M+\tau_{kt}(r_t-\delta(SLR_t, \Lambda_t^{slr}))K_t+\rho_tB_{t+1}^G \tag{17}$$

The market clearing condition for government bonds is given by $B_{t+1}^G = B_{t+1}$. This specification captures only the domestic market for U.S. government debt.[25] The *marginal cost of public funds* (MCF_t) - which measures the welfare cost of raising an additional dollar of government revenues - is defined in the standard way by the ratio of public to private marginal utility of consumption:

$$MCF_t \equiv \frac{\lambda_{1t}}{U_{ct}} \tag{18}$$

where λ_{1t} is the Lagrange multiplier on the resource constraint in the planner's problem (see Appendix). If the government could impose lump-sum taxes, then the MCF would be equal to one. In contrast, if revenues must be raised through distortionary instruments, the MCF may deviate from unity, though the extent to which it does so is a quantitative question.

programs as mandatory and new adaptation initiatives as discretionary. Endogenizing G_t^c would be straightforward but does not add insights to the theoretical results (see Online Appendix). Endogenizing G_t^T would also be possible but is of limited interest in our representative agent setting.

[24] Modeling production or utility damage adaptation as depending on additional capital stocks rather than flow expenditure does not change the core intuition behind the theory results (see Barrage 2015).

[25] On the one one hand, ignoring the current stock of foreign-held U.S. debt underestimates the government's future revenue-raising obligations. On the other hand, abstracting from the foreign supply of loanable funds may lead to an overestimate of the costs of U.S. borrowing costs.

Climate System Global temperature change depends on the history of global greenhouse gas emissions, that is, the sum of rest-of-world (ROW) emissions $E_t^{M,ROW}$ and domestic emissions $\{E_s^M\}_{s=0}^t \equiv \{(1-\mu_s)E_s\}_{s=0}^t$. Atmospheric temperature change T_t at time t then depends on the history of carbon emissions, initial conditions $\mathbf{S}_0$ (e.g., carbon stocks), and exogenous shifters $\{\eta_s\}_{s=0}^t$ (e.g., non-CO_2 forcings) via:

$$T_t = F_t\left(\mathbf{S}_0, E_0^M + E_0^{M,ROW}, E_1^M + E_1^{M,ROW}, ..., E_t^M + E_t^{M,ROW}, \eta_0, ...\eta_t\right) \tag{19}$$

Sea level rise is modeled as a function of the history of global temperature change, along with initial condition SLR_0, following Rahmstorf (2007):

$$SLR_t = f_t^{slr}(SLR_0, T_1, T_2, ...T_t) \tag{20}$$

3.1 Theoretical Analysis

This section theoretically investigates how fiscal climate impacts and general fiscal constraints affect optimal carbon pricing or the social cost of carbon,[26] and adaptation investment. Competitive equilibrium is defined in the conventional way. The social planner's problem is to maximize the representative agent's lifetime utility (2) subject to the constraints of (i) feasibility, (ii) the optimizing behavior of households and firms, and (iii) laws of nature (19)-(20).

We first preview the main results intuitively. First, we show that the SCC must account for the effects of climate change on government consumption requirements, regardless of whether revenues are raised with distortionary instruments. This real resource cost of climate change is missing in standard estimates of the SCC (e.g., EPA 2023). Second, while the prior "Double Dividend" literature typically finds that tax distortions *reduce* the optimal carbon price (such as by decreasing the valuation of non-market damages), we show that climate impacts on public transfer obligations can potentially overturn this result: When $MCF > 1$, a term is *added* to the optimal carbon price expression to account for transfer payment impacts which would not be welfare-relevant in a first-best setting. Third, we show that fiscal constraints tilt optimal public adaptation towards protecting production and capital over non-market goods: the former should be provided fully regardless of the cost of public funds, whereas provision of the latter is distorted when funds are scarce.

Before presenting these results, we introduce two definitions. As a comparison benchmark, we first define *the standard Pigouvian SCC* that is generally estimated and recom-

[26] We use "social cost of carbon" and "optimal carbon price" interchangeably but differentiate how they are calculated in different settings (see, e.g., Definition 1).

mended as optimal carbon price by the literature as follows:

The literature's standard Pigouvian SCC is defined as the present value of future production damages, non-market impacts, and sea level rise capital costs arising from a marginal increase in carbon emissions, valued and discounted based on the household's marginal utility of consumption:

$$SCC_t^{Lit} = \sum_{j=0}^{\infty} \frac{\beta^j U_{ct+j}}{U_{ct}} \cdot \underbrace{\left[\frac{-\partial Y_{t+j}}{\partial T_{t+j}}\right]}_{\text{Output Impacts}} \cdot \frac{\partial T_{t+j}}{\partial E_t^M} \tag{21}$$
$$+ \sum_{j=0}^{\infty} \left[\sum_{m=0}^{\infty} \frac{\beta^{j+m} U_{ct+j+m}}{U_{ct}} \cdot \underbrace{\frac{\partial \delta_{t+j+m} K_{t+j+m}}{\partial SLR_{t+j+m}} \frac{\partial SLR_{t+j+m}}{\partial T_{t+j}}}_{\text{SLR Impacts}} \right] \frac{\partial T_{t+j}}{\partial E_t^M}$$
$$+ \sum_{j=0}^{\infty} \underbrace{\left[\frac{-\beta^j U_{Tt+j}}{U_{ct}}\right]}_{\text{Non-Market Impacts}} \frac{\partial T_{t+j}}{\partial E_t^M}$$

Expression (21) is evaluated at different allocations across studies and settings. Our focus here is on *structural changes* to the SCC that arise as a result of fiscal costs and tax distortions. The effects of allocation dependence on SCC levels are considered in Section 5. Finally, for notational convenience, we also define the equilibrium discount factor $M_{t,j}$ as:

$$M_{t,j} \equiv \begin{cases} 1 & \text{if } j = 0 \\ \prod_{m=1}^{j} \frac{1}{(1+r_{t+m}-\delta_{t+m})} & \text{o.w.} \end{cases} \tag{22}$$

We note that $M_{t,j}$ discounts future damages at the pre-tax interest rate. If there are intertemporal distortions such as capital income taxes, this discount factor will differ from the consumer's marginal rate of substitution ($\beta^j \frac{U_{ct+j}}{U_{ct}}$). Formally, $M_{t,j} = \beta^j \frac{U_{c,t+j}}{U_{c,t}} \frac{MCF_{t+j}}{MCF_t}$. Such wedges can contribute to differences between the optimal carbon price in our setting and the traditionally defined Pigouvian carbon levy (as in Barrage (2020a) and discussed below).

Proposition 1 *The optimal carbon price in period $t > 0$, that is, the carbon price that can decentralize the optimal allocation along with other taxes set appropriately, is implicitly* *defined by:*

$$\tau^*_{Et} = \sum_{j=0}^{\infty} M_{t,j} \cdot \underbrace{\left[\frac{-\partial Y_{t+j}}{\partial T_{t+j}}\right]}_{\text{Output Impacts}} \cdot \frac{\partial T_{t+j}}{\partial E^M_t} \tag{23}$$

$$+ \sum_{j=0}^{\infty} \left[\sum_{m=0}^{\infty} M_{t,j+m} \cdot \underbrace{\frac{\partial \delta_{t+j+m} K_{t+j+m}}{\partial SLR_{t+j+m}} \frac{\partial SLR_{t+j+m}}{\partial T_{t+j}}}_{\text{SLR Impacts}} \right] \frac{\partial T_{t+j}}{\partial E^M_t} \tag{24}$$

$$+ \sum_{j=0}^{\infty} (\frac{1}{MCF_t}) \underbrace{\left[\frac{-\beta^j U_{Tt+j}}{U_{ct}}\right]}_{\text{Utility Impacts}} \frac{\partial T_{t+j}}{\partial E^M_t} \tag{25}$$

$$+ \sum_{j=0}^{\infty} M_{t,j} \cdot \underbrace{\left[\frac{\partial \gamma^c_{t+j}}{\partial T_{t+j}}\right]}_{\text{Gov't Cons. Cost Impacts}} \frac{\partial T_{t+j}}{\partial E^M_t} \tag{26}$$

$$+ \sum_{j=0}^{\infty} \beta^j (\frac{MCF_t - 1}{MCF_t}) \underbrace{\left[\frac{\partial G^T_{t+j}}{\partial T_{t+j}}\right]}_{\text{Gov't Transfer Impacts}} \underbrace{\left(\frac{U_{ct+j}}{[U_{cct} C_t + U_{ct} + U_{lct} L_t - U_{cct} G^T_t(T_t)]}\right)}_{\text{Offer Curve Impacts}} \frac{\partial T_{t+j}}{\partial E^M_t}$$

Proof: OA Section A3.1. Before discussing the results, we highlight the following corollary:

Corollary 1 *In a first-best setting where the government has access to lump-sum levies*, *the optimal carbon price* τ^{*FB}_{Et} *is defined by the standard Pigouvian SCC plus the present value of marginal government consumption cost impacts:*

$$\tau^{*FB}_{Et} = SCC^{Lit}_t + \sum_{j=0}^{\infty} \frac{\beta^j U_{ct+j}}{U_{ct}} \underbrace{\left[\frac{\partial \gamma^c_{t+j}}{\partial T_{t+j}}\right]}_{\text{Gov't Cons. Cost Impacts}} \frac{\partial T_{t+j}}{\partial E^M_t} \tag{27}$$

Proof: This expression follows straightforwardly from evaluating τ^*_{Et} in Proposition 1 at the first-best where $MCF_t = 1$ for all t. We highlight two results from Proposition 1.

Remark 1: The social cost of carbon must account for the impacts of climate change on government consumption requirements. This is true regardless of whether the tax system is distortionary (23) or not (27) as these impacts represent real resource costs. Standard estimates of the SCC generally omit these costs.

Remark 2: The presence of distortionary taxes affects the optimal carbon price in multiple ways. First, market damages (to production, capital, and government costs) are discounted at the marginal rate of transformation (22) which may differ from the household's discount factor if there are intertemporal wedges such as capital income taxes. Second, the valuation of non-market damages is discounted based on the MCF as in prior literature. Consumption of environmental quality utility is thus effectively "taxed" (distorted) like other consumption (via the consumption-labor wedge, see OA Section A3.1 and Barrage (2020a)). Third, however, if $MCF > 1$, we find a novel component that must be added to the SCC to account for the welfare costs of climate change impacts on household transfer payments. If climate change increases transfers and the implementability constraint is binding, this term will be positive, adding to the social cost of carbon, ceteris paribus. This term is missing from prior literature calling for lower carbon prices as a result of distortionary taxes.[27]

Proposition 1 establishes that the optimal carbon price depends both on fiscal climate impacts and the tax system. In turn, we also find that optimal income taxes in our setting depend *structurally* on fiscal climate impacts. For example, in the standard dynamic Ramsey taxation framework, with additional assumptions about preferences one can characterize optimal capital income taxes explicitly. In our setting, however, dynamic distortions depend on whether $G_t^T(T)/C_t$ is increasing or decreasing over time, which, in turn, depends on climate change's impacts on public transfers. Optimal labor taxes in our framework similarly depend on climate change's fiscal impacts and may increase or decrease over time also depending on $G_t^T(T)/C_t$ (ceteris paribus).

Before proceeding to quantification, we turn to the model's implications for public climate adaptation expenditures γ_t^u, γ_t^y, and γ_t^{slr}. First, we note that these do not enter the SCC explicitly for standard envelope condition reasons (e.g., Lemoine et al. 2026).[28] At the same time, public adaptation still affects the SCC both as it is evaluated at *residual* marginal damages net of public adaptation (e.g., $\frac{-\partial Y_{t+j}}{\partial T_{t+j}}$ in (23) is $D'(T_{t+j})(1-\Lambda_{t+j}^y)F_{1,t+j})$, and because it changes the equilibrium at which (23) evaluated. Second, we investigate how public adaptation should respond to fiscal constraints.

Proposition 2 *Scarcity of public funds ($MCF > 1$) tilts optimal adaptation rules towards the protection of production damages. Formally, for all $t > 0$, optimal public adaptation satisfies the following:*

1. Public adaptation against non-market damages is distorted in proportion to the marginal cost of public funds. The optimal allocation maintains a wedge between the marginal rates of substitution and transformation between consumption and adaptive capacity to reduce

[27] E.g., Barrage (2020a) or Bovenberg and Goulder (2002). We note again that these results differ in heterogeneous agent economies where taxes serve redistributive purposes (Douenne et al. 2026).

[28] In contrast, γ_t^c appears in the SCC because the costs of providing G_t^c depends on the climate. If the costs of physically producing, e.g., sea walls also depended on the climate, these cost shifts would also be included in the SCC.

climate change utility impacts:

$$\frac{U_{\Lambda_t^u}}{U_{ct}} \frac{1}{MCF_t} = \frac{1}{f^u_{\gamma^u_t}}$$

2. Public adaptation against production damages should be fully provided (undistorted) regardless of the welfare cost of raising revenues. The optimal allocation equates the marginal rates of transformation between consumption and adaptive capacity Λ_t^y from public adaptation spending γ_t^y and avoided climate damages in the final goods sector:

$$\frac{\partial Y_t}{\partial \Lambda_t^y} = \frac{1}{f^y_{\gamma^y_t}}$$

3. Public adaptation to protect against sea-level rise should be fully provided (undistorted) if optimal policy leaves private capital investment undistorted (zero effective capital income tax). Define the marginal protection benefit as $b_{t+1} \equiv \frac{-\partial \delta}{\partial \Lambda^{slr}_{t+1}} f^{slr}_{\gamma^{slr}_{t+1}} K_{t+1}$. The optimal allocation satisfies:

$$[b_{t+1} + (1 - \delta^{\Gamma})] = \frac{1}{M_{t,1}} = \frac{U_{c,t}}{\beta U_{c,t+1}} \frac{MCF_t}{MCF_{t+1}} \tag{28}$$

Proof: OA Section A3.3.

The intuition for these results derives from well-known properties of optimal tax systems. First, the need to consider the MCF in optimal utility-enhancing public goods provision follows from Atkinson and Stern's (1974) modified Samuelson rule (with minor modifications as relevant to our setting). Second, the optimality of full provision of production adaptation follows from the desirability of production efficiency (Diamond and Mirrlees 1971). Judd (1999) showed in a general dynamic setting that public production inputs should be fully provided even when financed with distortionary taxes; Proposition 2 showcases the relevance of this insight for climate adaptation. Finally, the intuition for (28) is simply that the planner seeks to equate the marginal rates of transformation between current and future output via investment in adaptation and private capital. Whether this rate of return is equal to the household's intertemporal MRS, however, depends on whether there are dynamic distortions at the optimum.

4 Model Quantification

Government Spending, Initial Taxes, and Debt Government services and their associated costs are specified as follows. First, it is again helpful to separate government services into health ($G_t^{c,h}$) and non-health ($G_t^{c,nh}$) components. We assume that existing government services will continue to be provided at their baseline *rates*. For example, Medicare will remain at its current generosity and coverage *rates*, though the *level* of expenditure associated with the program will change with population growth g_t^{Pop}, productivity growth g_t^{TFP}, and a healthcare cost adjustment g_t^H to reflect rising relative costs due to demographic and technological change.[29] Concretely, expenditures required to provide given government service levels *absent climate change* follow:

$$\begin{aligned}
\overline{\gamma_t^{c,nh}} &\equiv \gamma_t^{c,nh}(G_t^{c,nh}, T_t = 0) = \overline{\gamma_{t-1}^{c,nh}} \cdot (1 + g_t^{Pop} + g_t^{TFP}) \\
\overline{\gamma_t^{c,h}} &\equiv \gamma_t^{c,h}(G_t^{c,h}, T_t = 0) = \overline{\gamma_{t-1}^{c,h}} \cdot (1 + g_t^{Pop} + g_t^{TFP} + g_t^H) \\
\overline{G_t^T} &\equiv G_t^T(T_t = 0) = \overline{G_{t-1}^T} \cdot (1 + g_t^{Pop} + g_t^{TFP})
\end{aligned} \tag{29}$$

We empirically test this assumption by applying it from 1970 onwards and show that it performs very well in capturing long-run trends over the past 50 years (see OA Figure A8). Initial spending levels in the model base year are taken from the U.S. National Income and Product Accounts data (BEA) and the U.S. Center for Medicare & Medicaid Services (see Footnote 6).

Next we quantify fiscal climate impacts based on Table 2. For health, we combine the estimated heat damage function ($0.166T_t^2$) with a hurricane impacts term that is linear in warming over 1980-99 levels T_{90} (Holland and Bruyere 2014, Jewson 2021; see Sec. 7.1)[30] and a linear term for air quality (+0.04%/2.5°C) to yield:

$$\gamma_t^{c,h}(G_t^{c,h}, T_t) = \overline{\gamma_t^{c,h}} \cdot (1 + \underbrace{0.0002T_t}_{\text{Air Quality}} + \underbrace{0.0018(T_t - T_{90})}_{\text{Hurricanes}} + \underbrace{0.00166T_t^2}_{\text{Heat Days}}) \tag{30}$$

For non-health government consumption, we sum projected impacts in Table 2. A linear function fits the two resulting calibration moments (+0.78% at 2.5°C, +1.32% at 4.3°C) almost perfectly, yielding:

$$\gamma_t^{c,nh}(G_t^{c,nh}, T_t) = \overline{\gamma_t^{c,nh}} \cdot (1 + 0.0031T_t) \tag{31}$$

Finally, for transfers, we again adopt the hurricane specification (+0.28%/(2.5°C-0.61°C)):

$$G_t^T(T_t) = \overline{G_t^T} \cdot (1 + 0.0015(T_t - T_{90})) \tag{32}$$

29 CBO (2021b) projections imply an annualized average public health expenditure share growth rate of 1.623% through 2050. We assume the public healthcare expenditure share remains constant thereafter.

30 Linearizing the Table 2 estimate of a +0.34% increase in health expenditures from 2.5°C warming over pre-industrial temperatures (RCP 4.5) and adjusting for warming from pre-industrial to 1980-99 of 0.61°C yields 0.34/(2.5°C-0.61°C) = 0.18.

Next, public adaptation Λ_t^i, $i \in \{y, u, slr\}$, depends on both general government services and potential newly dedicated spending. Quantifying the protective effect of existing government services is straightforward as empirically measured climate damages exactly capture residual damages net of the existing level of public adaptation. That is, we can define observed climate damages $\widehat{D}(T_t) \equiv D(T_t)(1 - \Lambda_t^y(G_t^c, 0))$. Importantly with regards to the risk of double-counting, existing damage functions do not capture the costs of maintaining this level of adaptation as in(30)-(31 (see OA Section A2.1). For new potential public adaptation initiatives, costs and benefits are subject to substantial uncertainty. The empirical evidence base for adaptation costs and benefits is generally only still emerging (Carleton et al. 2024). While public adaptation cost functions for production and utility damages have been explored at the global level (Barrage 2020b), these quantifications remain highly stylized. One notable exception in our setting is sea-level rise, where a long-standing literature quantifies adaptation costs and benefits at a locally resolved scale across the United States (e.g., Neumann et al. 2010, 2014). We thus proceed as follows: For production and utility damages, we incorporate the adaptation benefits of existing public services - consistent also with the assumption that these services will be provided going forward - but do not attempt to optimize additional adaptation initiatives. For sea-level rise, we take advantage of the richer literature basis to quantify $\Lambda_t^{slr} = f^{slr}(\Gamma_t)$ as described below.

The model is calibrated to a 2025 base year. Initial debt B_0 is set to the 2025 federal debt held by the public (96.76% of GDP, FRED) net of foreign holdings (31%, CRS 2026). Bond issuance and the evolution of U.S. government debt thereafter are endogenized (and optimized) in the model. That is, the government optimizes to which extent to finance additional spending requirements with debt versus taxes. For initial taxes, OECD estimates the average effective labor tax wedge in the United States as 30% for 2025. The average effective consumption tax has been estimated at 6.1% (Carey and Tchilinguirian, 2000), implying an overall effective labor-consumption wedge of around 35%. For tax burdens on capital, a detailed review by the Congressional Budget Office (2014) estimates a 29% effective marginal rate on business capital income.[31]

Production Production of the final consumption-investment good is Cobb-Douglas with standard expenditure shares ($\alpha = 0.3$ and $v = 0.03$ as in, e.g., Golosov et al. 2014):

$$Y_t = [1 - \widehat{D}(T_t)] \cdot A_{1t} K_{1t}^{\alpha} L_{1t}^{1-\alpha-v} E_t^v$$

Base year total factor productivity is inferred by matching initial U.S. output given initial

[31] CBO (2014) estimate a lower rate (18%) if owner-occupied housing is included, but this figure does not account for local property taxes. The more self-contained estimate for business capital is thus preferred.

capital, labor, and energy inputs. Initial carbon energy use is 4.904 gigatons of CO_2 (EIA 2026), equivalent to 1.336 gigatons of carbon.[32] Normalizing available work time per annum to unity, L_0 is set at initial labor time share 0.2324 (OECD 2015) times the initial population of 342 million (U.S. Census 2026). This aggregate labor is distributed between the final good and energy sectors based on profit maximization and initial energy production.[33] The initial aggregate private capital stock K_0 is inferred assuming a real interest rate of 5% and a depreciation rate of 10%,[34] and this capital stock is distributed across sectors to be consistent with profit maximization and initial energy production.[35] Benchmark productivity growth follows the RICE Model (Nordhaus 2010) though we consider robustness to alternative values. Base year savings is set- to match 17% of GDP as per World Bank data for the United States in 2024.

Both fossil fuel-based and clean energy are produced with Cobb-Douglas technology:

$$E_t = A_{2t}(K_{2t}^{1-\alpha_E} L_{2t}^{\alpha_E}) \tag{33}$$

The labor share is set to $\alpha_E = 0.403$ (Barrage 2020a). The quantification of abatement cost function $\Theta_t(\mu_t)$ matches mitigation cost assumptions in the DICE-2023 model (see OA Section A4.3).

Climate damages net of public adaptation $\widehat{D}(T_t)$ are modeled in a standard form:

$$(1 - \widehat{D}(T_t)) = 1/(1 + \alpha_y T_t^2) \tag{34}$$

We consider three damage quantifications, compared here based on their predicted GDP-equivalent impacts in a high warming scenario (RCP 8.5 in 2100): (1) Moderate damages of 2.5% as in the U.S. damage function in RICE (Nordhaus 2010) or more recent estimates by Casey et al. (2023), (2) Elevated damages of 4% comparable to spatially differentiated estimates from Hsiang et al. (2017) or Bilal and Rossi-Hansberg (2025), and (3) High damages of 6%.[36] We disaggregate these estimates into production and utility damages assuming

[32] We measure emissions in gigatons of *carbon* (GtC) unless noted otherwise. One GtC corresponds to around 3.67 gigatons of carbon dioxide ($GtCO_2$).

[33] The labor share in final goods production is $(1 - \alpha - v)/(\alpha_E \cdot v + 1 - \alpha - v) = 98.23\%$.

[34] By its nature, the model adopts one depreciation rate for private capital, aggregating over regions with different present-day climatic risks. Fried (2022) finds that differences in current depreciation from storms are small, with annual average losses of 0.01% and 0.18% of the capital stock in low vs. high risk counties, respectively.

[35] The capital share in final goods production is $(\alpha)/((1 - \alpha_E)v + \alpha) = 94.37\%$.

[36] While some recent literature finds higher headline numbers (e.g., 10% loss in North America as in Nath et al. 2025), these commonly refer to *cumulative* effects of warming on GDP levels over decades. Importantly, our model endogenizes the growth effects of contemporaneous TFP reductions via changes in capital accumulation, labor supply, and fiscal policy. The calibration of the damage function should therefore only reflect contemporaneous TFP losses.

a 50%-50% split.[37] The parameter θ_1 in (34) is set to match the resulting production loss estimates (see Table A9).

Sea Level Rise Sea level rise resulting from the history of temperature changes is quantified based on Rahmstorf (2007) as described in Appendix 7.3. Both gross sea level rise damages and the costs and benefits of adaptation are quantified based on the EPA's Coastal Property Model runs for the Climate Change Impacts and Risk Analysis project (EPA 2017). The Coastal Property Model (Neumann et al. 2010, 2014) considers locally differentiated property values and vulnerabilities, sea level rise effects, and cyclone surge impacts of climate change. It estimates costs resulting both from increased storm surge damages and property abandonment. Importantly, the model also considers and optimizes adaptation responses, as described below.

In order to construct a gross-of-adaptation SLR damage function, we utilize model results from 'no adaptation' runs for both RCP scenarios 4.5 and 8.5[38] Total gross damages appear approximately linear in global mean sea level rise (see OA Section A4.2). We translate these level damages into depreciation rates by (i) deflating future values into base year property value equivalents,[39] and (ii) dividing by the base year capital stock. Regressing the resulting observations of depreciation rates on global sea level rise values yields a benchmark estimate of 0.0186% capital loss per decade per centimeter SLR (over 2000 levels). Letting $\overline{\delta}$ denote baseline capital depreciation, we consequently set capital depreciation in (5) to be:

$$\begin{aligned} \delta(SLR_t, \Lambda_t^{slr}) &= \overline{\delta} + \delta^{SLR} \cdot SLR_t \cdot (1 - \Lambda_t^{slr}) \\ &= \overline{\delta} + 0.000186 \cdot SLR_t \cdot (1 - \Lambda_t^{slr}) \end{aligned} \tag{35}$$

In order to quantify adaptation costs and effectiveness, we use the 'adaptation' model runs which optimize over beach nourishment, shoreline armoring (e.g., sea walls), and property elevation. The model estimates annual expenditures on these coastal protection measures and residual damages incurred. In line with prior literature, notably Fried (2022), adaptive capacity in the model depends on the protective capital stock *relative* to gross damages (i.e., capital at risk) via:

[37] While Barrage (2020a) finds around 70% production damages for a RICE-based specification, estimates in Hsiang et al. (2017) imply that non-market effects dominate after 2.5°C warming. We therefore assume a 50% split as in-between.

[38] We are grateful to Jeremy Martinich for sharing both model results and input assumptions.

[39] The projections assume that property values will increase in future years in line with GDP growth at an elasticity of 0.45 (Neumann et al. 2010). We use the relevant GDP projections used by EPA (2017).

$$\Lambda_t^{slr} = \left(\iota_1 \frac{\Gamma_t}{(\delta^{SLR} \cdot SLR_t \cdot K_t)}\right)^{\iota_2} \tag{36}$$

We quantify adaptation cost parameters ι_1, ι_2, and δ^Γ (in 16) by minimizing the sum of squared deviations between equations (16), (36), an intra-temporal optimality condition for adaptation expenditures,[40] and the observed values of Λ_t^{slr}, Γ_t, and gross damages obtained from the EPA's Coastal Property Model, all aggregated to the decadal level.[41] The deviation-minimizing parameters are $\iota_1 = 10.7965$, $\iota_2 = 0.0840$, and $\delta^\Gamma = 0.2780$, implying an *annual* protective capital depreciation rate of 3.2%. Though not targeted thereto, this value is very close to the adaptation capital depreciation rate in Fried (2022) of 3% per year.

Preferences The specification of preferences is as in the benchmark COMET but with quantitative adjustments for the U.S. setting. Utility is defined over per-capita consumption $c_t \equiv C_t/N_t$, where N_t is the period t population and labor supply is $l_t \equiv L_t/N_t$. The dynastic household maximizes the population-weighted lifetime utility:

$$\sum_{t=0}^{\infty} \beta^t N_t U(c_t, l_t, T_t)$$

$$U(c_t, l_t, T_t) = \frac{\left[c_t \cdot (1 - \varsigma l_t)^\gamma\right]^{1-\sigma}}{1-\sigma} + \frac{\left(1 + \alpha_u T_t^2\right)^{-(1-\sigma)}}{1-\sigma}$$

Benchmark preference parameters are set to jointly match base year labor supply $l_0 = 0.2324$ and a Frisch elasticity of labor supply of 0.78, which is the central micro estimates identified by Chetty et al. (2011), given initial tax rates[42] and assumed values of $\sigma = 1.5$ and a pure rate of social time preference of 1.5% per year, implying $\beta = (.985)^{10}$. Alternative discounting and labor supply parameterizations are considered as well. The climate disutility parameter α_u is chosen to match an aggregate consumption loss-equivalent of disutility from climate change at $2.5°C$ implied by each damages specification.

Carbon Cycle and Climate Model The COMET-US builds on the updated representation of the climate system and carbon cycle of the FAIR model (Millar et al. 2017) as

[40] The intra-temporal optimality condition for minimizing the sum of gross damages and adaptation costs is that $\frac{\partial \Lambda_t^{slr}}{\partial \lambda_t^{slr}} = \frac{1}{\text{GrossDamages}_t}$.

[41] I add one assumption-based moment, namely that spending only 50% of prescribed adaptation funds in the base 2010-2020 period would achieve 60% of the benchmark adaptation effectiveness. This moment was added as the Coastal Property Model results imply very high levels of optimal adaptation effectiveness, around 95% or higher, across all periods, thus limiting the range of 'observations' available to quantify the full curvature of the adaptation cost function.

[42] Initial tax rates are set to zero in the lump-sum taxation (theoretical first-best) scenarios.

implemented in DICE-2023 (Barrage and Nordhaus 2024). This framework addresses concerns raised about the previous DICE model carbon cycle based on recent climate science (e.g., Dietz et al. 2021b). Details are provided in OA Section A4.4.

Given the U.S. focus of the model, rest of the world emissions must be specified. As a baseline we consider business-as-usual emissions projections from the RICE Model, including both industrial and land use-based CO_2 emissions. Absent U.S. climate policy, these emissions lead to around $3.5°C$ warming over pre-industrial temperatures by 2100, substantially below the RCP 8.5 scenario but closely in line with the broader IAM literature (e.g., Gillingham et al. 2018; Barrage and Nordhaus 2024). In reality, U.S. climate policy may increase or decrease global emissions through mechanisms such as clean technology costs (e.g. Aghion et al. 2016), free-riding (e.g., Nordhaus 2015), leakage (e.g., Harstad 2012), and hold-up (e.g., Battaglini and Harstad 2016). For robustness, we consider the possibility that ROW emissions respond to U.S. mitigation with some elasticity. Non-CO_2 forcings are taken as exogenous.

5 Quantitative Results

Fiscal Costs of Climate Change: Magnitudes We first evaluate the magnitude of the projected fiscal costs of climate change in the benchmark scenario with fully optimized distortionary fiscal policy and moderate production damages. For impacts on existing program costs, we calculate the difference between public expenditures in each category (health, consumption, transfers) with vs. without climate impacts (subtracting (30)-(32) from their respective counterparts in (29)). For sea-level rise adaptation costs, we simply observe optimal investment in each period. Finally, here we also consider the costs of reduced tax revenues from climate impacts on productivity and the capital stock. We approximate these as the relevant tax rate times the loss in the tax base holding all else constant:

$$\Delta\text{Revenue}_t^L = \tau_{lt}^* \cdot [\widehat{D}(T_t) \cdot w_t] \cdot L_t$$
$$\Delta\text{Revenue}_t^K = \tau_{kt}^* \cdot [\widehat{D}(T_t) r_t + \delta^{SLR} SLR_t (1 - \Lambda_t^{slr})] \cdot K_t$$

The estimated impacts are large. Climate costs to U.S. taxpayers are estimated to rise from around \$50 billion (\$2025) per year at present to over \$800 billion per year by end-of-century.[43] Optimized domestic U.S. climate policy (ignoring global damages or emissions responses) would raise comparable magnitudes of funds in the same equilibrium, rising from

[43] The simulations assume optimized U.S. climate policy but business-as-usual ROW emissions resulting in around 3.5°C warming over pre-industrial temperatures by 2100 (similar to RCP 6.0).

around \$32 billion per year initially to around \$400 billion per year by end-of-century. Figure 4 shows fiscal climate costs in levels; OA Figure A10 shows a proportional decomposition. Public healthcare costs account for the plurality of impacts, which is especially noteworthy as it has received little attention to date as a climate impact channel.

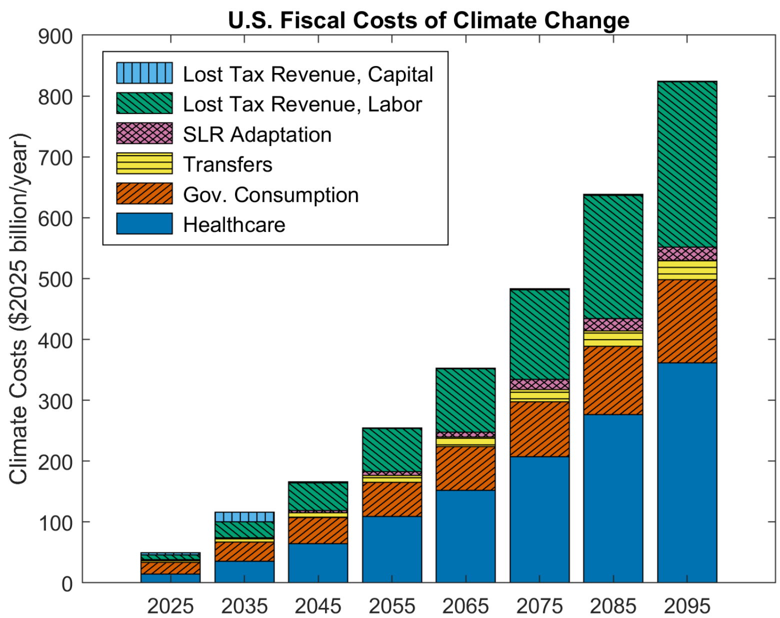


Figure 4: Fiscal costs of climate change via public program costs, sea level rise adaptation, and foregone tax revenues in the benchmark scenario

Public Expenditure Impacts and the Social Cost of Carbon Next we consider how the main empirical novelty of this paper - the estimated impacts of climate change on public program costs - affect the social cost of carbon, or, equivalently, how quantitatively important the result of Proposition 1 - demonstrating their theoretical relevance to the SCC - is in the U.S. context. To this end, Figure 5 presents estimates of the optimal carbon price in 2035[44,45] across a variety of parameter choices both without (as in prior literature) and

[44] The optimal carbon price in the initial period (2025-35) differs structurally from that in other periods due to carbon pricing and climate damage impacts on initial wealth values and earnings (in the implementability constraint). Since Proposition 1 focuses on the optimal carbon price for t>0 we present the numerical equivalent here.

[45] Our planner considers only domestic impacts. Consequently, the "optimal" carbon price too low from a global perspective. This choice is motivated by the facts that (i) the goal of this paper is to quantify the relative importance of fiscal costs, and (ii) this paper only quantifies said fiscal costs for the United States. In order to produce an appropriate counterfactual for the global SCC with and without fiscal

with fiscal damage functions (30)-(31) included. We also consider one scenario that omits the broader literature estimates of government consumption impacts in Table 2, and one that omits our estimated heat healthcare cost effects.

The first central finding is that fiscal costs increase the social cost of carbon by +20-40%. Somewhat remarkably, while the *level* of the SCC varies significantly across scenarios, the *relative impact of fiscal costs* is similar across all cases considered. For example, if other countries partly match U.S. mitigation rates, the optimal U.S. carbon price is substantially higher, but the relative effect of fiscal costs is similar to the benchmark (35-40%).[46] The second main finding is that the welfare costs of climate impacts on public program costs are large, estimated at around $6-7 trillion in initial period equivalent variation (0.6% in permanent consumption-equivalent). The third main finding is that these results are broadly robust: Climate change impacts on public program costs have a substantial impact on both welfare and the SCC regardless of (i) the level of climate production and utility damages assumed (though the relative contribution of fiscal costs is smaller compared to higher baseline damages), (ii) whether raising public funds is costly (though the welfare costs are smaller when MCF=1), (iii) productivity growth is higher or lower than assumed, (iv) we exclude either literature-based estimates of government consumption impacts or our empirical heat health damage estimates (though the latter are quantitatively important).

costs, one would need to empirically estimate fiscal impacts for the rest of the world, which is beyond the scope of the present study, but clearly an important area for future work.

[46] The displayed simulations assume ROW emissions decline 0.3 p.p. for every 1 p.p. increase in the U.S. mitigation rate. We also explored a symmetric negative spillover case where ROW emission increase 0.3 p.p. for every 1 p.p. U.S. mititgation. This scenario yielded a zero optimal carbon price as it implies full backfiring of U.S. policy (since U.S. emissions are less than 30% of the global total).

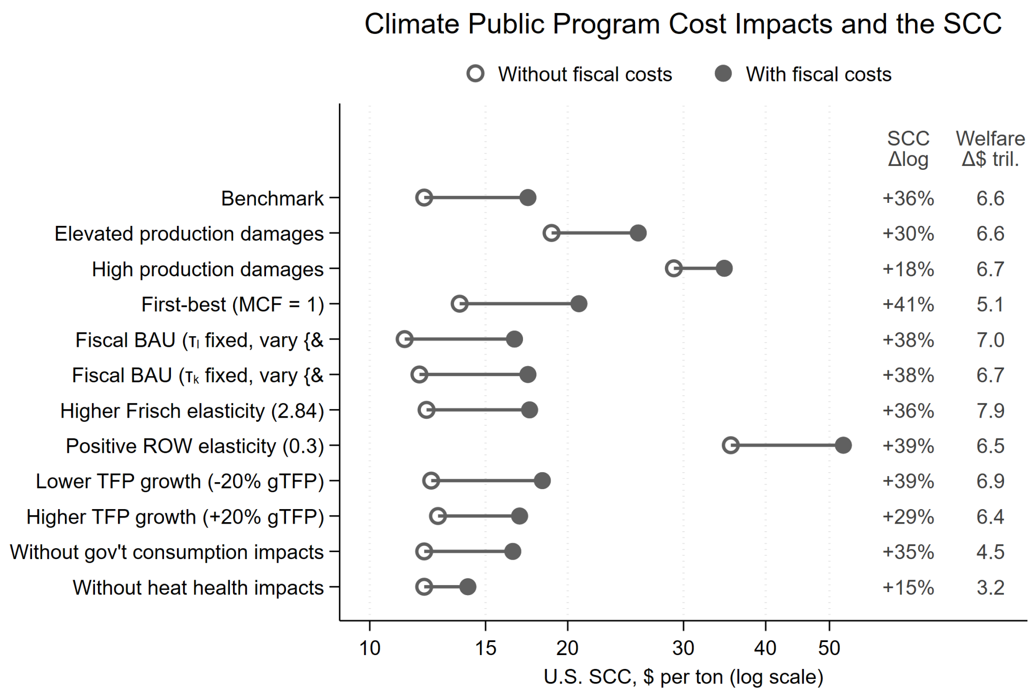


Figure 5: Effect of climate change impacts on public healthcare costs, government consumption requirements, and transfer payments on the optimal carbon price (SCC) in 2035 and on welfare (in initial period consumption equivalent variation $2025 trillions).

Climate Policy, Fiscal Impacts, and Welfare Finally, we consider the broader policy implications of different fiscal scenarios. To this end, the model runs cross three income tax and two climate policy scenarios, namely:

1. "First-Best": The government can levy lump-sum taxes. This assumption is arguably counterfactual but standard in the literature.

2. "Optimized Distortionary": The government can optimize its revenue-raising taxes, but cannot impose lump-sum levies.

3. "Fiscal BAU": Labor taxes are fixed at $\overline{\tau_l} = 41.5\%$ but the government can vary other taxes.

The model has difficulty solving if income taxes remain at their observed initial levels. In particular, the government's intertemporal budget constraint does not hold if current tax rates are simply carried forward, in line with other projections highlighting the fiscal challenges posed by current U.S. policy (e.g., Treasury 2024). Scenario 3 thus considers modified business-as-usual income taxes. For U.S. carbon and energy taxes, the model either optimizes both ("Opt"), or assumes no carbon or energy taxes until 2115 ("No"). All scenarios solve the social planner's problem in primal form and then characterize taxes that can implement the scenario's (constrained) optimal allocation. Restricted scenarios add constraints to the planner's problem in terms of allocations: For example, the "no energy tax" scenario requires that the marginal product of energy be equal to its marginal production cost, and the "no carbon tax" constraint requires the marginal abatement cost to be zero. The government dynamically optimizes both taxes and new bond issuance.

Table 3 summarizes the results. The central finding is that the estimated welfare gains from optimized carbon and energy pricing are substantially higher (20-100% for levels) when fiscal general equilibrium effects are taken into account. Intuitively, this is because both the revenues raised and the public expenditure savings of avoided climate change are significantly higher in a world with scarce public funds.[47] More broadly, allowing carbon and energy levies also helps substitute for missing tax instruments in our constrained fiscal scenarios. Interestingly, the welfare gains of carbon pricing are higher even though the optimal stringency of climate policy is lower in the presence of distortionary taxes. This latter result matches many prior studies (e.g., Bovenberg and Goulder 1996; Barrage 2020a). The reason for this somewhat counterintuitive result is that fiscal interactions alter both the costs and benefits of carbon pricing policies.

Finally, the simulations assume that the U.S. planner can put a price on carbon emissions. Politically, it may be easier to subsidize clean energy instead, as in the Inflation Reduction Act (Bistline et al. 2023). Restricting the planner to the use of subsidies[48] yields slightly lower optimal mitigation rates, higher capital income taxes, a higher MCF (1.07), and a reduction in the welfare gains from climate policy by over 50%, though they remain positive and substantial ($81 billion).

6 Conclusion

Climate change is increasingly being recognized as a potential threat to fiscal sustainability. This paper presents what is to the best of our knowledge a first systematic quantification

[47] Policy-induced U.S. emissions reductions range from 7-11% in 2055 and 13-18% in 2105 depending on the damages scenario, with associated global temperature reduction benefits of 0.04-0.11°C by 2105.

[48] In primal terms we formally add the allocation-based constraint that $F_{1Et} + \mu_t \Theta_t'(\mu_t) - \Theta(\mu_t) = F_{1Lt}/F_{2Lt}$, restricting the energy wedge such that, in a decentralization with clean energy subsidies the latter will be weakly positive.

Table 3: Fiscal Policy, Climate Policy, and Welfare

Scenario: Income	Scenario: Carbon & Energy	Labor Tax (Avg. 2025-2125)	Capital Tax (Avg. 2025-2125)	MCF (Avg. 2025-2125)	Carbon Tax ($/mtC) (2035-45)	ΔWelfare: EV ΔC_{2025} ($2025 bil.)	ΔWelfare: CEV (%)
First-Best	No	0.0	0.00	1.0	0		
First-Best	Opt.	0.0	0.00	1.0	20.8	153	0.01
Opt.	No	44.0	$5.2^{\dagger}$	1.04	0		
Opt.	Opt.	44.0	$5.3^{\dagger}$	1.03	17.4	179	0.01
BAU $\overline{\tau}_l$, vary τ_k	No	41.5	20.8	1.18	0		
BAU $\overline{\tau}_l$, vary τ_k	Opt.	41.5	20.2	1.19	16.5	311	0.06

Each row shows (constrained) optimal fiscal and climate policy outcomes across a given model scenario. For each income tax scenario, outcomes without and with carbon and energy taxation are shown in the first and second rows, respectively. The last columns show welfare effects of allowing carbon and energy taxes in initial equivalent variation ($2025) and permanent consumption-equivalent (%). Simulations assume benchmark "moderate" climate damages and no global emissions benefit from U.S. mitigation.

†Consists of high initial capital income tax falling to around zero thereafter.

and integration of fiscal costs of climate change into a macroeconomic integrated assessment model with a focus on the United States. The central finding is that fiscal impacts are of first-order policy importance: We estimate that climate change impacts on public expenditures impose $6-7 trillion in welfare costs ($2025) and increase the U.S. social cost of carbon by 20-40%. One of the most empirically important but previously understudied impact channel is through public healthcare costs, which are projected to grow as a result of both increases in extreme heat days and other climatic risks such as hurricanes.

The analysis makes important simplifying assumptions. For example, local, state, and federal finances are all aggregated into a central fiscal authority. In reality, the distribution of climate change's fiscal impacts across levels of government may be important. Certain costs - such as road elevation to protect against flooding - may fall disproportionately on local governments which also face a higher cost of raising public funds. Indeed, recent empirical work has found significantly higher long-term municipal bond spreads in U.S. counties more vulnerable to future climate risks (e.g., Painter 2020; Goldsmith-Pinkham et al. 2023). At the same time, the U.S. federal government has historically enjoyed disproportionately low borrowing costs (Krishnamurthy and Vissing-Jorgensen 2012), a feature absent from our model which could decrease the costs of debt-financed fiscal climate impacts. Rigorously accounting for how such differential interest rates would interact with climate risks and their joint implications for debt sustainability would likely require a stochastic framework with economic and default risk building on Mehrotra and Sergeyev (2021) to incorporate not only climate costs but also (fiscal) risks - an important area for future research.

The United States faces large increases in public expenditure obligations relative to tax receipts in the coming decades (Treasury 2024). This paper's results suggest that climate change may add to this fiscal imbalance. Importantly, the analysis also finds that appropriately designed domestic climate policy and international emissions reductions may allow for lower tax burdens and yield substantial net economic benefits for the U.S. economy.

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7 Appendix

7.1 Damage Function

In order to derive a damage function for public healthcare costs from extreme heat, we associate cost estimates with global mean surface temperature change projections as shown in Figure 3. One noteworthy nuance is that these estimates pertain to the *total* annual public healthcare costs due to extreme heat days, whereas a damage function should describe *additional* costs from warming. Econometrically, one can attempt to extrapolate by regressing total healthcare cost impacts across Monte Carlo draws in scenario i and year t, $\%\Delta\text{HealthCosts}_{it}$ on the square of global temperature change T_{it} in the relevant scenario-year and attempt to infer damages absent warming based on the regression intercept β_0 :

$$\%\Delta\text{HealthCosts}_{it} = \beta_0 + \beta_1 T_{it}^2 + \varepsilon_{it}$$

The results of this regression, shown in Column (1) of Table A1 below, reveal a small, *negative,* and imprecise intercept estimate. Consequently, a regression-based extrapolation does not suggest positive public healthcare costs from extreme heat in a counterfactual world where temperatures are at pre-industrial levels. Given that the damage estimates do not actually include extreme heat day information for $T_t = 0$, however, our preferred specification assumes that costs at pre-industrial temperatures would be zero by imposing $\beta_0 = 0$. The results for this specification are shown in Column (2) of Table A1. Results from additional specifications such as with cubic and quartic terms are visualized in OA Figure A6.

Table A1: Damage Function Estimation

	%Δ Annual Public Healthcare Costs due to Extreme Heat	
	(1)	(2)
T_t^2	0.189***	0.166***
	(.0036)	(0.0021)
Constant	-0.213	
	(0.0276)	
Obs.	389	389
R-Sq.	0.8787	0.9414

Table shows results of weighted regression of means of estimated public healthcare cost impact of extreme heat across Monte Carlo draws within each climate scenario (SSP2-4.5, SSP3-7.0, RCP 8.5) on the square of the corresponding mean global surface temperature change mean in the MAGICC model, Meinshausen et al. 2011) in Col. (2) along with a constant in Col. (1). Weights = 1 for RCP 8.5 and = 2 for the other scenarios. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

One caveat to this approach is that it infers damages for warming below base period levels (up to around $1°C$ over pre-industrial temperatures) by extrapolating from the estimated quadratic damage function without data on changes in the number of extreme heat days or damages from lower levels of warming as observed earlier in the 20th Century. An alternative to extrapolation would be to set warming damages up until $1°C$ to zero. On the one hand, given climate science estimates that anthropogenic greenhouse gas forcings have significantly increased extreme heat days in the U.S. in the 20th Century (e.g. Seong et al. 2021, Mascioli et al. 2016), the benchmark allows damages from this earlier warming. On the other hand, however, it is useful to note that the implications of a downward-shifted damage function with zero impacts until $1°C$ can be bounded by the "no heat healthcare impacts" scenario in Figure 5, which continue to show economically significant increases in the U.S. social cost of carbon from fiscal climate impacts.

7.2 Literature Synthesis Details

The estimates presented in Table 2 focus on impacts by 2100 in emissions scenarios RCP 4.5 and RCP 8.5, for which we use global mean surface temperature change predictions from the MAGICC model (Meinshausen et al. 2011) corresponding to around $2.5°C$ and $4.3°C$ over pre-industrial levels, respectively. This section fills in further details on Table 2. Further discussion of the cited grey literature with regards to its treatment of uncertainty and adaptation is presented in OA Section A2.4.

Healthcare - Extreme heat: We evaluate the damage function from Section at $2.5°C$ and $4.3°C$, respectively, to infer projected changes in public health expenditures (+1.03% and +3.07%, resp).

Healthcare & Income Support - Hurricanes: For the estimation using the Deryugina (2017) data we use her replication files to first create outcome variables that are either (i) the log of the sum of Medicare and non-Medicare public medical expenditures per capita, or

(ii) the log of the sum of unemployment benefits, income maintenance transfers (e.g., Supplemental Nutrition Assistance Program), and retirement and disability insurance benefits, and re-run the "Wind Speed Regressions" "Event study" specification for these outcomes, which yields impact estimates for the 10 years following the storm. Table A2 shows the results. In order to map Deryugina's 10-year estimates into the annual impact formulation of our model and damage function, we then calculate the present value of estimated impacts over the 10 years for each storm category assuming an annual discount rate of 3%. That is, the present value of the 10-year impacts is then assumed to occur in the hurricane year. To quantify baseline hurricane risk, we first calculate the average number of Category 1, 2, and 3+ hurricanes experienced by each county in the Deryugina data (1969-2014). To quantify future risks, we use Monte Carlo simulation results of future annual U.S. landfall-making storm realizations (number and wind speeds) from Bakkensen and Barrage (2026) which, in turn, are based on synthetic tropical tracks under a future climate (2080-2100 under the IPCC's A1B emissions scenario processed through different climate models of which we focus on NOAA's Geophysical Fluid Dynamics Laboratory model) from Emanuel et al. (2008). Compared to historical data in the satellite era (1971-2020, NOAA 2023), the average number of annual hurricane landfalls is projected to increase from 0.74 to 1.9 for Category 1, from 0.34 to 1.02 for Category 2, and from 0.5 to 1.66 for Category 3+ storms. Given that (i) the A1B scenario is associated with $2.8°C$ warming over 1980-1999 temperatures (IPCC AR4 multi-model mean), (ii) cyclone intensity can be assumed to increase linearily with global temperatures (Holland and Bruyere 2014) but only above the base period (GFDL 2018), we then calculate the percent increase in each type of hurricane activity per $1°C$ warming above the 1980-1999 level. We divide these aggregate risk increases across space by assuming that future cyclone tracks will remain geographically distributed as historical ones. After raising each county's baseline cyclone risk for each storm category proportionately, we then calculate the associated local percent increase in annual public health expenditures, and then aggregate to the national level by calculating the base year total public health transfer share-weighted total amount, which is \$2.7 billion dollars per year. For income support payments, the corresponding figure is \$1.7 billion dollars per year (in the 2016 economy). We then divide by total public health expenditures (see footnote 6) and government transfers (from NIPA) in 2016 to compute the corresponding percent program expenditure increases per $1°C$ warming, and finally multiply by projected warming *over 1980-1999 temperatures* in the RCP 4.5 and 8.5 scenarios to derive the numbers in Table 2, where we assume $0.61°C$ warming from pre-industrial until the end of the 20th century in line with IPCC estimates.

Table A2: Hurricane Strike Impacts

Hurricane Saffir-Simpson Category:	Public Medical	Transfers
Cat. 1	3.7%	1.2%
Cat. 2	3.6%	1.8%
Cat. 3+	4.8%	6.76%

Table displays avg. annual county-level per capita percent change in public medical and transfer expenditures across the estimated hurricane impact coefficients for years 0-10 after hurricane strike based on the data and code of Deryugina (2017). Data include federal, state, and local payments.

Air Quality-Related Healthcare: Garcia-Menendez et al. (2015) use coupled earth systems and a global atmospheric chemistry model to study climate change impacts on concentrations of fine particulate matter (PM2.5) and ground-level ozone across the United States. OMB (2016) uses results from the authors on several morbidity outcomes (e.g., respiratory hospital admissions) to quantify associated changes in federal health care costs. Their central estimates suggest an extra $1.2 billion per year in today's terms in a 'no policy' baseline (leading to $6°C$ global mean surface temperature change by end of century) compared to a scenario limiting warming to $1.5°C$. We interpolate linearily to derive the figures in Table 2.

Crop-Insurance Subsidies: In a joint analysis with USDA, OMB (2016) projects program costs to increase 40% by 2080 under RCP 8.5, and 23% by 2080 under RCP 4.5. We translate dollar terms into percentages using base period crop insurance program expenditures of slightly over $6 billion per year on average. Given the relevant median projections for future global temperature change, these estimates imply an approximately linear increase of around +14% increase in costs per degree warming, as shown in Table A3 below.

Table A3: Crop Insurance Cost Increase by 2080

	RCP 8.5	RCP 4.5	Source
Increase	+40%	+23%	OMB (2016)
Global Temp. Change (by 2075)	$2.85°C$	$1.6°C$	IPCC (2014)
Per $1°C$ impact:	+14.04%	+14.38%	

Diffenbaugh et al. (2021) estimate that damages from observed warming from 1991-2017 accounted for 19% of U.S. crop insurance payments over this time period. The observed global temperature anomaly over this time period increased from $0.58°C$ to $1.19°C$ relative to 1881-1910 levels. These estimates thus imply an approximately 25% increase in crop insurance costs due to 0.61° additional warming, implying a linear effect of +41% per $1°C$.

The calculations in Table 2 take the average of the Diffenbaugh et al. (2021) and OMB (2016) estimates, yielding +28% per 1°C.

Federal Wildfire Suppression Costs: The USDA (2015) projections reported in OMB (2016) imply annual cost increases of +45% for the Department of Interior (DOI) and 117% for Forest Service (FS) by mid-century (2041-2059), and further cost increases of +72% for DOI and +192% for FS by late-century (2081-2099) under the RCP8.5 scenario. Table A4 summarizes these results and the implied cost increases per degree of warming, which again appear close to linear. Base year wildfire suppression expenditures for each agency are from the National Interagency Fire Center.[49]

Table A4: Wildfire Suppression Cost Increases

	RCP 8.5		Source
	2041-59	2081-99	
Global Temp. Change	2.0°C	3.7°C	IPCC (2014)
Forest Service	+117%	+192%	OMB (2016), USDA FS (2016)
Per 1°C impact:	+58.5	+51.9	
DOI	+45%	+72%	OMB (2016), USDA FS (2016)
Per 1°C impact:	+22.5%	+19.5%	

Hurricane-related disaster spending: The CBO's (2016) central estimates imply an increase in expected annual direct hurricane damages from 0.16% of GDP at present to 0.22% by 2075 under RCP 8.5. Approximately 45% of this increase is due to climate change, based on changes in sea levels and hurricane patterns. The remainder is due to projected increases in coastal development. CBO further estimates that, in recent years, federal hurricane aid has average around 62% of direct damages, or 0.10% of GDP. Assuming that the federal aid-damage ratio will remain at 62 percent in the future, CBO thus projects a benchmark increase in federal spending from 0.10% to 0.13% of GDP by 2075. We consider the climate-related 45% of this change as impact at the associated global temperature change. Importantly, for hurricanes, we again focus on temperature change over a more recent baseline as changes in hurricane patterns were not yet apparent in the 20th Century (GFDL 2018). The mean predicted global temperature changes for RCP 8.5 are 2.0°C for 2046-2065, and 3.7°C for 2081-2100, above a 1986-2005 baseline (IPCC AR5). Interpolating linearly yields 2.85°C by 2075. Linearizing also for hurricane changes (Holland and Bruyere 2014) suggests +0.005% of GDP per 1°C over 1986-2005 temperatures. Multiplying by the relevant temperature change in each RCP and by the relevant government consumption shares of GDP yields the Table 2 estimates.

[49] URL (last accessed January 2024): [https://www.nifc.gov/fire-information/statistics/suppression-costs]

Urban Drainage Infrastructure: The EPA (2017) estimates of the costs of maintaining service levels in urban drainage infrastructure - assuming cities will want to remain prepared for 50-year storm events - are shown in Table A5. Given that impacts appear roughly linear - and certainly not convex - we use a benchmark estimate from a linear regression of projected costs on global temperature change, yielding \$1.83 billions per year per $1°C$ (in today's terms) for the calculations in Table 2.

Table A5: Urban Drainage Infrastructure Costs

	RCP 8.5		RCP 4.5		Source
	2050	2090	2050	2090	
Global Temp. Change	$2.0°C$	$3.7°C$	$1.4°C$	$1.8°C$	IPCC (2014)
Annual Cost (\$2015 bil)	4.3	5.6	3.7	4.1	EPA (2017)
Per $1°C$ impact:	2.2	1.5	2.6	2.3	

Road Maintenance: EPA (2017) estimate changes in U.S. road maintenance costs with both reactive and optimized proactive adaptation to changing climate conditions. We take the average between these two limiting cases and across the climate models considered, which implies annual costs of \$6.35 billion in RCP 8.5 and \$2.55 billion in RCP 4.5, and compute the figures in Table 2 based on the corresponding per-degree costs.

Endangered Species Act (ESA): Moore et al. (2022) estimate that the present value of ESA-related expenditures will increase 12.5% due to $2°C$ of warming, and 47.5% due to $5°C$ warming, implying an average per degree increase of +7.9%. We apply this increase to base year total government ESA expenditures (FWS, 2017) to infer annual spending impacts.

7.3 Sea Level Rise

Rahmstorf (2007) estimates that sea level rise can be approximated as proportional to global temperature change over pre-industrial levels at a rate of 3.4 millimeters/year per $°C$. We thus model SLR_t in cm over 1993-2008 levels as:

$$SLR_t = SLR_{t-1} + (\frac{T_t + T_{t-1}}{2}) \cdot 0.34 \cdot 10$$

with $SLR_{2020} = 5.6$ cm, the average across scenarios from NOAA (2017 Tech. Rep. NOS CO-OPS 83) as relevant for the EPA modeling.