NATIONAL ACADEMIES Sciences Engineering Medicine

Incorporating Climate into Macroeconomic Modeling

Workshop | June 14–15, 2023

JUNE 2023

Session 1:
Current Federal Macroeconomic Modeling Examples

NATIONAL ACADEMIES *Sciences Engineering Medicine*

Congressional Budget Office
Nonpartisan Analysis for the U.S. Congress

Incorporating Climate Methodology Into CBO's Macroeconomic Forecasting Model

June 14, 2023

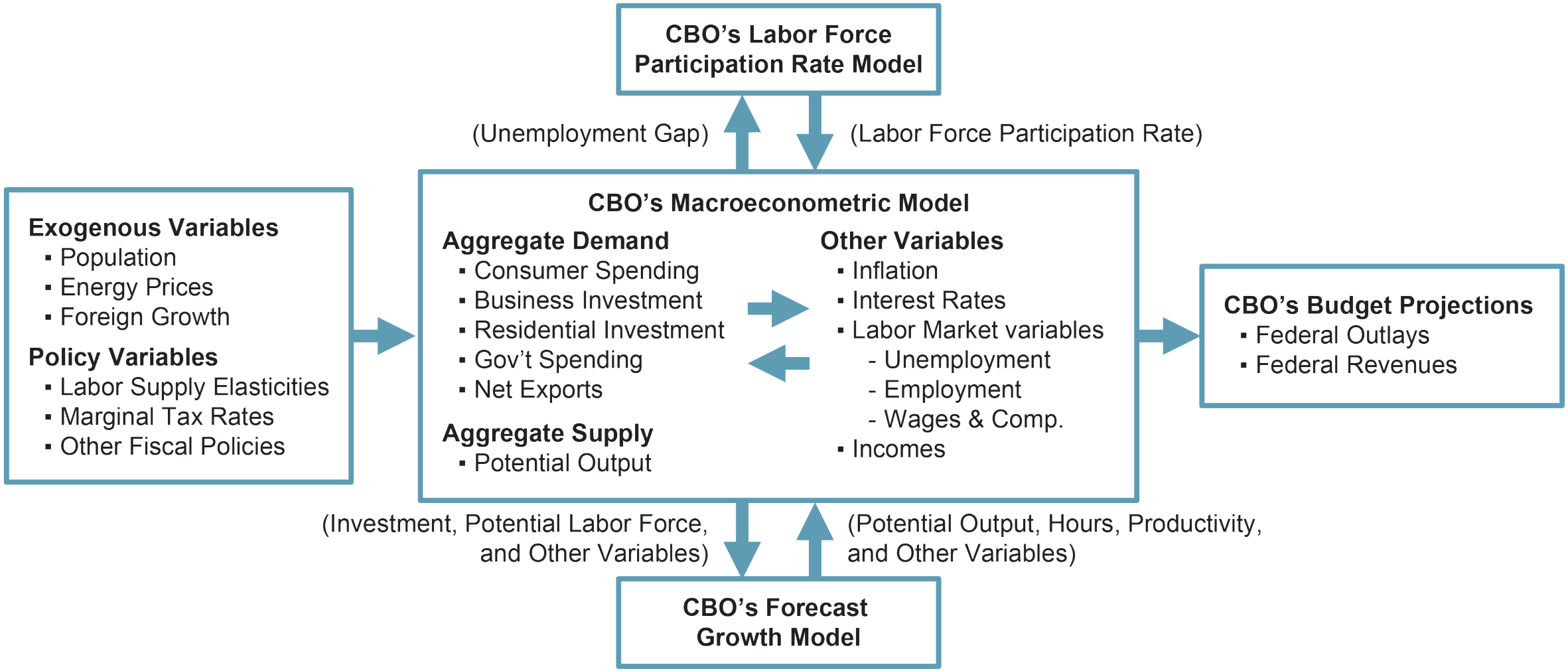
Presentation at the
National Academies of Sciences, Engineering, and Medicine

Robert Arnold

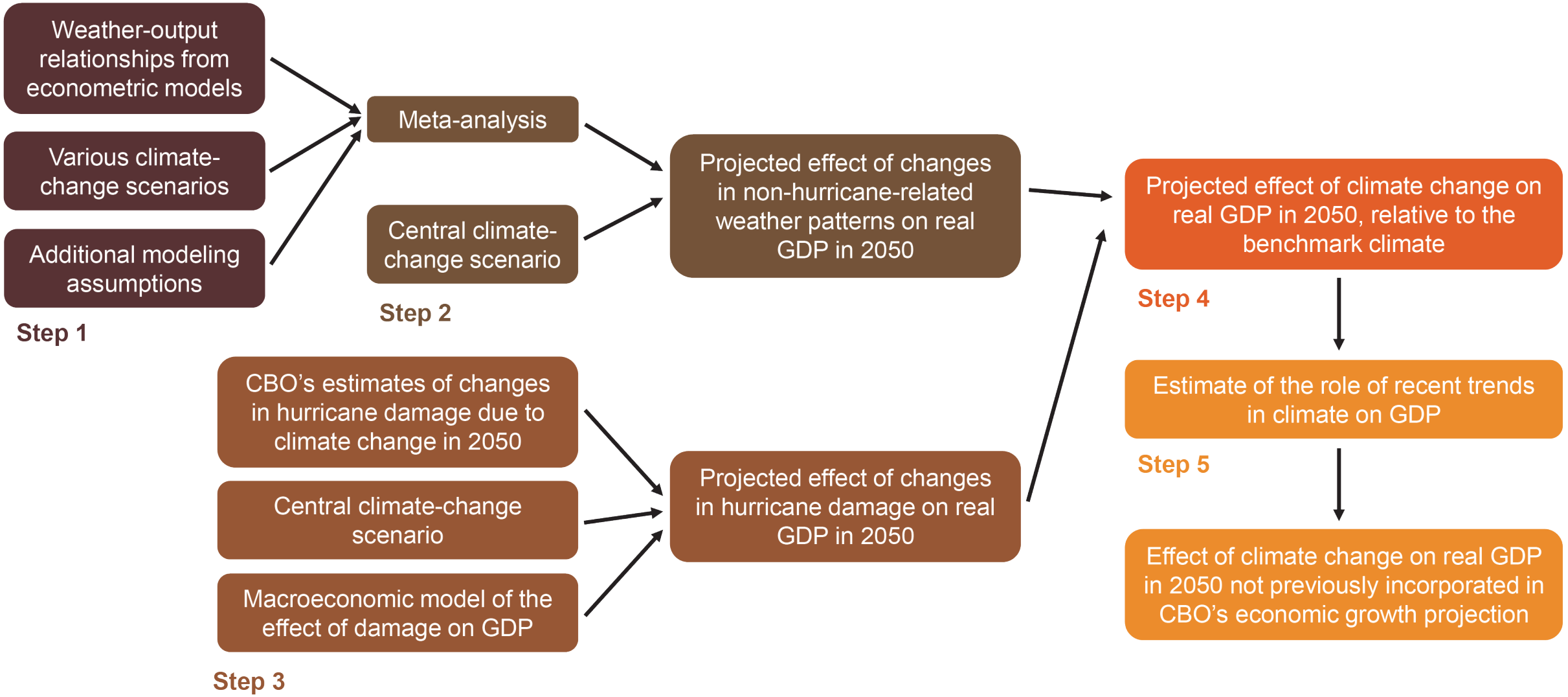
Macroeconomic Analysis Division

For information about the organization, see www.nationalacademies.org.

CBO's Forecasting Model



Schematic of CBO's Climate Methodology



Current Federal Macroeconomic Modeling Examples and Pathways by Which Climate Enters (or Not) into Macroeconomic Models

Fran Moore (CEA) and John Lindner (OMB)

June 14, 2023

Sessions Objectives

Understanding the goals of macroeconomic models and understanding the inputs to macroeconomic models used at the decision-making level.

Prompting and discussion questions:

- What are the inputs to macroeconomic models used for forecasting GDP and other headline numbers?
- How are these models' inputs being generated to represent real world processes and impacts?
- How might inputs be affected by climate and how can those effects be quantified?
- How can outputs of sectoral or other models be used to adjust inputs to macroeconomic models?

What are the inputs to macroeconomic models used for forecasting GDP and other headline numbers?

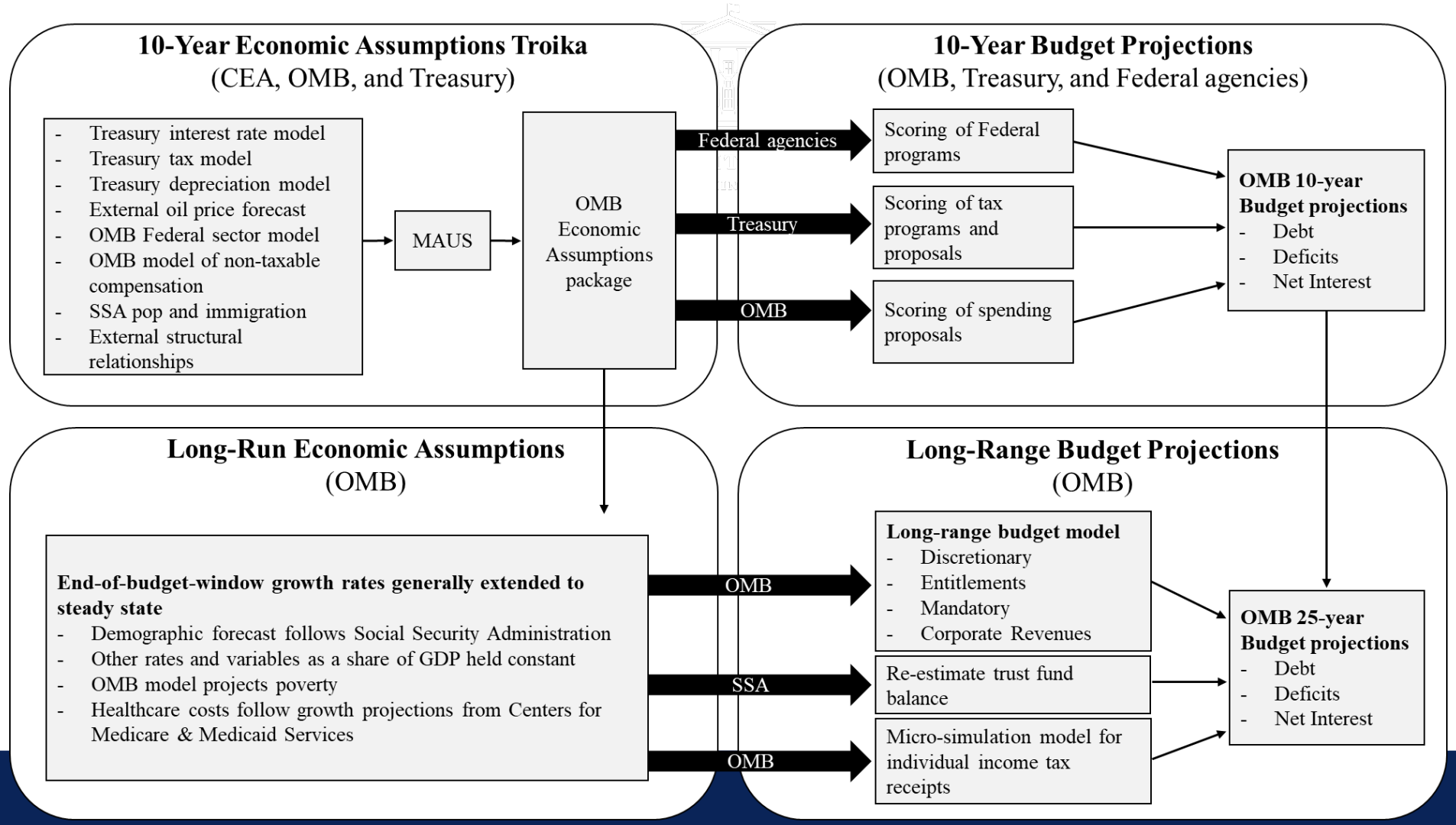
General comments:

- It depends upon the model and framework you use
  - And this depends upon the question you want to answer

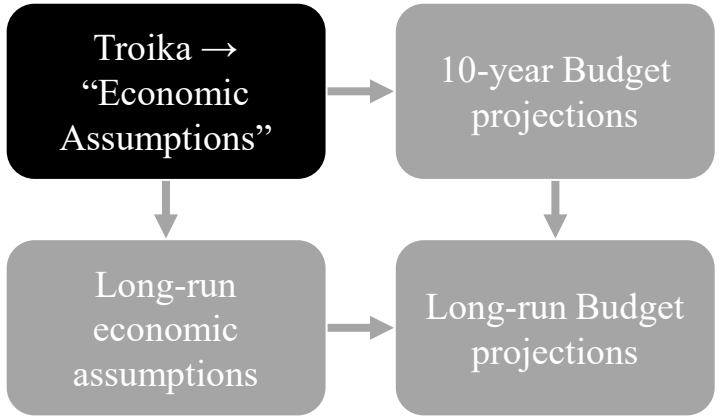
- We are operating in the world of models that are focused on macroeconomic forecasting
  - Our peers use a variety of approaches to produce a forecast

- The models are still just tools
  - Forecasting is an artform and judgment is involved

What are the inputs to macroeconomic models used for forecasting GDP and other headline numbers?



What are the inputs to macroeconomic models used for forecasting GDP and other headline numbers?



- Many of the headline numbers are considered in isolation and modeled using external frameworks
  - This includes GDP, which is built up considering supply-side variables

- Each of these is consolidated into the Macroeconomic Advisers US (MAUS) model (now part of S&P)
  - Adjustments need to be made for internal consistency
  - The MAUS framework imposes additional structure on remaining variables of interest (in cases where that structure has not been overwritten), such as major National Income and Product Accounts tables

President's Economic Assumptions (FY24)

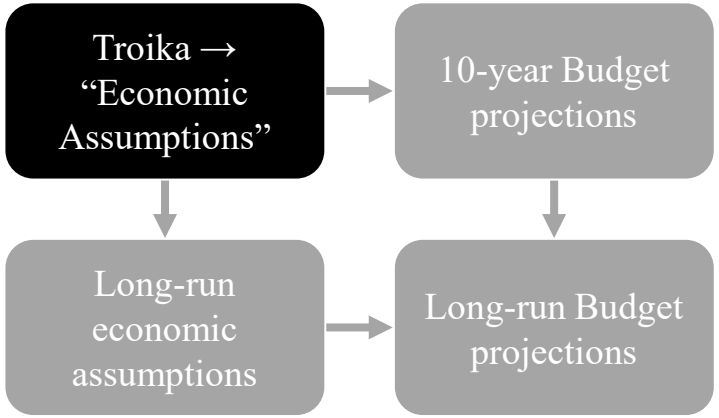


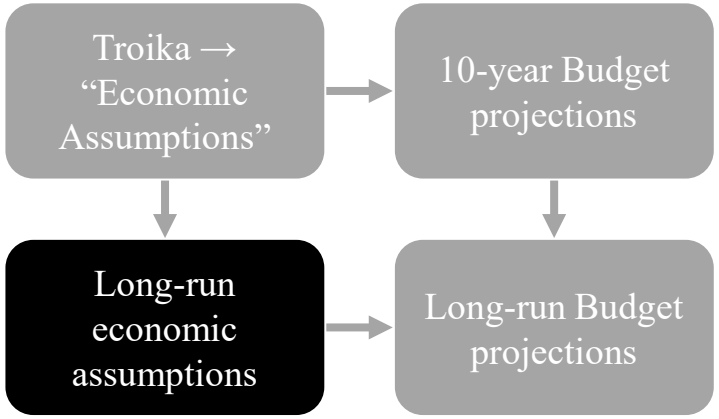
Table 2–1. ECONOMIC ASSUMPTIONS
(Calendar Years, Dollar Amounts in Billions)

	Actual	Projections											
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Gross Domestic Product (GDP)													
Levels, Dollar Amounts in Billions:													
Current Dollars	23,315	25,409	26,544	27,523	28,750	29,981	31,224	32,516	33,884	35,342	36,880	38,483	40,157
Real, Chained (2012) Dollars	19,610	19,971	20,092	20,385	20,852	21,300	21,726	22,160	22,617	23,106	23,615	24,134	24,665
Chained Price Index (2012=100), Annual Average	119	127	132	135	138	141	144	147	150	153	156	160	163
Percent Change, Fourth-Quarter-over-Fourth-Quarter:													
Current Dollars	12.2	6.7	3.2	4.3	4.6	4.1	4.1	4.1	4.2	4.3	4.4	4.3	4.3
Real, Chained (2012) Dollars	5.7	0.2	0.4	2.1	2.4	2.0	2.0	2.0	2.1	2.2	2.2	2.2	2.2
Chained Price Index (2012=100)	6.1	6.6	2.8	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Incomes, Billions of Current Dollars													
Domestic Corporate Profits	2,359	2,576	2,626	2,533	2,576	2,702	2,879	3,040	3,183	3,310	3,445	3,592	3,747
Employee Compensation	12,538	13,582	14,312	14,989	15,694	16,419	17,161	17,936	18,736	19,583	20,481	21,419	22,401
Wages and Salaries	10,290	11,205	11,812	12,358	12,938	13,532	14,136	14,768	15,424	16,118	16,850	17,634	18,484
Nonwage Personal Income	5,680	6,055	6,593	6,596	6,814	7,123	7,455	7,794	8,145	8,537	8,914	9,335	9,849

OMB provides quarterly forecasts of ~ 50 key macroeconomic variables over the budget window to agencies

- Agencies use these assumptions to project receipts and outlays for the Budget

What are the inputs into macroeconomic models used for forecasting GDP and other headline numbers?



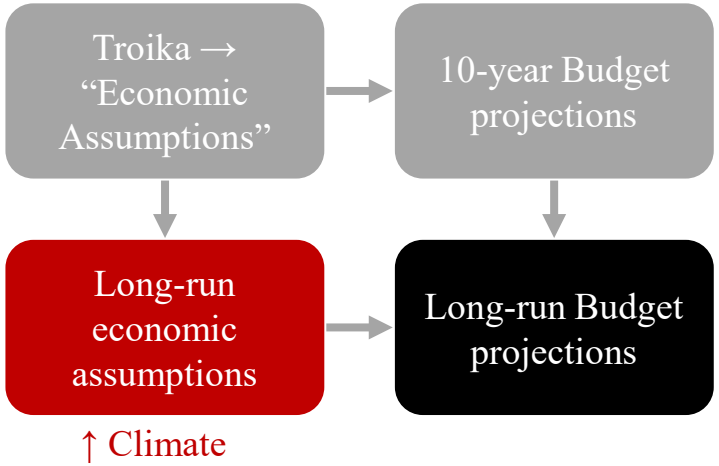
Summary of the bottom-left quadrant:

- Economy is broadly assumed to be on a balanced growth path at end of the budget window
  - Many variables are held constant
  - The underlying details of projections are not publicly available

- This is the section where we have considered climate impacts the last two years (FY23 and FY24 Budgets)
  - Adjustments were made to the long-run productivity growth path in alternative scenarios

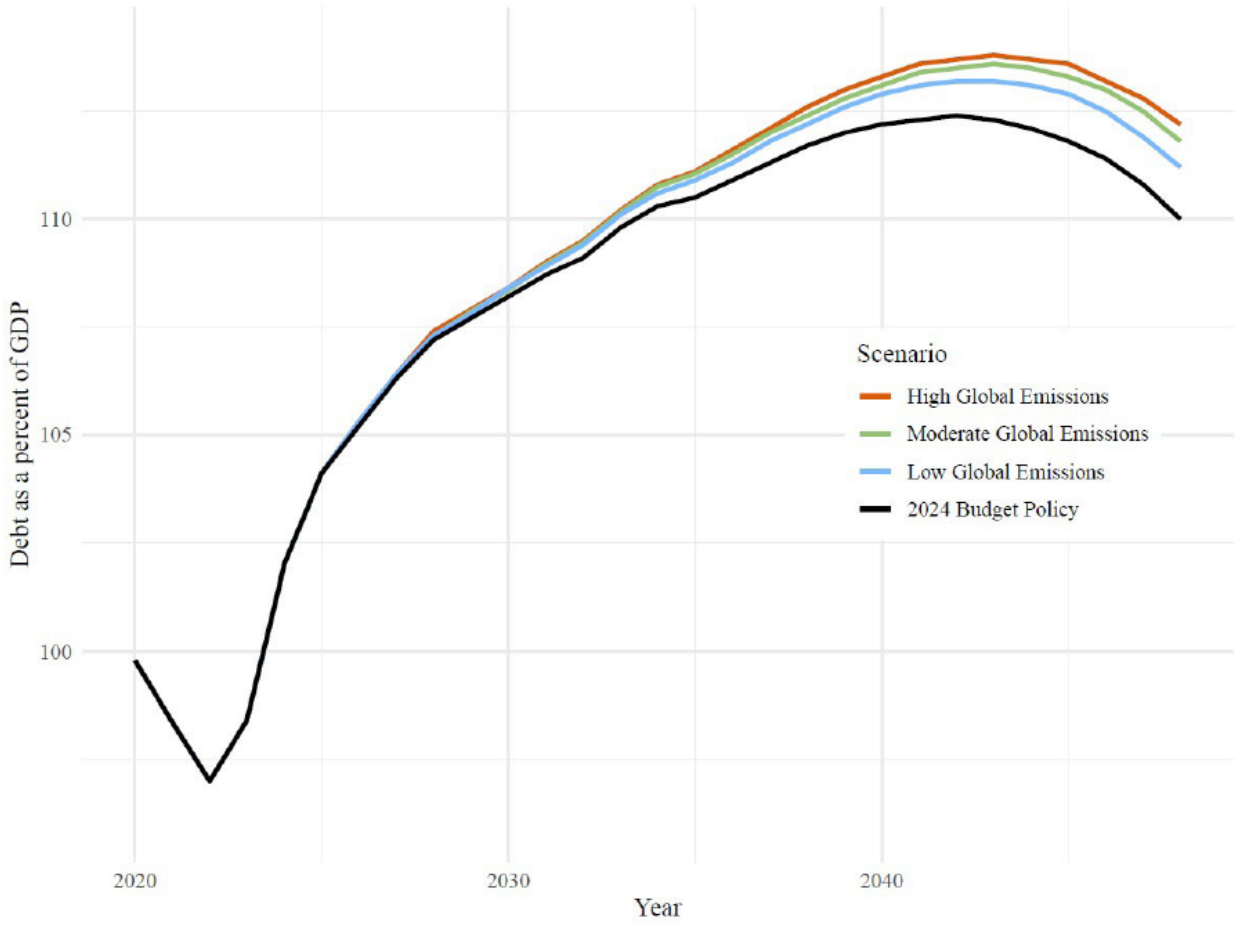
- These projections only extend 25 years into the future (mid-century)

Long-term Budget Outlook (LTBO)



- Chapter uses alternate scenarios to assess risks to fiscal outlook

Figure 2: Debt-to-GDP Ratio Projections under Scenarios including Physical Climate Risks in the FY 2024 Long-Term Budget Outlook



How are these models' inputs being generated to represent real world processes and impacts?

It depends upon which inputs we are considering

- The MAUS forecast is governed by historical, structural econometric relationships
  - These relationships are updated regularly

- However, headline Troika numbers are largely produced outside this framework
  - The underlying forecasting models for these numbers are often similar to the MAUS model but allow for greater flexibility so we can consider:
    - External forecasts
    - Market data
    - Policy

- There is currently no explicit consideration of climate impacts

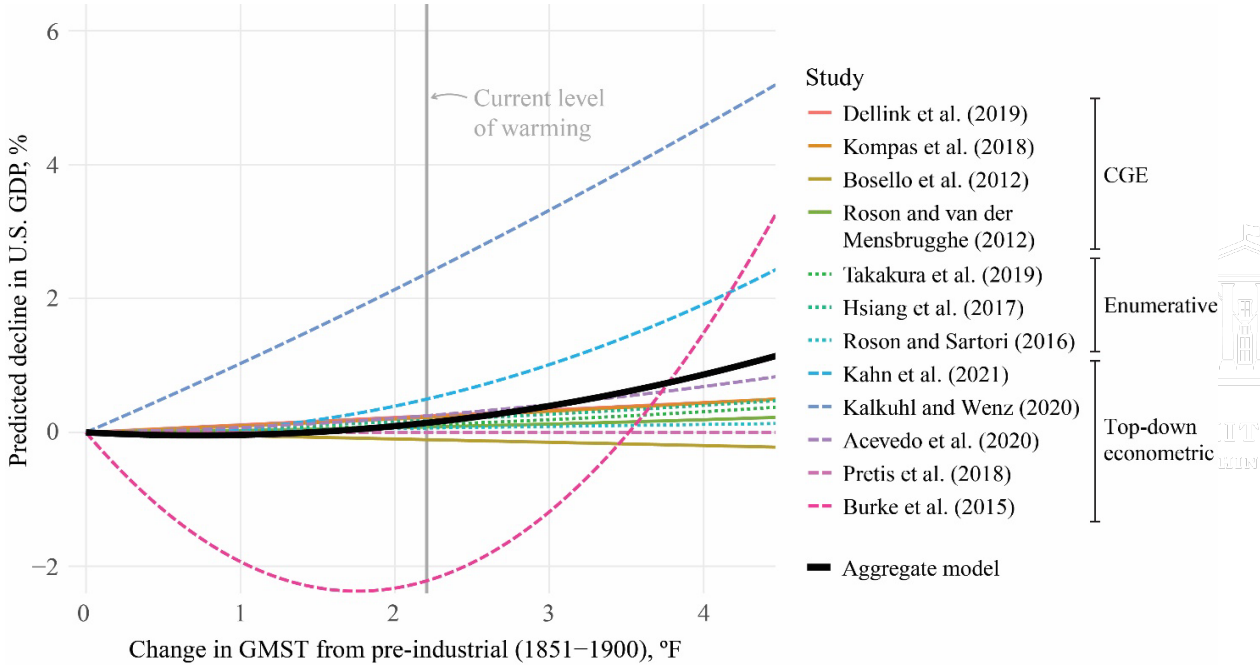
How might inputs be affected by climate and how can those effects be quantified?

- 2023 OMB / CEA White Paper (p. 13-18) describes several pathways by which climate change (i.e. physical risks) and the clean energy buildout (i.e. transition risks) can affect key macroeconomic variables: Labor, Capital and Productivity
  - Only a limited subset of possible pathways can currently be quantified

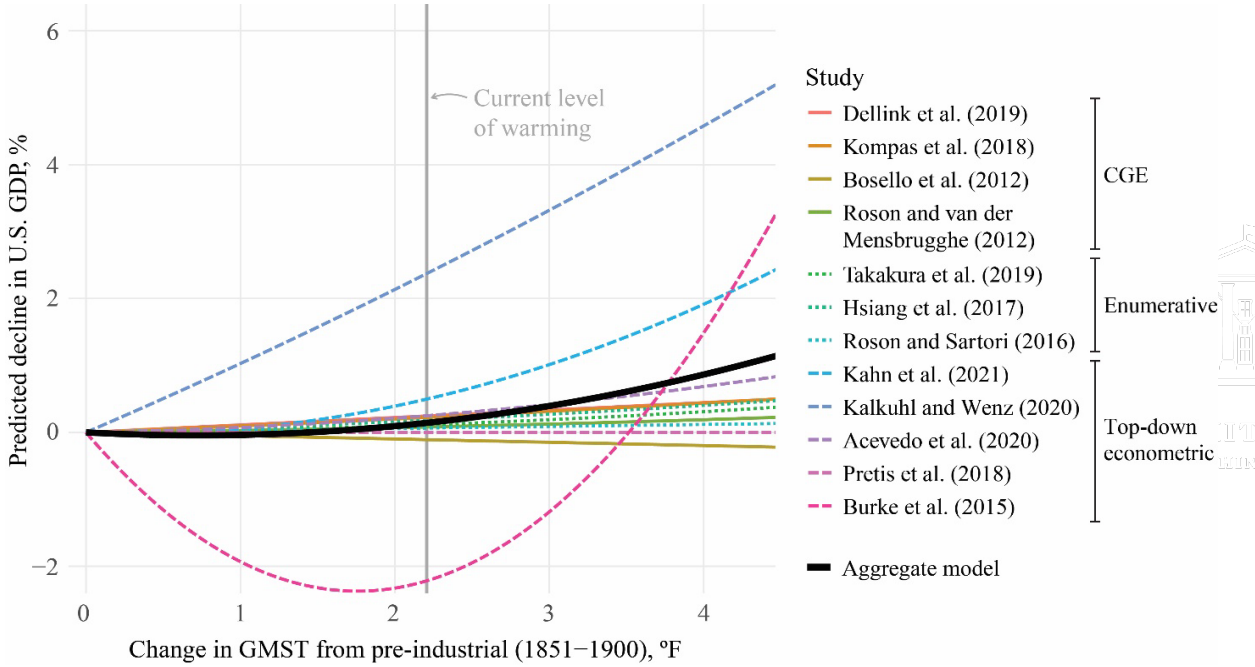
- FY24 climate risk alternatives introduced physical risks as productivity damages into the 25 year long-term budget outlook
  - Damages based on a comprehensive review of published estimates for US / North America

Model	Model type	Included damages					
		Agriculture	Energy	Tourism	Sea level rise	Labor productivity	Other
Hsiang et al. (2017)	Enumerative	X	X			X	Cyclones
Takakura et al. (2019)	Enumerative	X	X		X	X	Nutrition, flooding
Roson and Sartori (2016)	Enumerative	X	X	X	X	X	
Dellink et al. (2019)	CGE	X	X	X	X	X	Fisheries, cyclones
Kompas et al. (2018)	CGE	X			X	X	
Roson and van der Mensbrugghe (2012)	CGE	X	X	X	X	X	
Bosello et al. (2012)	CGE	X	X	X	X	X	Forest productivity, flooding
Acevedo et al. (2020)	Top-down econometric	Any variation in economic output associated with interannual temperature variation					
Kalkuhl and Wenz (2020)	Top-down econometric						
Kahn et al. (2021)	Top-down econometric						
Pretis et al. (2018)	Top-down econometric						
Burke et al. (2015)	Top-down econometric						

How might inputs be affected by climate and how can those effects be quantified?

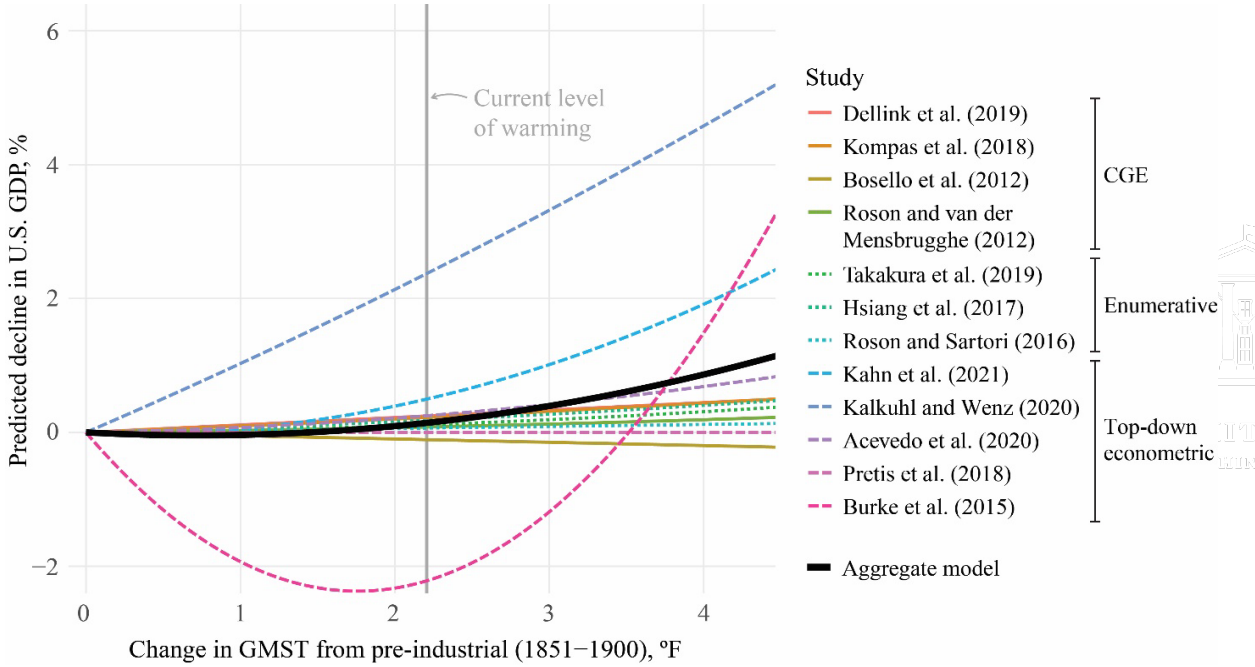


How might inputs be affected by climate and how can those effects be quantified?



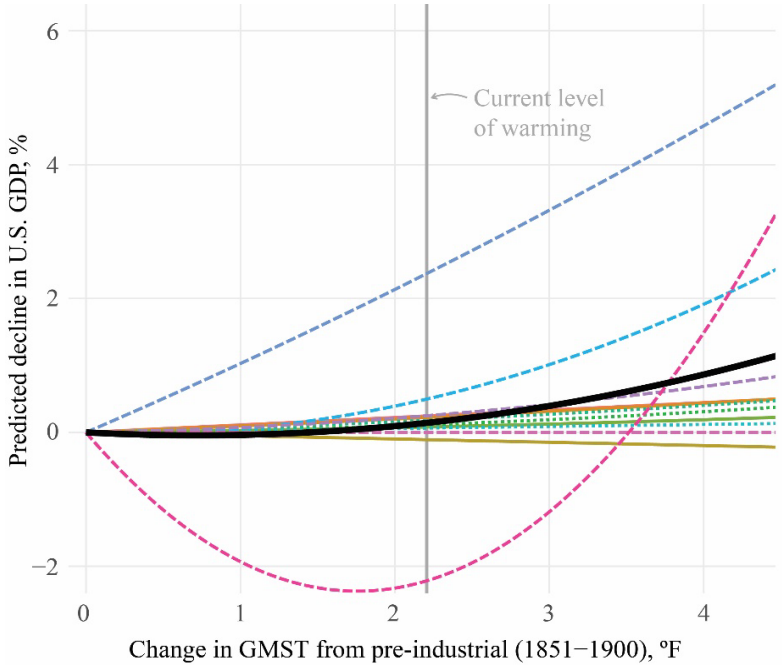
Aggregate damage function combined with 3 global temperature scenarios to generate 3 productivity impacts

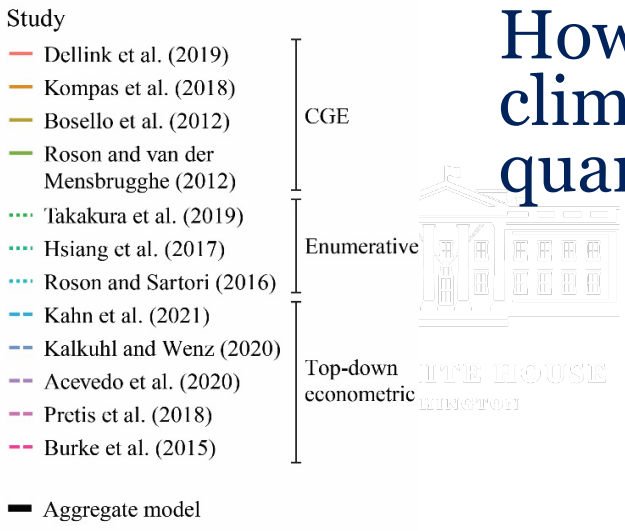
How might inputs be affected by climate and how can those effects be quantified?



Aggregate damage function combined with 3 global temperature scenarios to generate 3 productivity impacts → Altered GDP pathways passed to OMB budget model to generate alternate pathways for fiscal indicators

How might inputs be affected by climate and how can those effects be quantified?

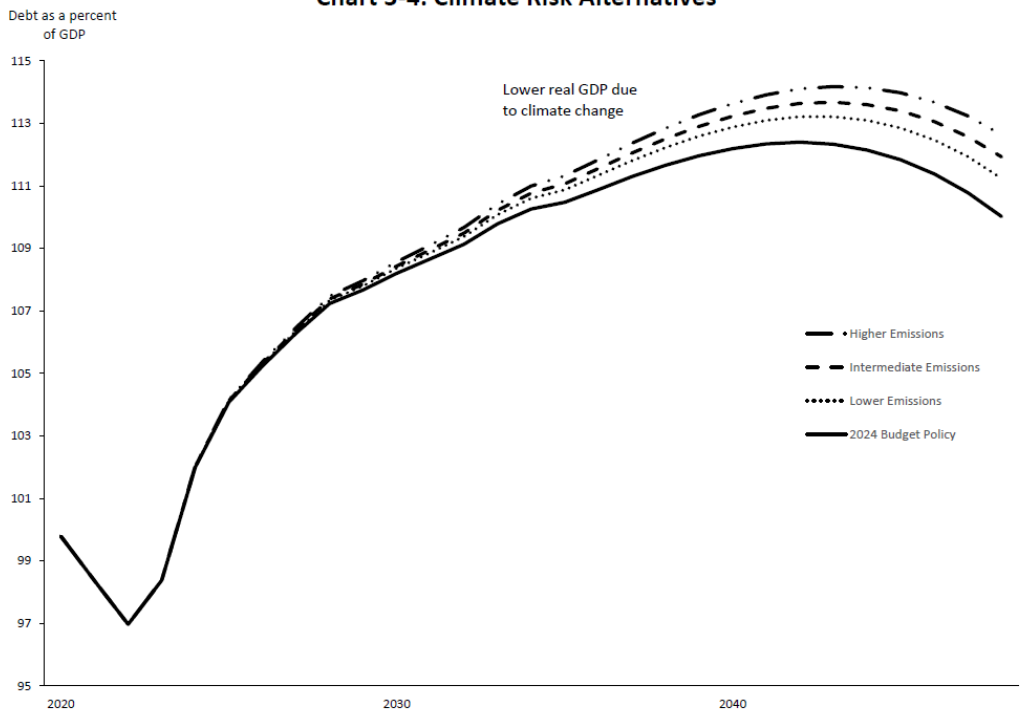




Aggregate damage function combined with 3 global temperature scenarios to generate 3 productivity impacts

Altered GDP pathways passed to OMB budget model to generate alternate pathways for fiscal indicators

Chart 3-4. Climate Risk Alternatives



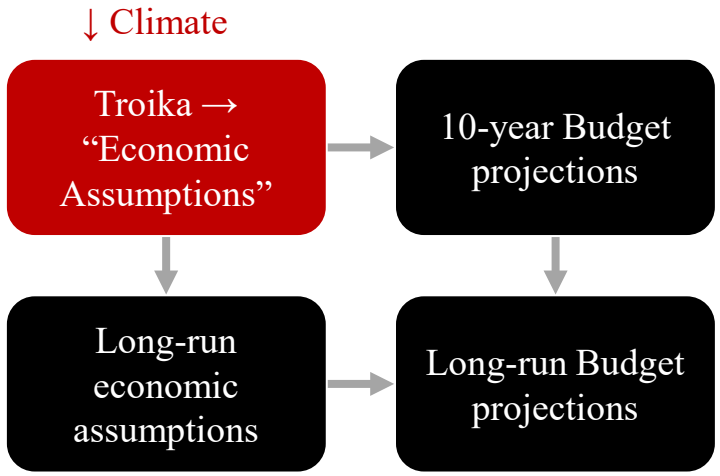
Climate-Macro Linkages: Transition Risks

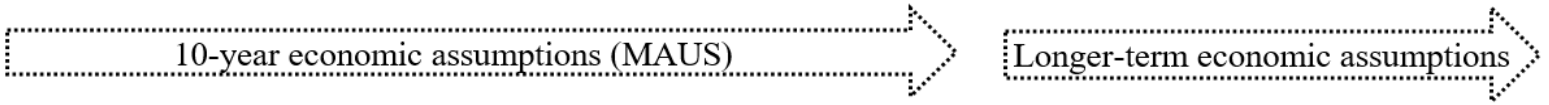
		Ability to Quantify
Capital	Increased Investment in Clean Technologies	Good
	Lower Investment or Premature Retirement of Fossil Fuel Infrastructure	Good
Productivity	Improved Energy Productivity from New Technologies	Good
Labor	Potential Skill and Geographic Mismatch from Shifting Energy (and Connected) Industries	Limited
Energy	Effects on Energy Price Levels and Volatility from Global Climate Policies	Moderate

Climate-Macro Linkages: Physical Risks

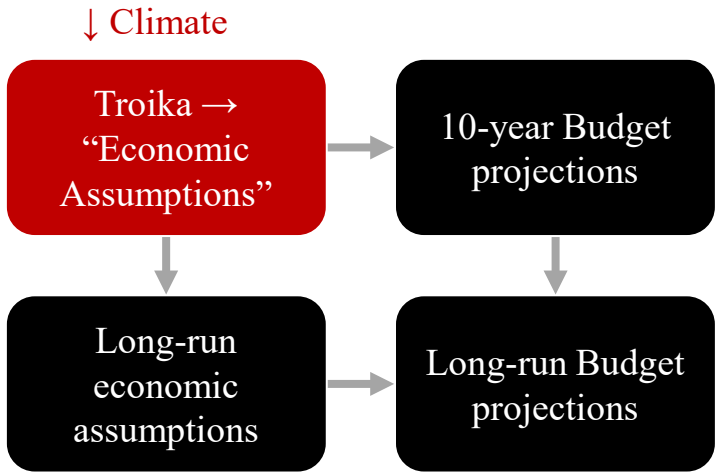
		Ability to Quantify
Capital	Destruction from storm damage, resources required for adaptive investments	Moderate
	Added uncertainty, risk premia and insurance availability	Limited
Labor	Labor supply	Moderate
	Population – Mortality and Migration	Moderate
Productivity	Land	Good
	Labor	Good
	Capital	Moderate

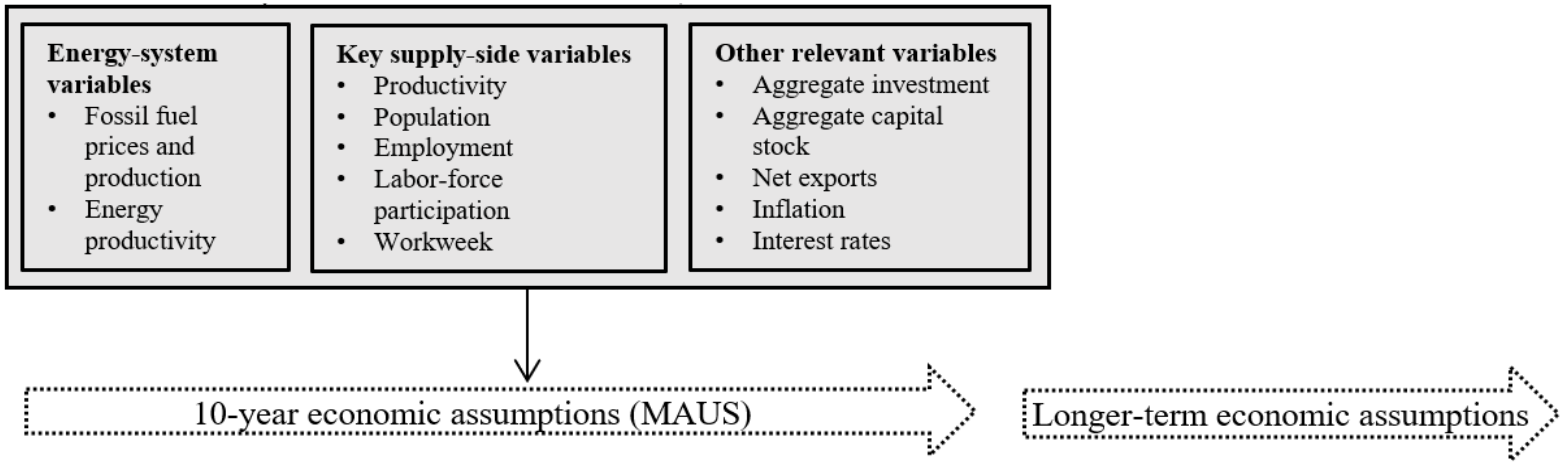
Potential Framework for Future Work



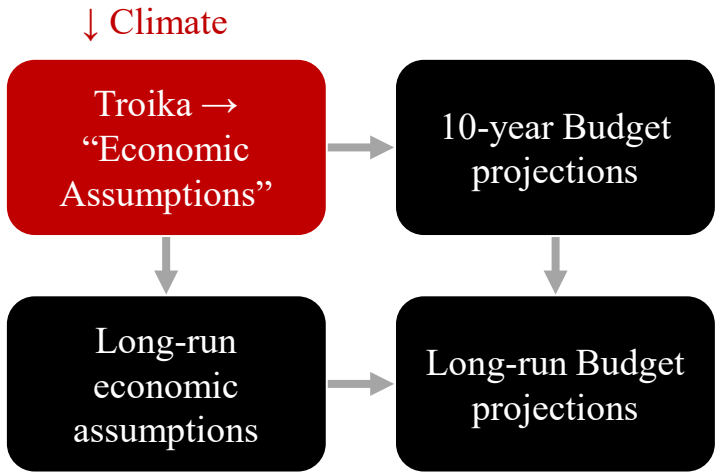


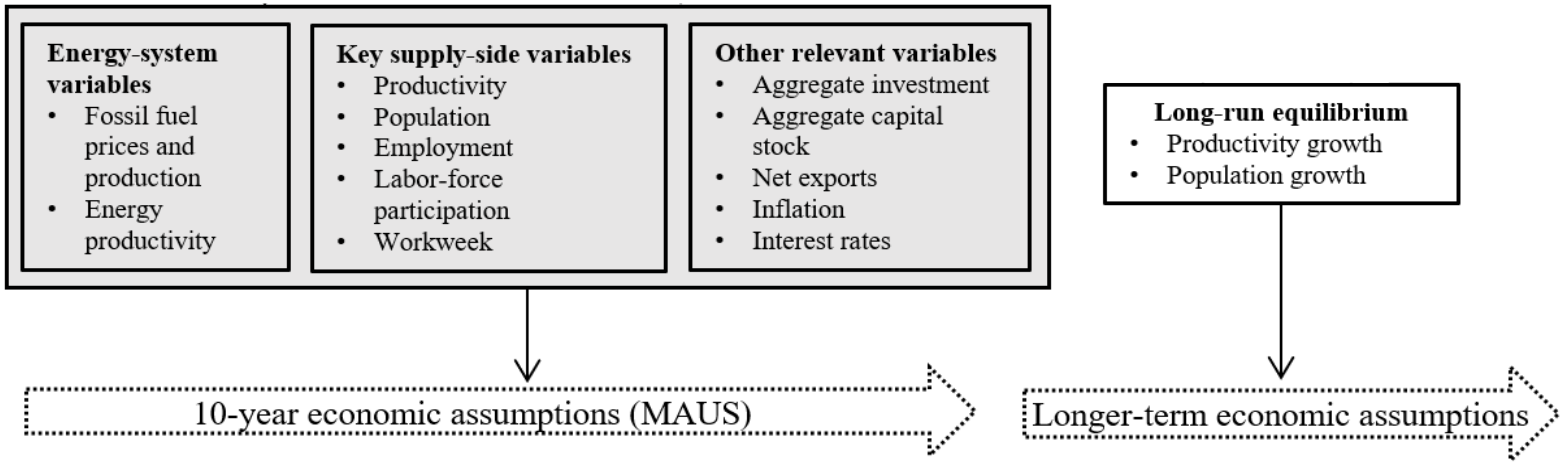
Potential Framework for Future Work



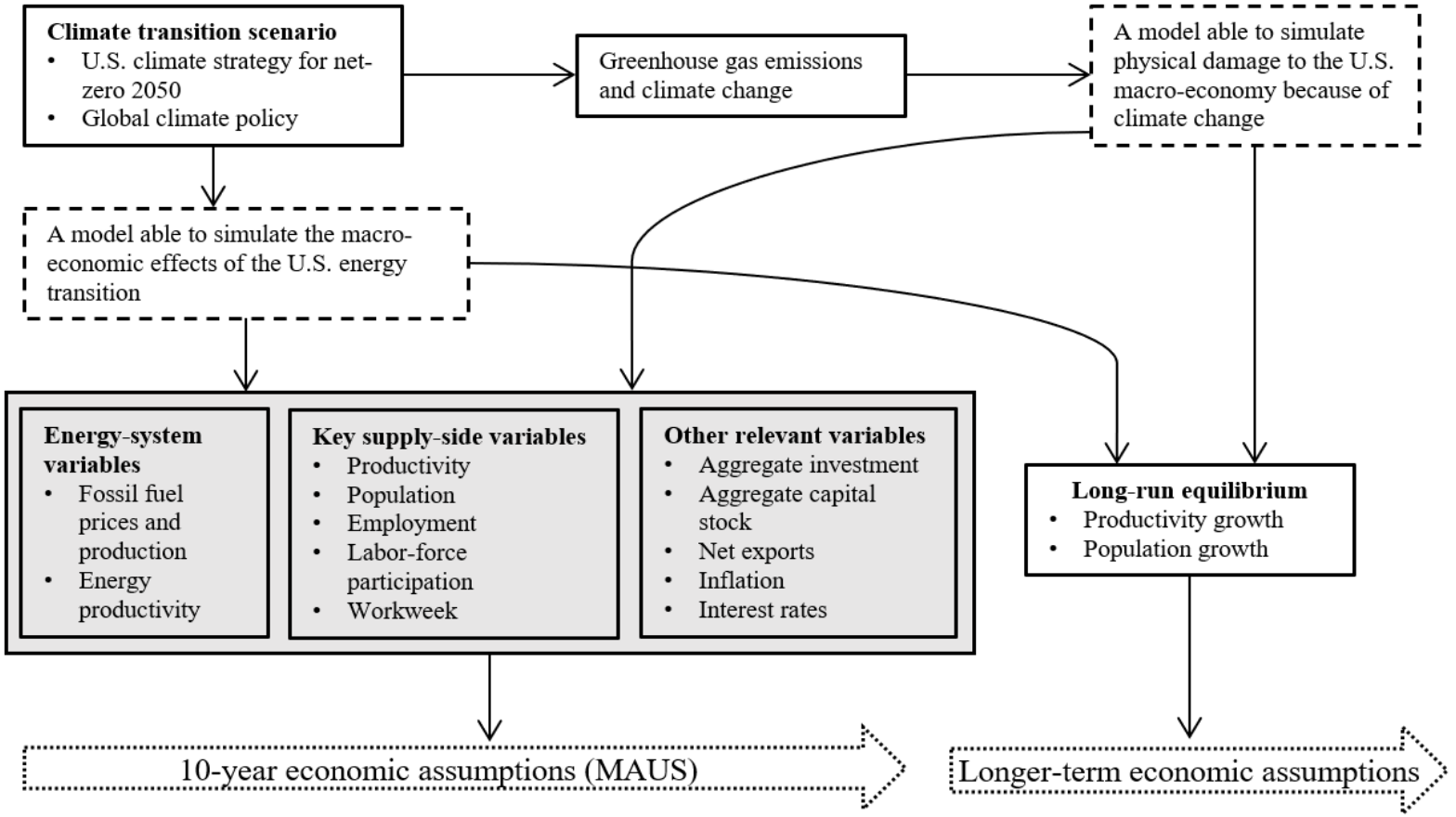


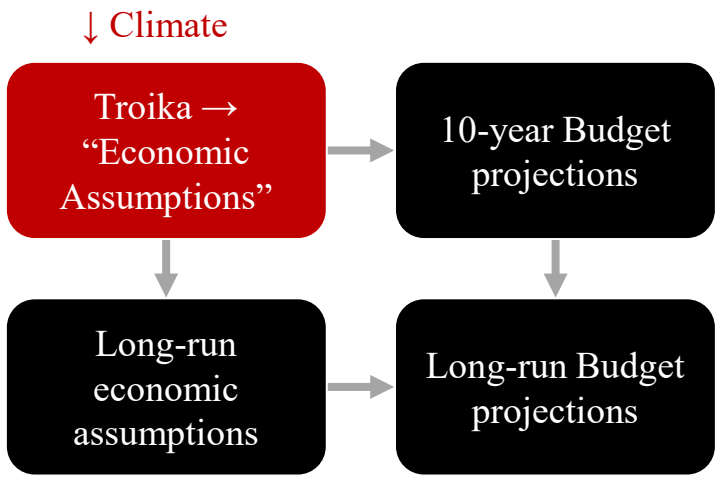
Potential Framework for Future Work



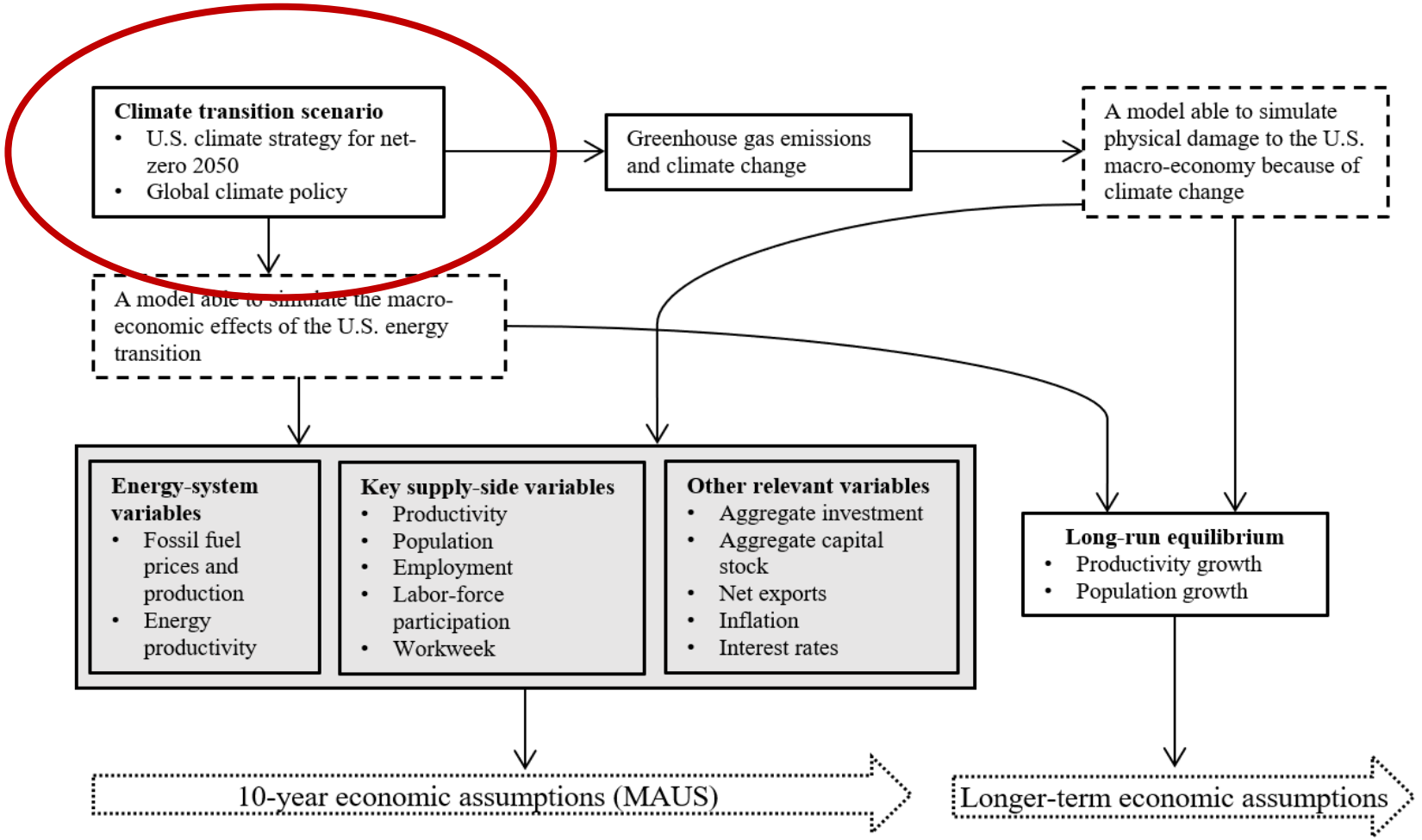


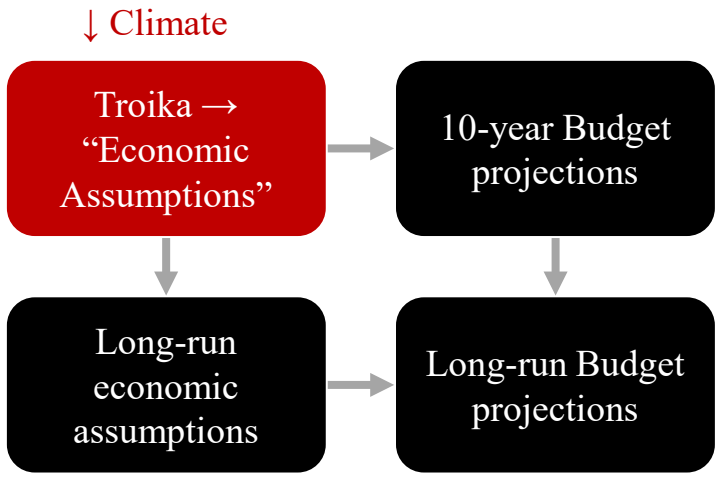
Potential Framework for Future Work



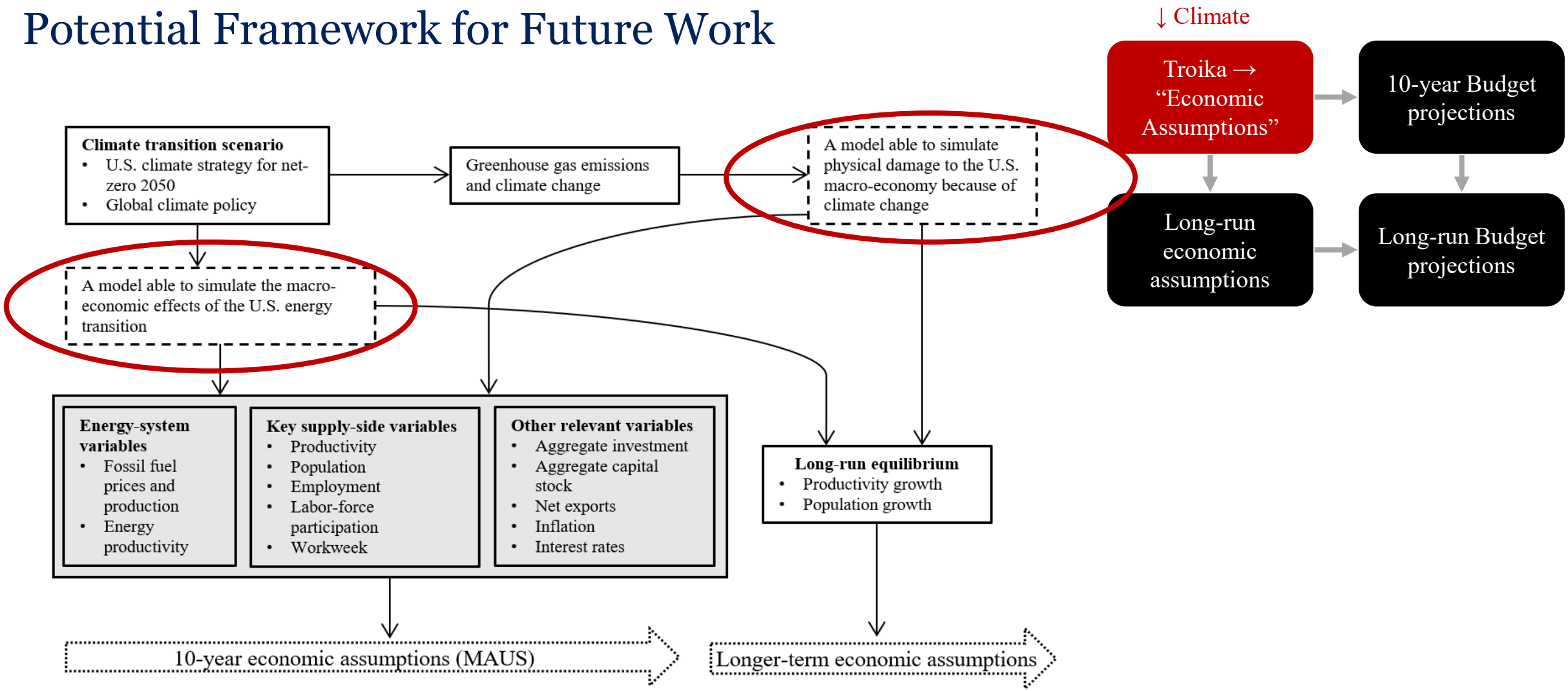


Potential Framework for Future Work

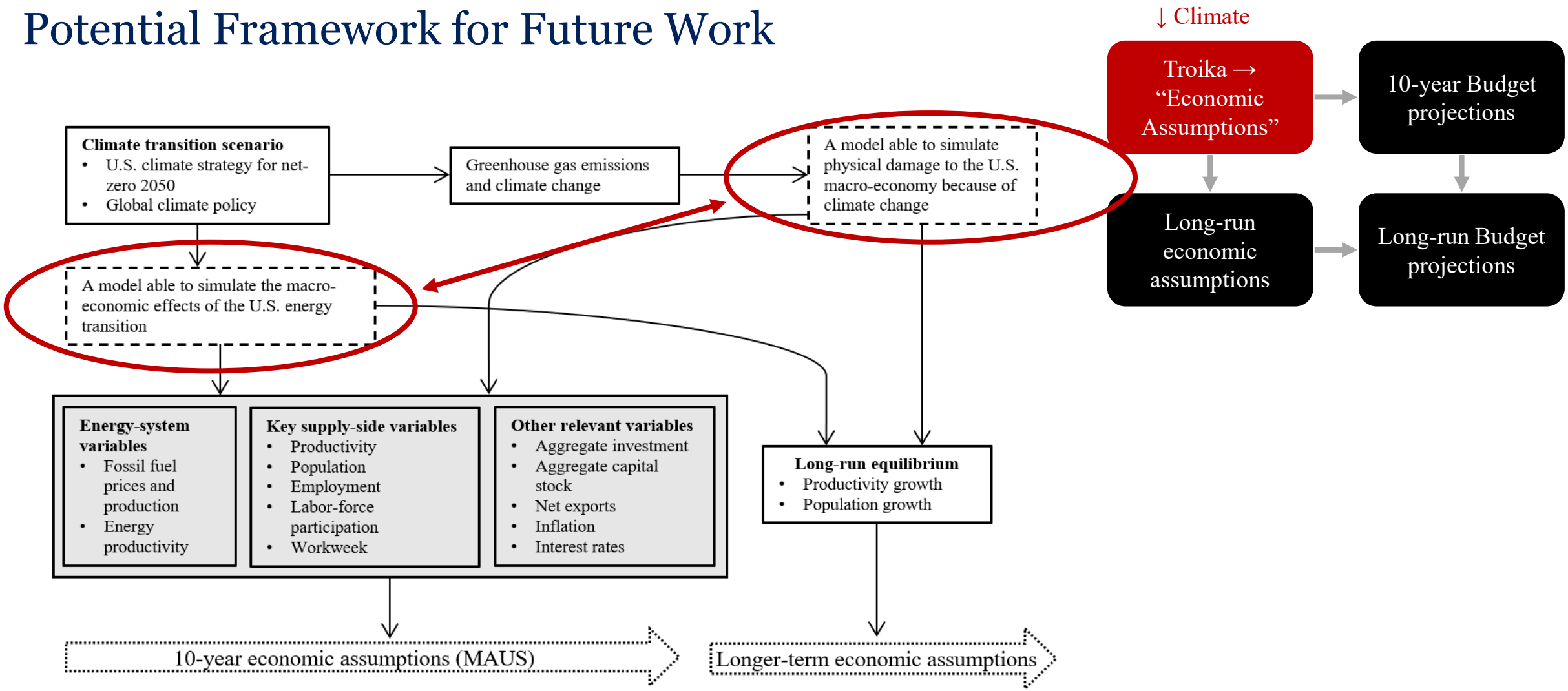




Potential Framework for Future Work



Potential Framework for Future Work



Identified Challenges

- Lack of a detailed energy sector within MAUS presents challenges
  - Historic relationships between energy production, investments, exports, and imports won't necessarily hold given major structural changes expected in energy production and use

- US only model creates challenges in capturing international spillovers in global markets (energy, capital, clean-energy technology and materials)

- Missing quantification of climate change damages in literature

- Available sectoral models tend to focus on equilibrium, least-cost outcomes
  - Imperfect ability to capture complex transition dynamics

- Limited variables included in long-term projections

- Difficulty of addressing or representing risks and uncertainty in single scenario of Economic Assumptions

Additional information

For additional information, please see:

- 2023 CEA/OMB White Paper: Methodologies and Considerations for Integrating the Physical and Transition Risks of Climate Change into Macroeconomic Forecasting for the President's Budget (pgs. 9-22)

- 2022 CEA/OMB White Paper: Climate-Related Macroeconomic Risks and Opportunities

- Recent Long-Term Budget Outlooks:
  - FY24 President's Budget (pgs. 21-22)
  - FY23 President's Budget (pgs. 33-34)

THE WHITE HOUSE
WASHINGTON

WH.GOV