

# Embedding Climate Change in Macroeconomic Analysis for Research and Policy

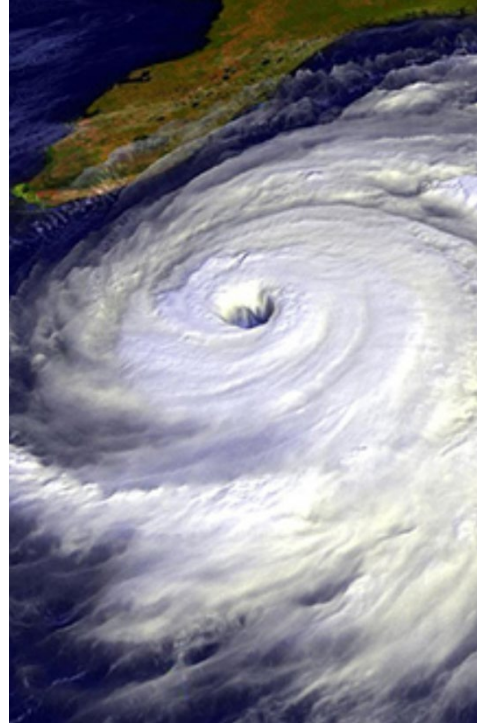
27<sup>th</sup> Annual Conference on Global Economic Analysis

June 5<sup>th</sup> 2024

Frances C. Moore



# Climate change is a big problem....

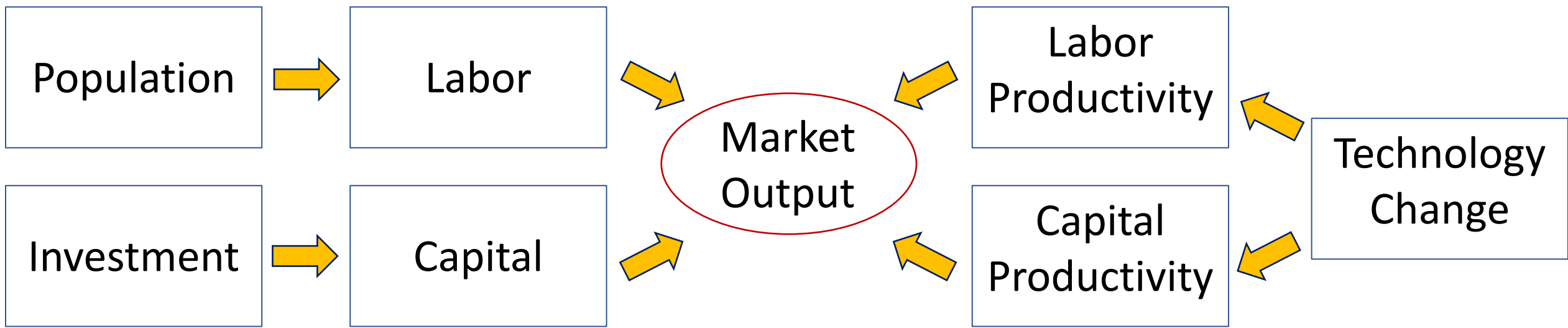


# Goals

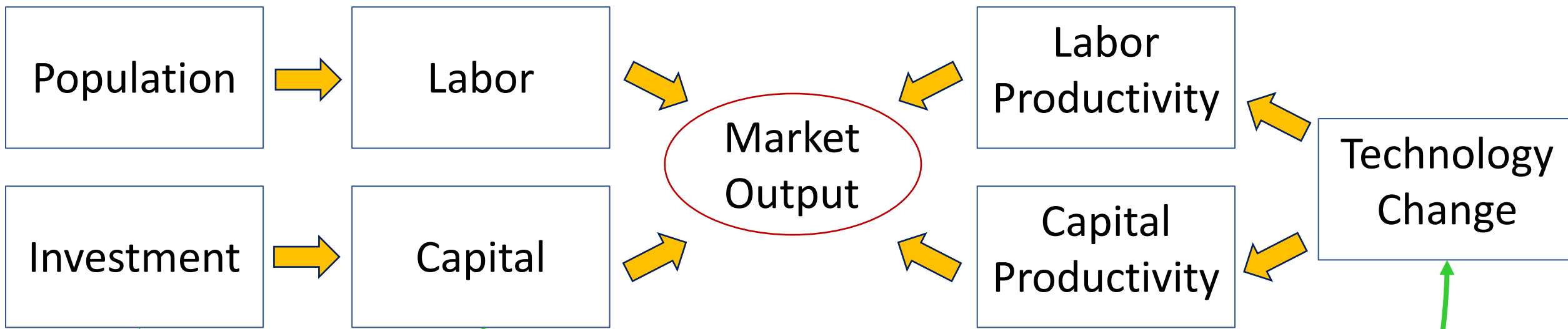
1. Highlight inter-relationships between climate change, climate policy, and macro-economic variables
2. Describe relevant evidence base and compare modeling frameworks
3. Draw connections to policy applications

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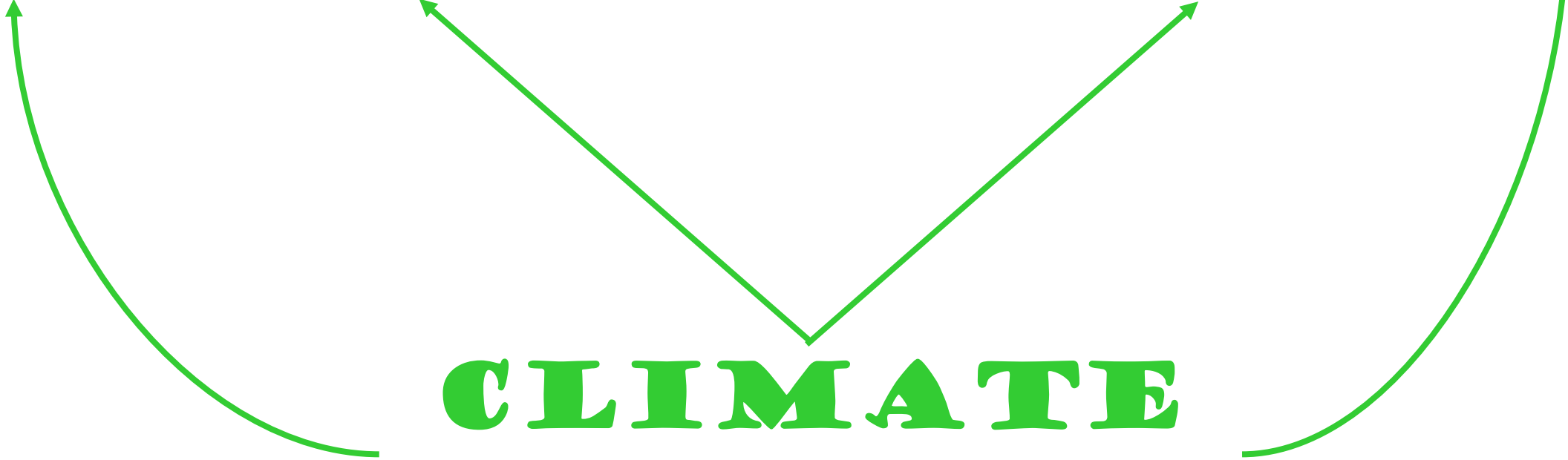
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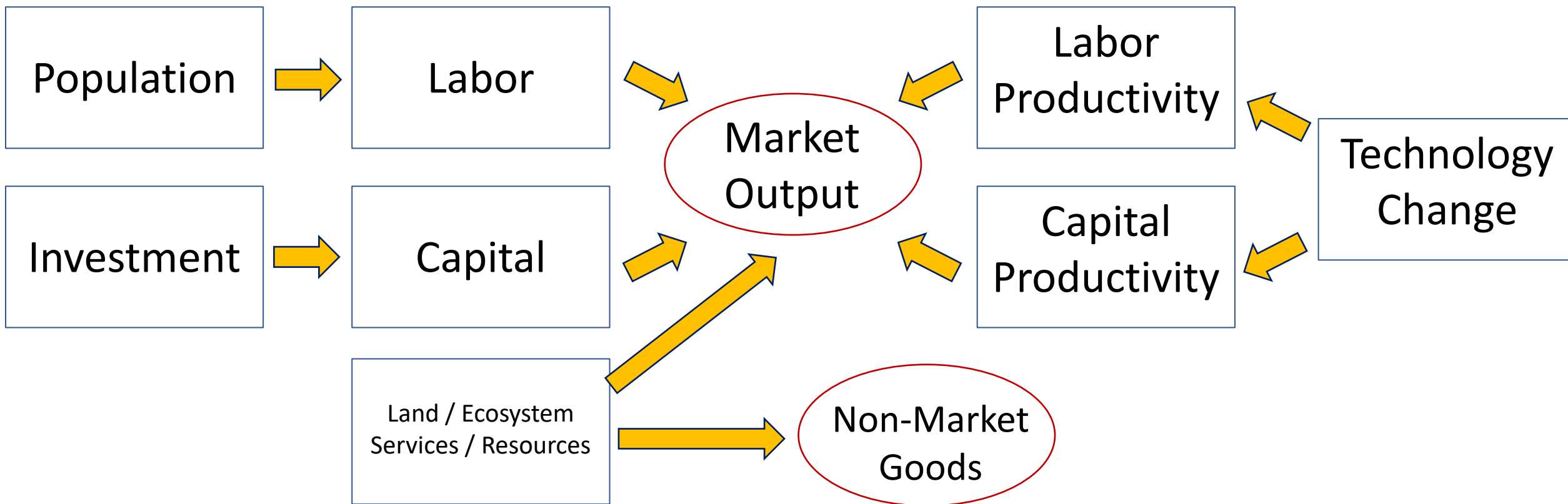


# CLIMATE CHANGE



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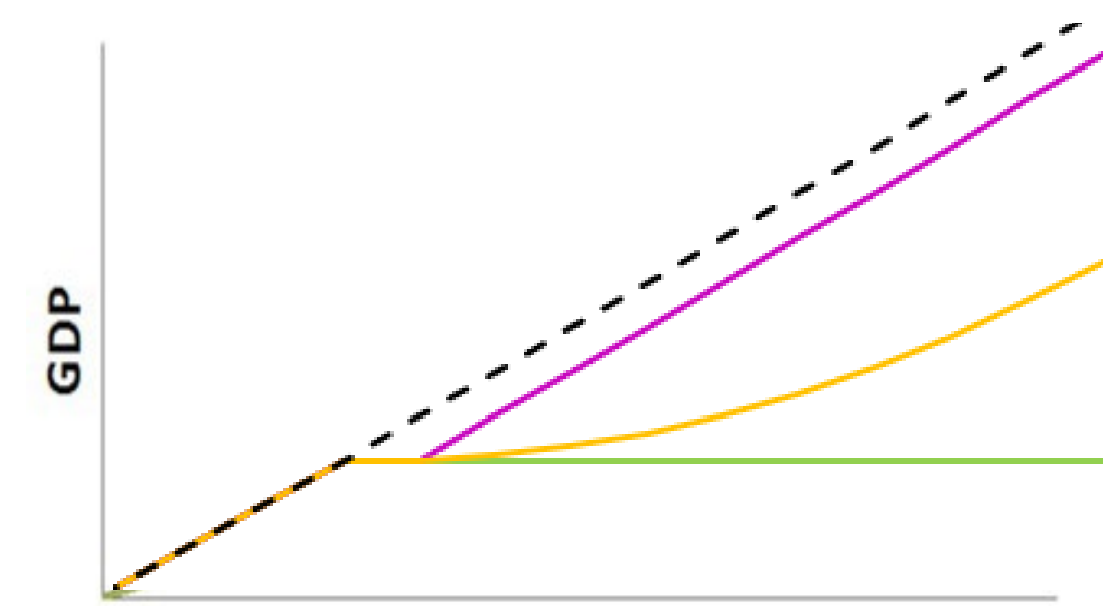
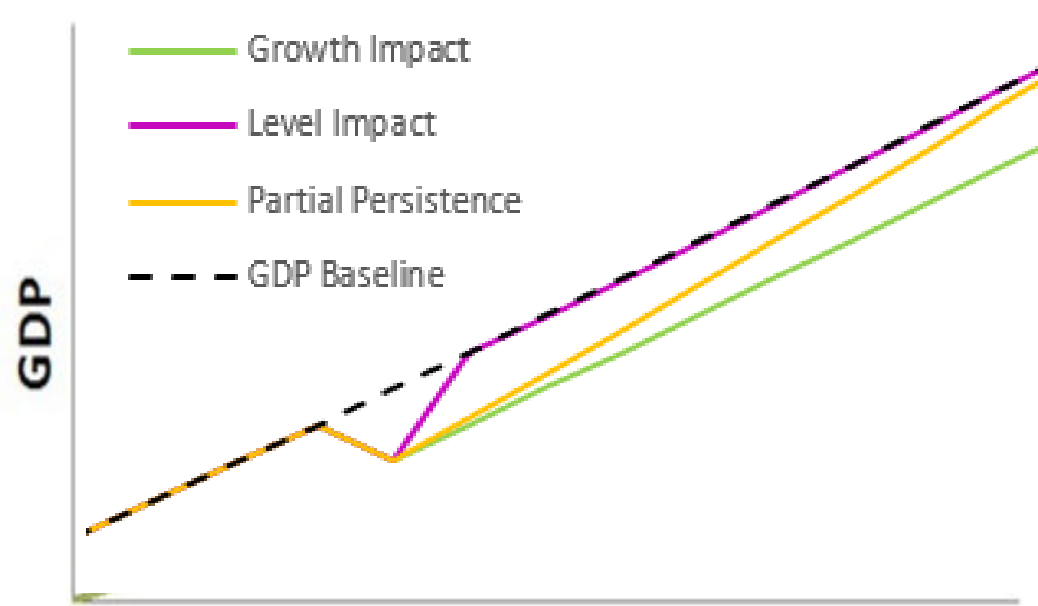
**CLIMATE CHANGE**

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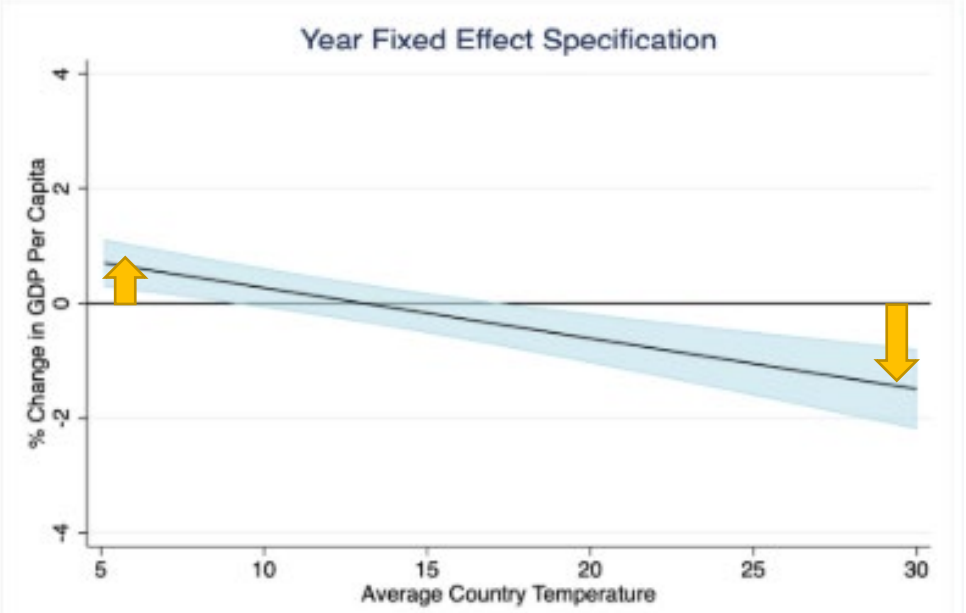
# Reduced Form Empirical Evidence



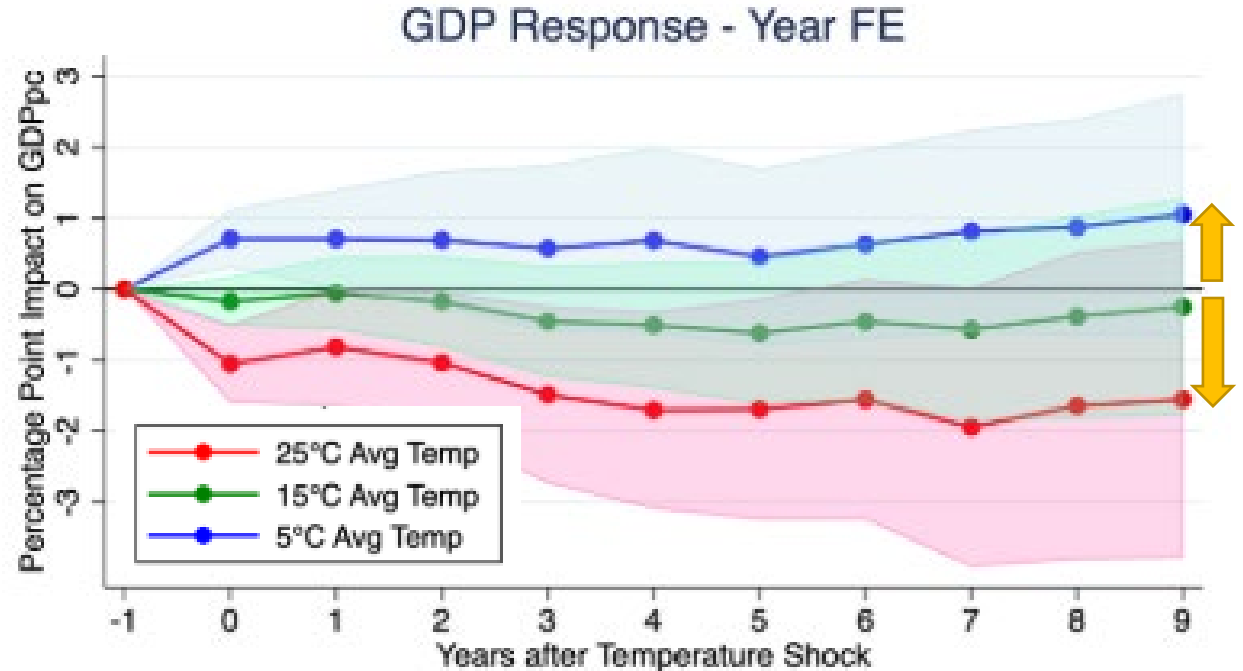
# Reduced Form Empirical Evidence

- Studies use natural temperature variation to estimate effects on output:
  - National or sub-national, inter-annual temperature variation (Dell, Jones and Olken 2012; Burke, Hsiang and Miguel, 2015; Nath, Ramey and Klenow, 2023; Kotz et al. 2024)
  - Global average inter-annual temperature variation (Bilal and Danzig, 2024)
  - El-Nino-driven variation (Callahan and Mankin, 2023)
  - Global, lower-frequency temperature variation (Bastien-Olvera et al. 2022)
- Estimate persistence using lagged variables, local projections, or low-frequency variation
- Emerging evidence:
  - 1) Aggregate economic output is sensitive to temperature / climatic variation
  - 2) Negative effects largest in hotter (poorer) countries, some positive effects in very cold countries
  - 3) Evidence for persistent effects on output for at least 10 years
  - 4) Substantial uncertainties, particularly projecting climate change impacts into the future

# Reduced Form Empirical Evidence

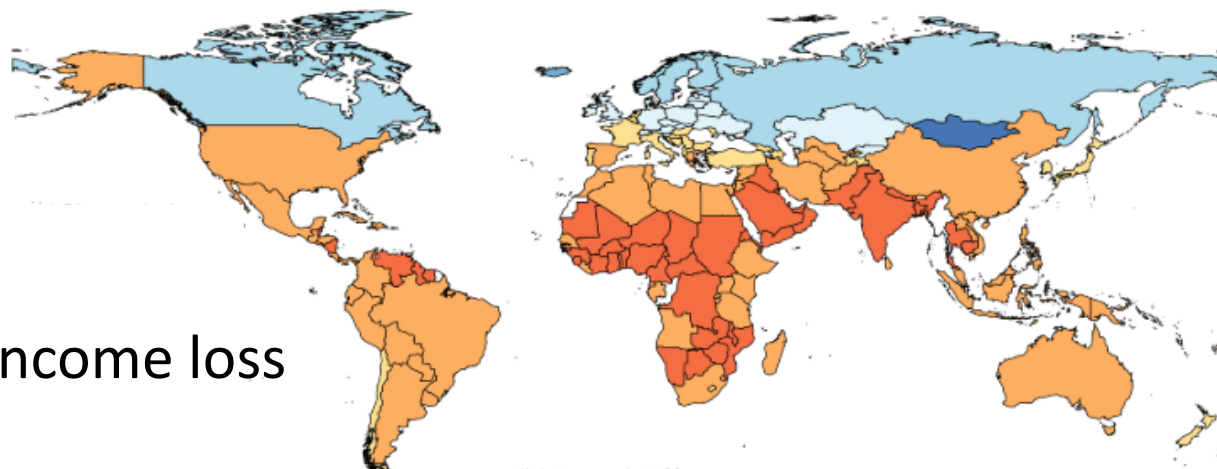


Contemporaneous Effect of 1 Degree Temperature Increase



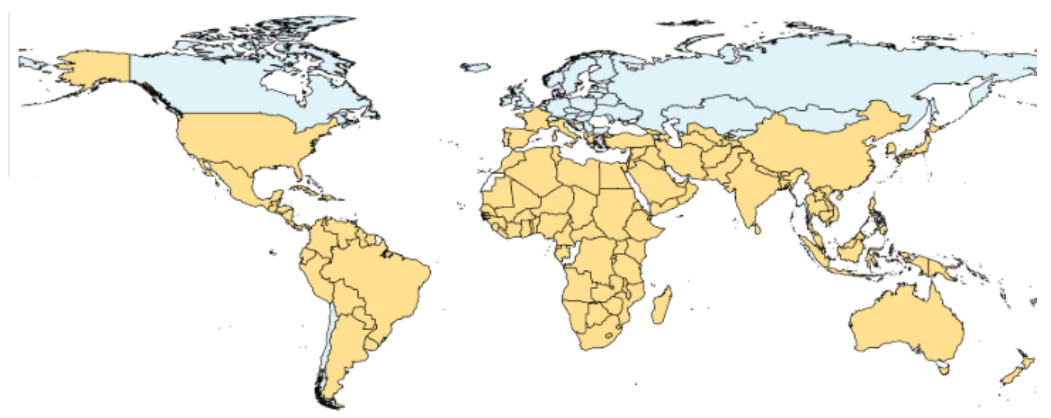
Persistence of Temperature Effect on GDP Levels Over 10 Years

(a) Persistent Growth Effects



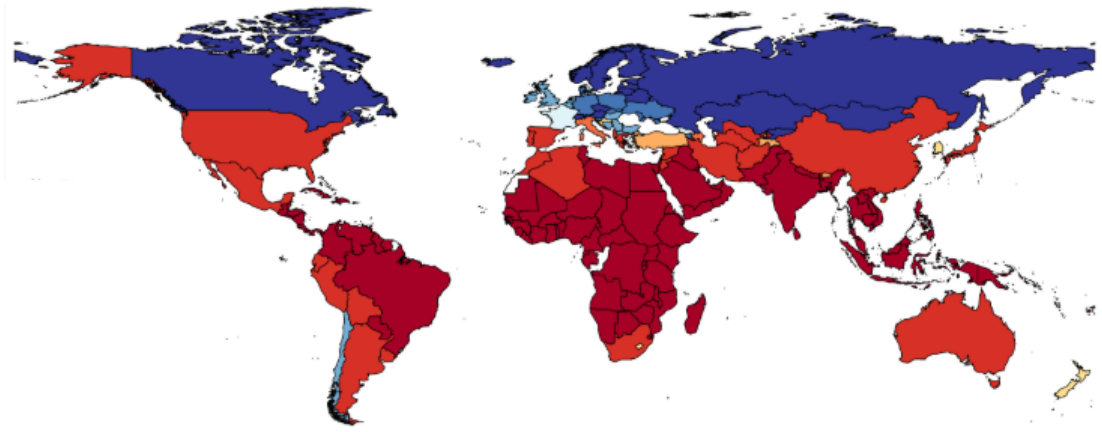
Global Median:  
19% per-capita income loss

(b) Level Effects



Global Median: 3.4% per-capita income loss

(c) Permanent Growth Effects



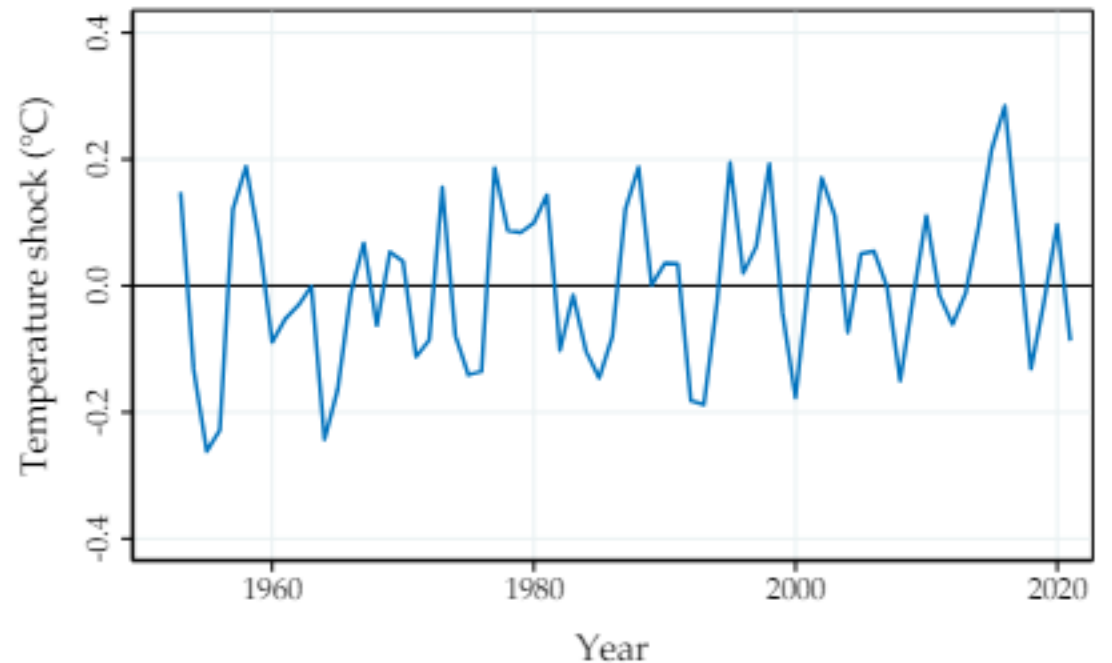
Global Median: 77% per-capita income loss

# 2099 GDP Effects Under RCP 8.5

# Climate Change Requires Projecting Far Out of Sample

- Climate change effects are:
  - Globally simultaneous: implications for trade adjustments and price effects distinct from idiosyncratic local shocks
  - Long-term: either intensifying effects or adaptive adjustments could amplify or dampen effects relative to short-run shocks
  - Larger than previous experience: linear extrapolation of local effects may be unwarranted

Figure 2: Global Temperature Shock



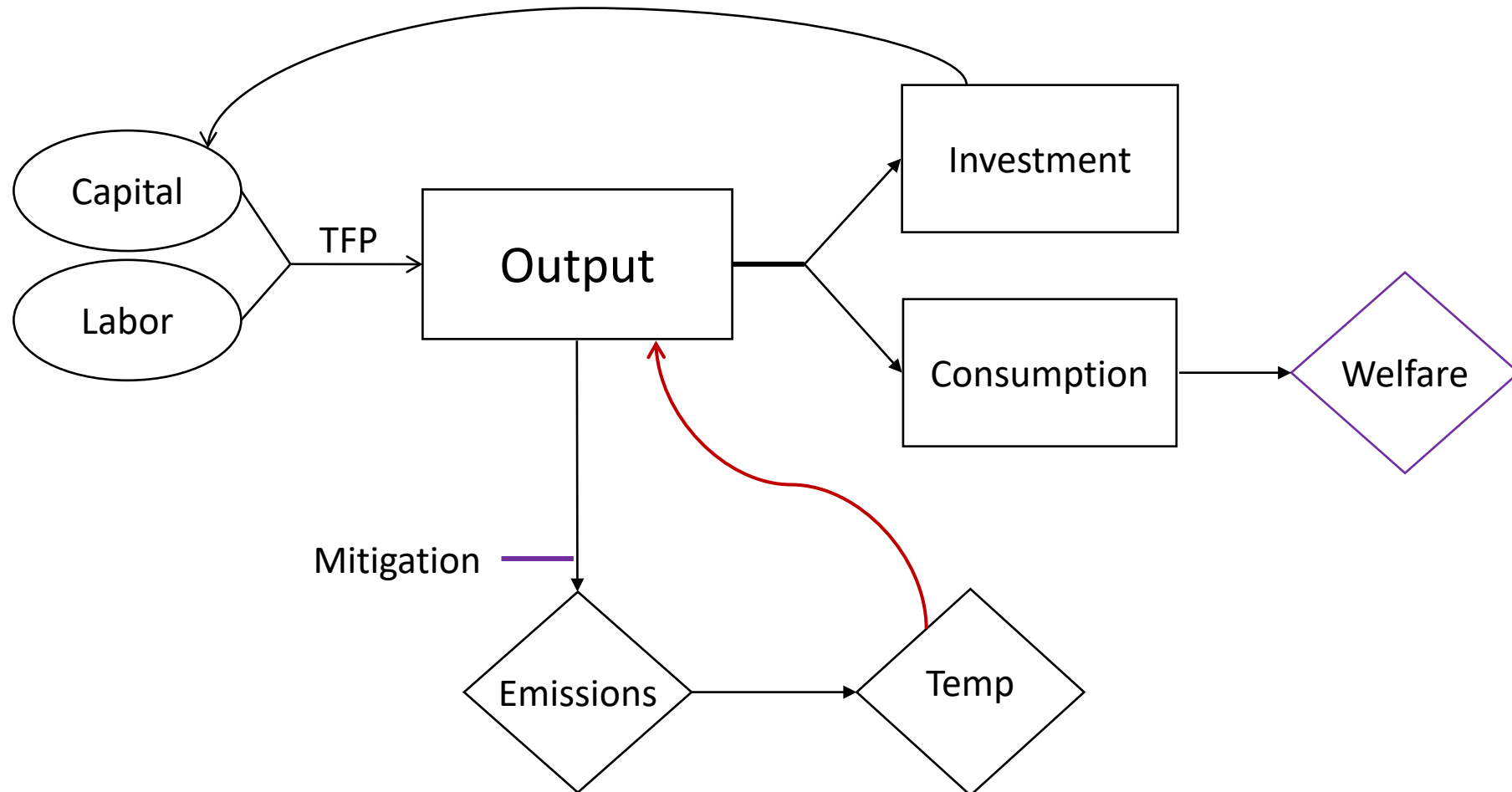
# Evidence / Research on Pathways Linking Climate Change and Growth

- Repeated capital destruction from extremes diverts investment and lowers growth trajectory (Hallegatte et al. 2007; Hsiang and Jina 2014; Liao and Kousky 2022)
- R&D diverted to climate change-adaptation slows rate of technological advance (Ortiz-Bobea et al. 2024)
- Extreme temperatures reduce work-hours and lower labor productivity (Rode et al. 2022; Graff-Zivin and Neidell, 2014; Lima et al. 2021)
- Hot temperatures and natural disasters reduce learning and slow human capital formation (Opper et al. 2023; Park, 2020; Park et al. 2020)
- Climate change increases risk of violent conflict (Mach et al. 2019; Hsiang, Burke and Miguel, 2013)
- Climate change likely to damage natural capital stock with potentially long-lived implications for human welfare (Bastien-Olvera and Moore, 2022)

# Goals

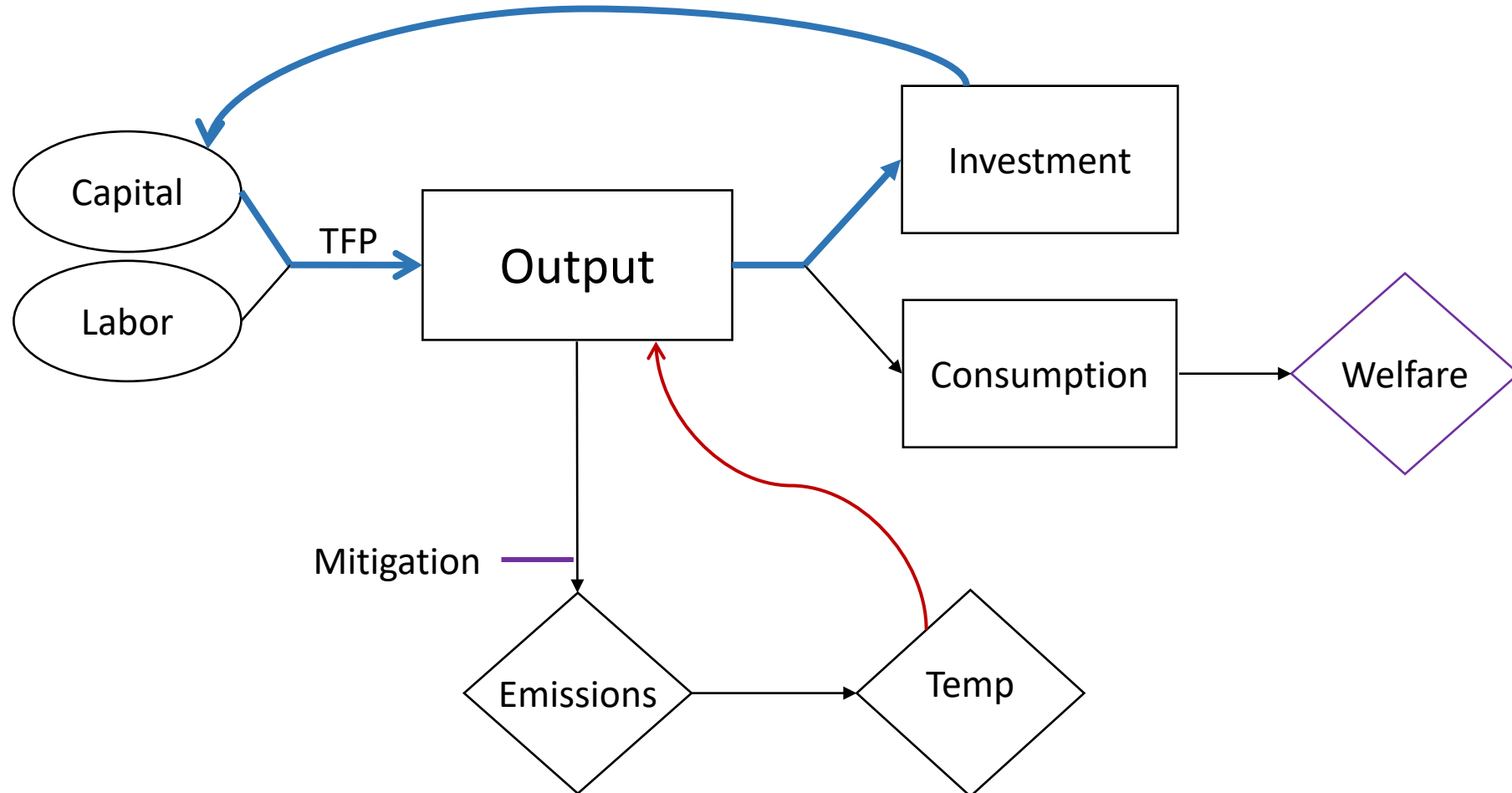
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# Application 1: Social Cost of Carbon

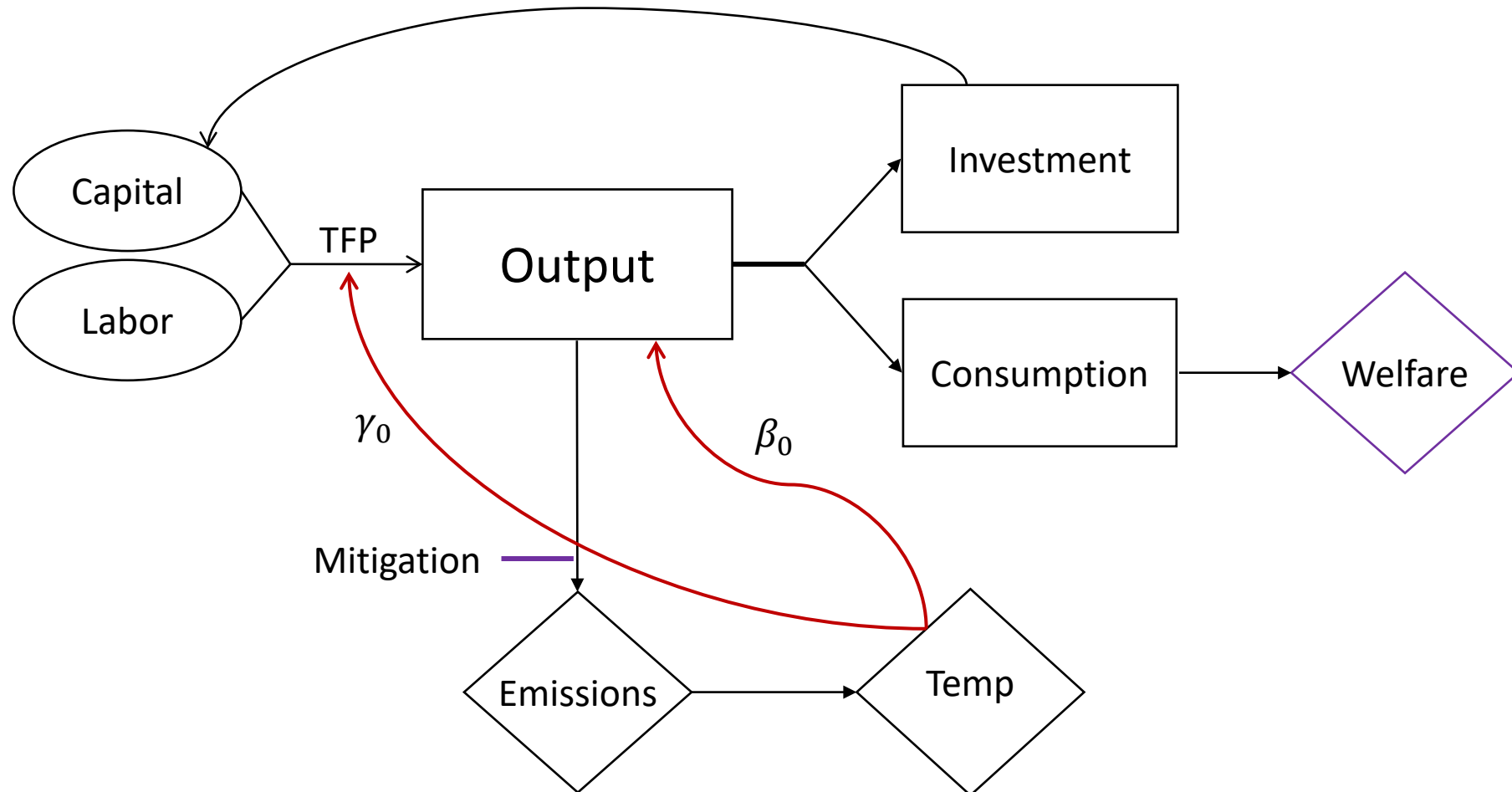




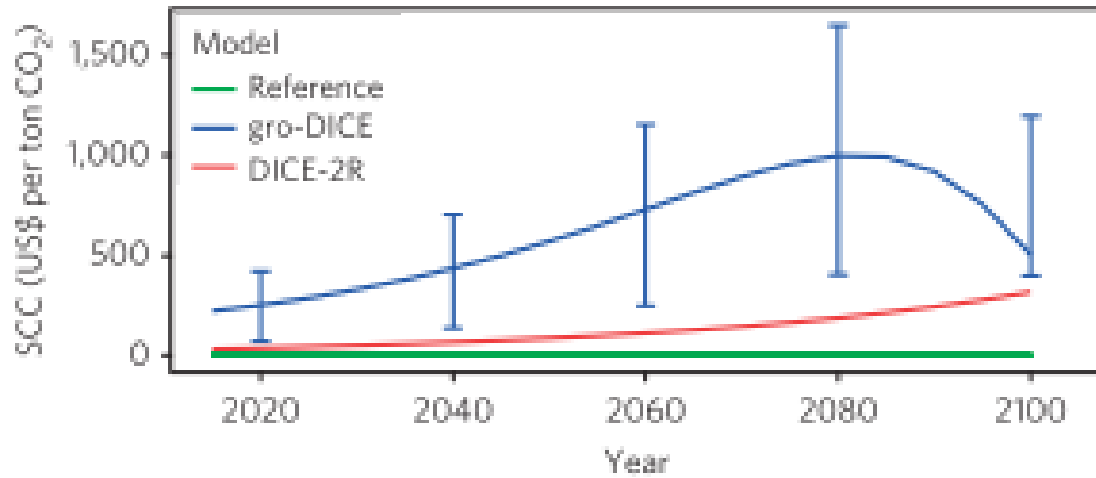
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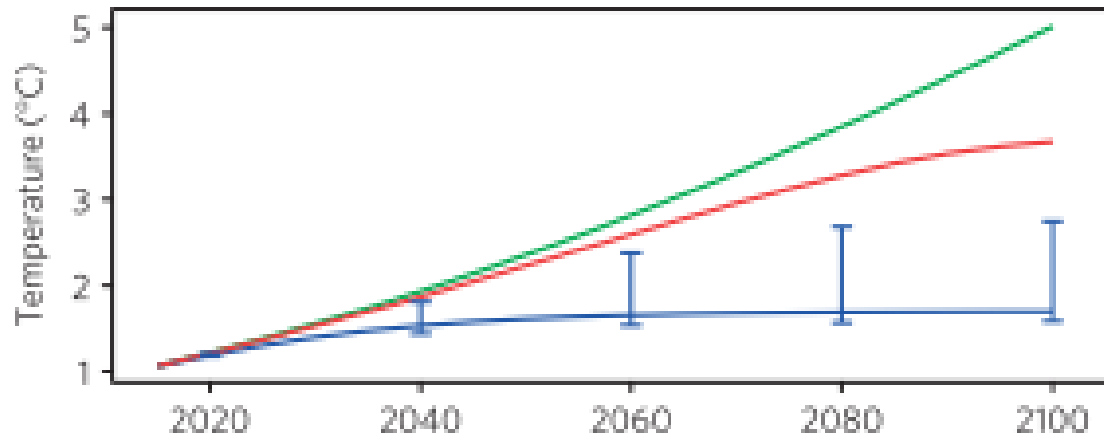
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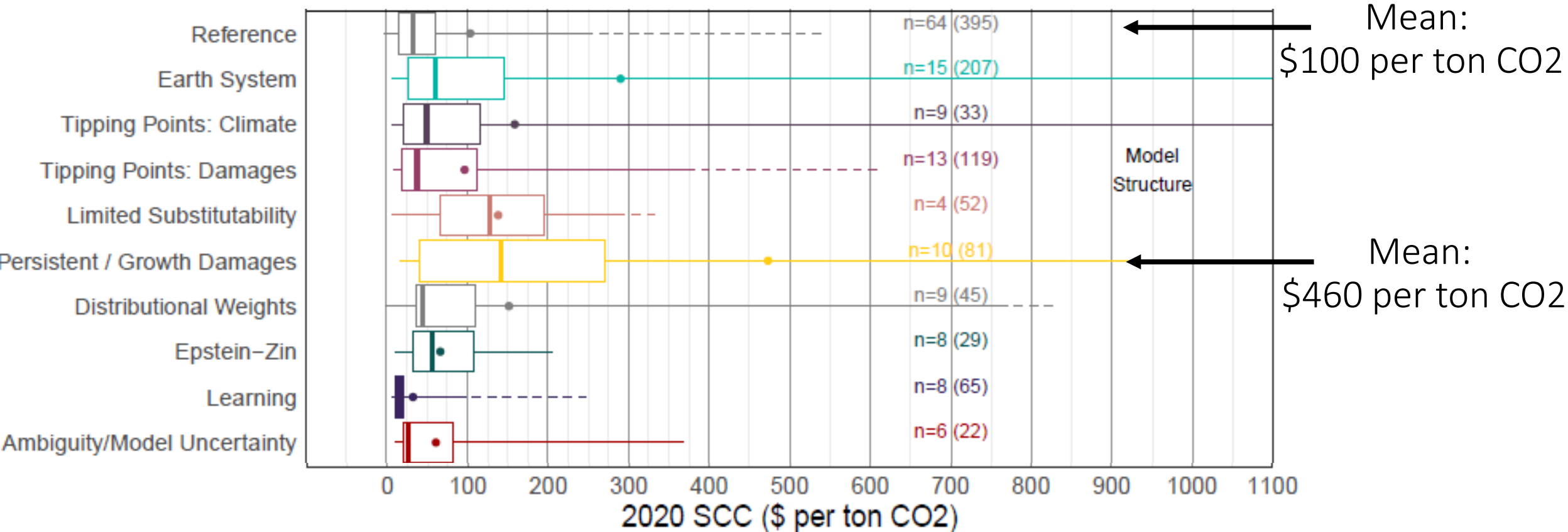


← SCC increases by 8 times



← Optimal 2100 temperatures decreased from >3° to <2°

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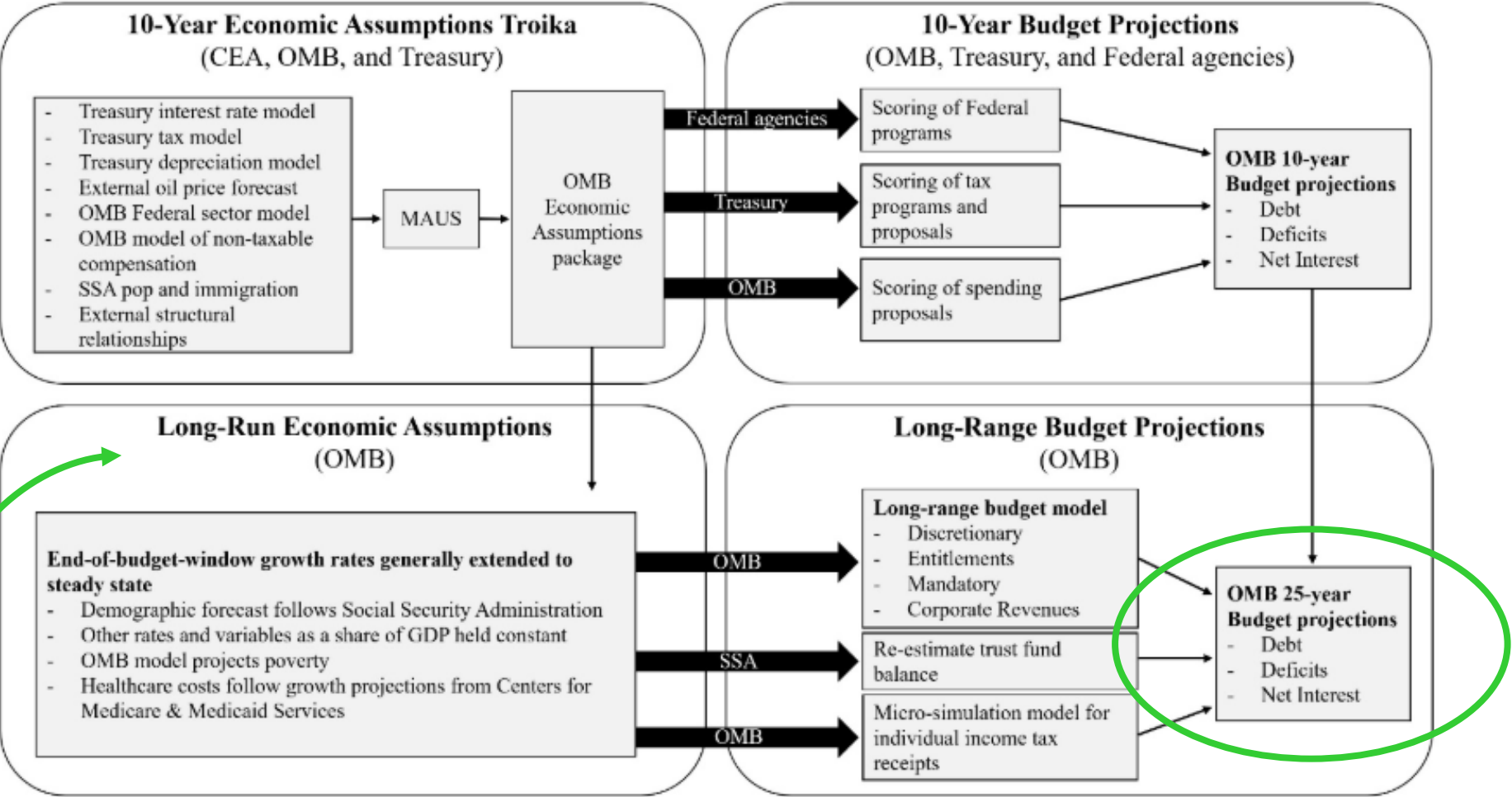
“Including an empirical estimate of damage persistence demonstrates that even minor departures from the assumption that climate shocks do not affect GDP growth have major economic implications and eclipse most other modeling decisions”

Kikstra et al., 2021

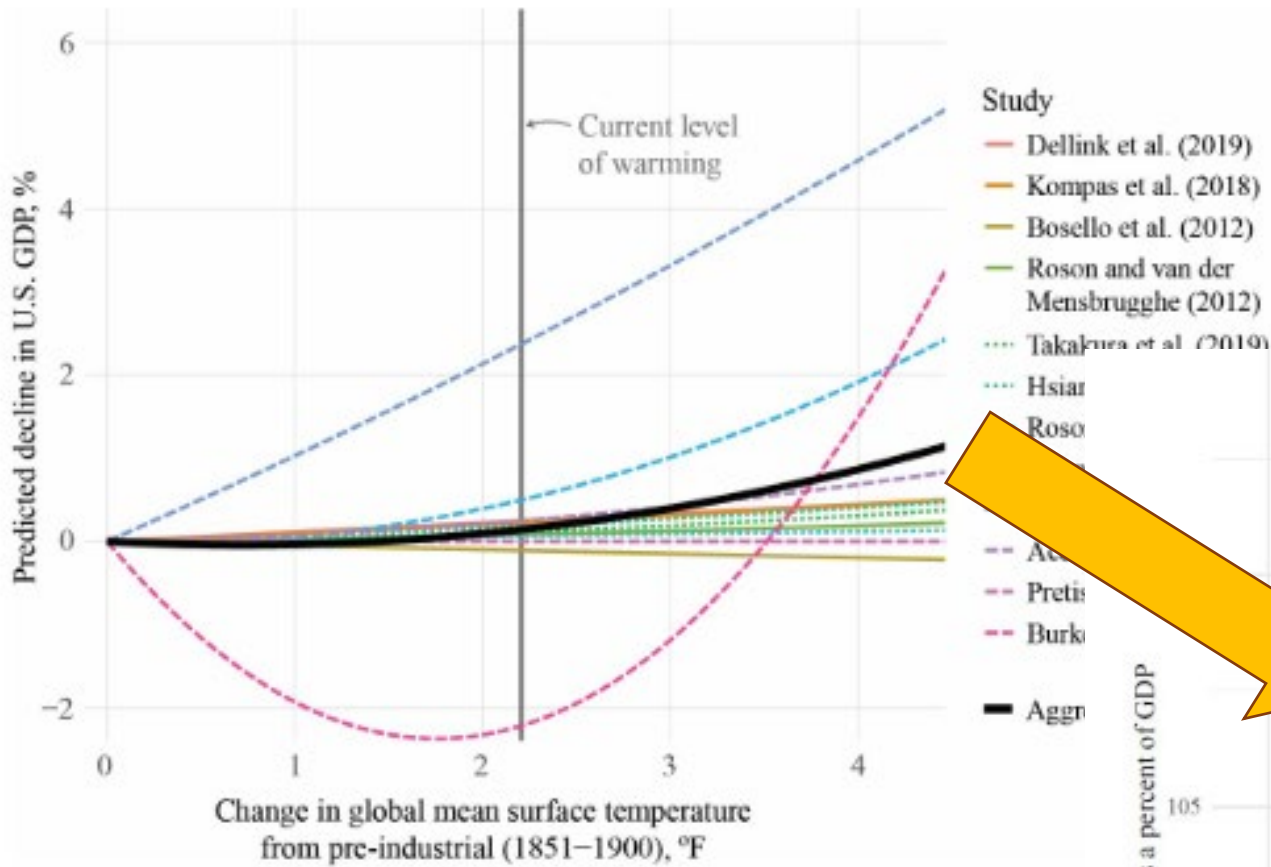
# Application 2: Macroeconomic Forecasting

- Several policy applications require forecasting economic growth over 10-20 years:
  - Government fiscal planning and budgeting
  - Long-term financial investments / obligations e.g. pension plans
- Very different application from social cost of carbon:
  - GDP not welfare
  - Shorter time horizons (10-20 years)
  - Total not marginal impacts

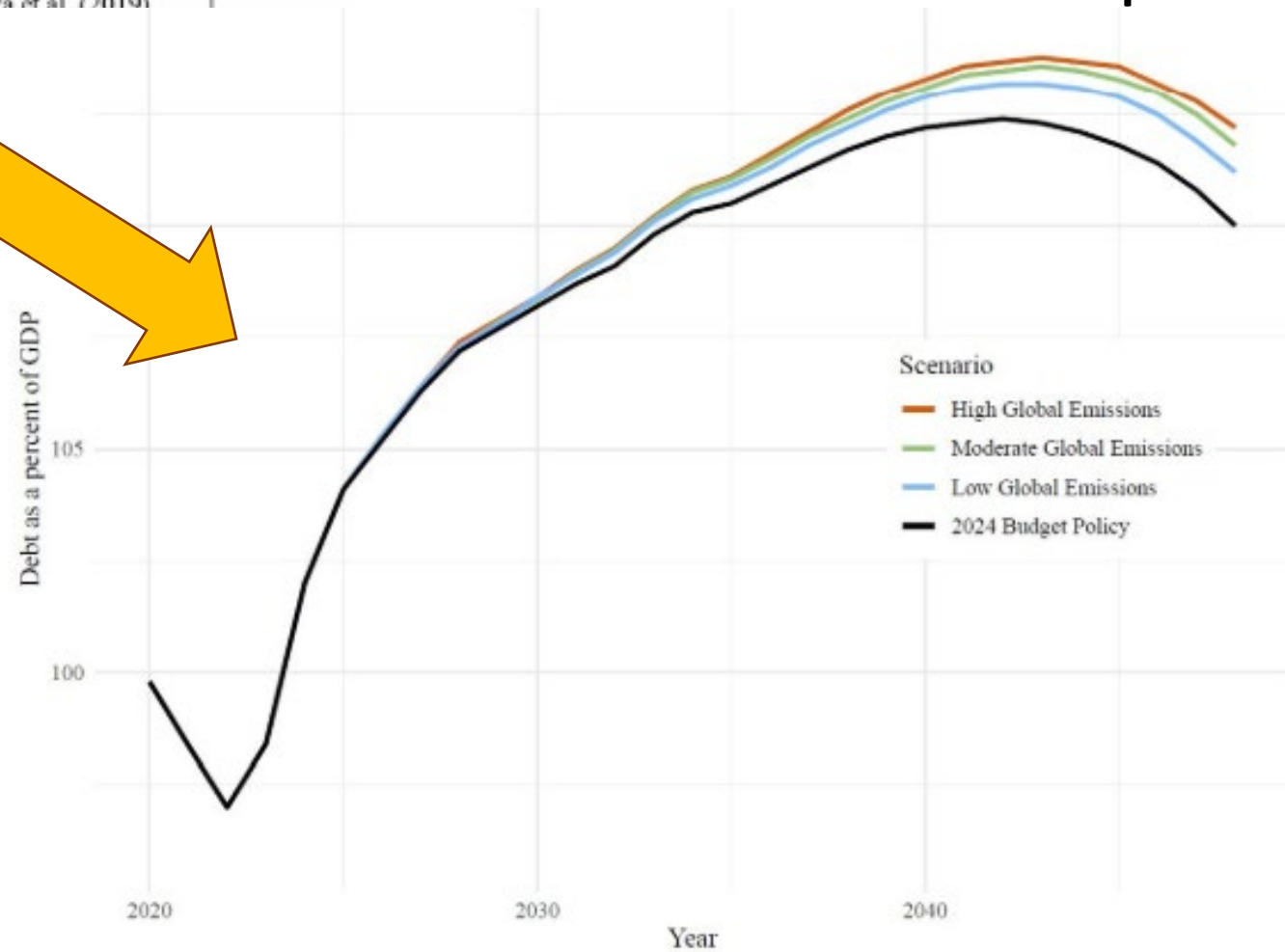
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**CLIMATE CHANGE**



# Debt / GDP Trajectory with and Without Climate Impacts





# Summary for Discussion

- There are a number of pathways by which climate change could plausibly affect determinants of growth
- Growing empirical evidence both for persistent effect of temperature shocks on economic output and relevant mechanisms that could generate persistent effects
- These dynamics effects are of first-order importance for the magnitude of aggregate climate change damages
- Forward projection of compounding, persistent effects still generates large uncertainties.
- Improved synthesis between structural models simulating drivers of growth and empirical findings on possible climate effects would have high value

# One Final Thought:



- Responses to climate change are substantial and also have plausible macroeconomic implications
- Global temperature targets require rapid build out of clean-energy infrastructure in next 30 years
- Implications for energy price levels and volatility, regional labor markets, and investment levels and productivity