Will Adaptation Save Us from Climate Change?

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Outline

I. Background on Climate Change

II. What Does Economic Theory Tell Us About Adaptation?

III. Empirical Evidence on Adaptation to Environmental Threats

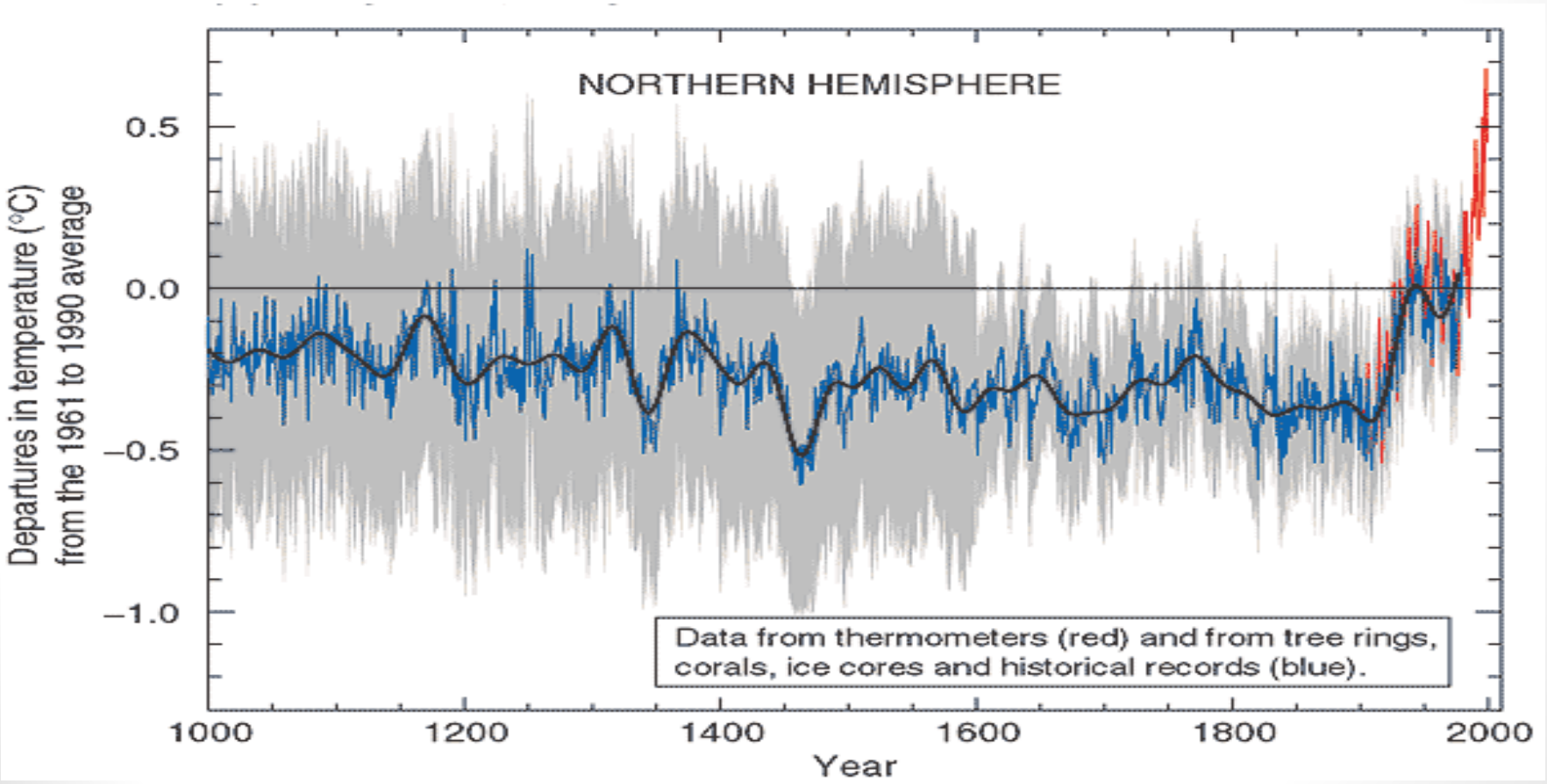
IV. Conclusions

I. Background on Climate Change

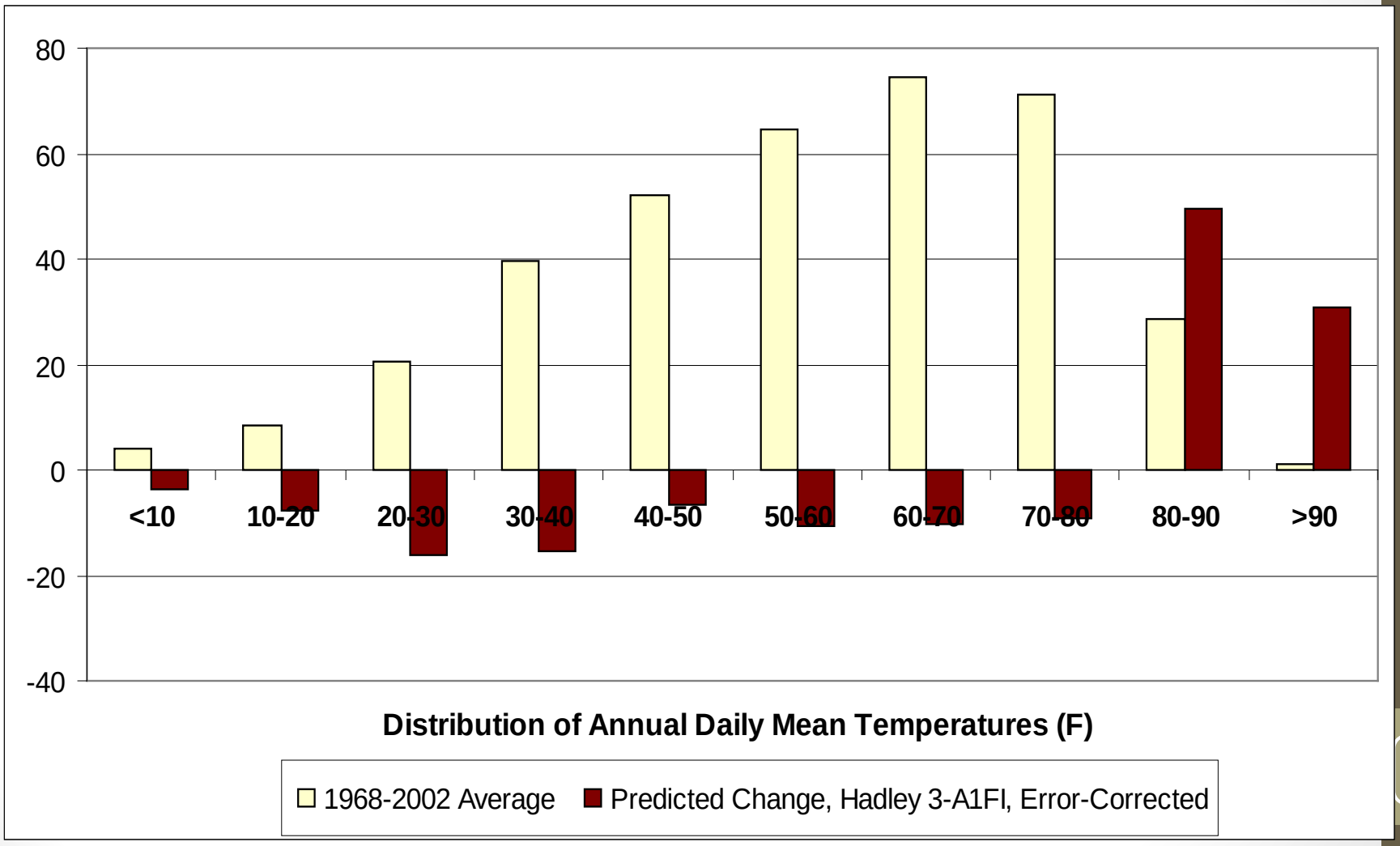
A. Temperatures have been Increasing and are Expected to Rise Further

Climate Change and Temperatures

- There is near consensus that emissions from human activity (CO_2) will lead to climate changes (e.g., increased temperature, precipitation, and variability)



Current Daily Temperature Distribution and Projected Change at the End of the Century



Adverse Effects of Climate Change

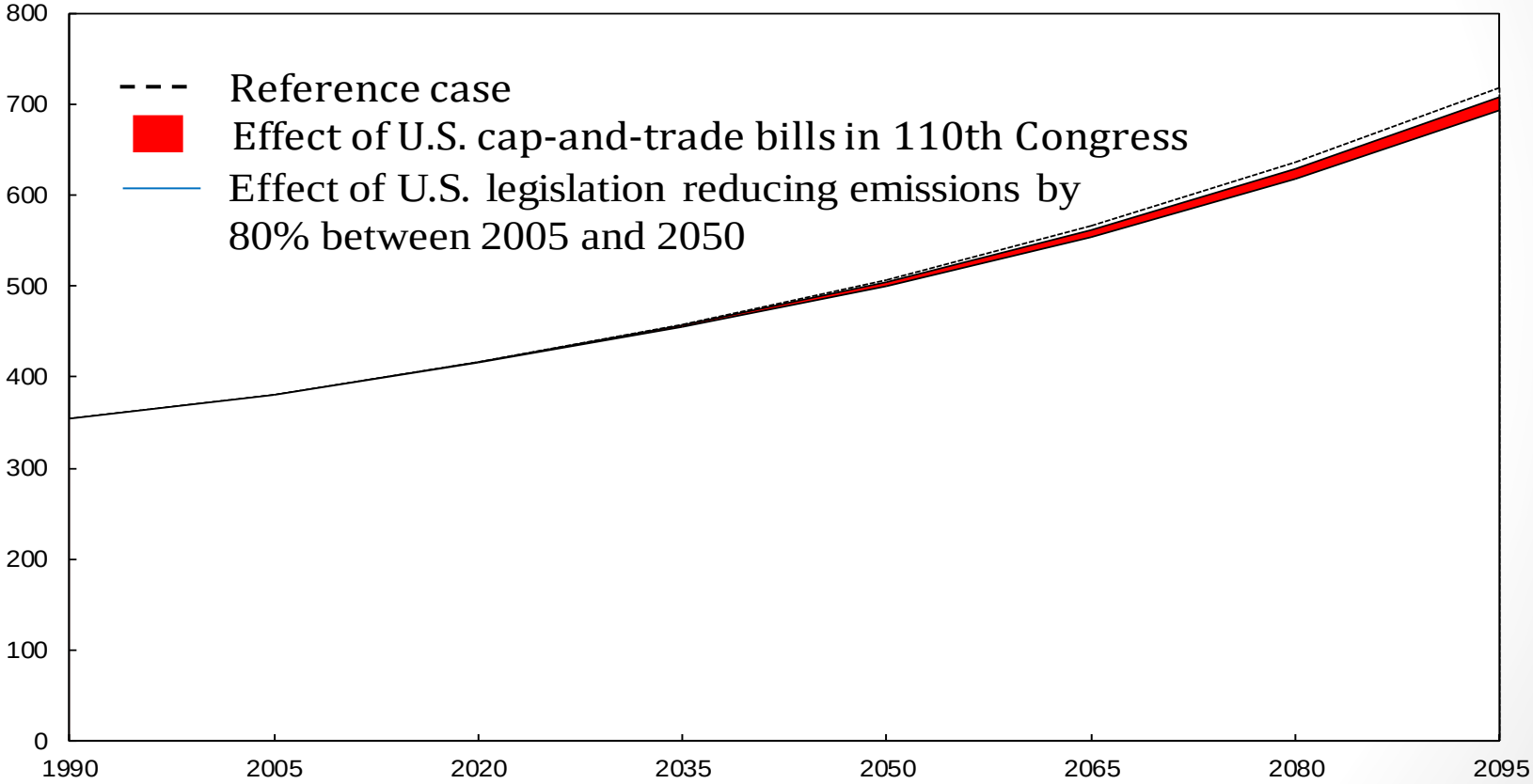
- According to the 4th Report of the IPCC, the negative impacts of climate change include:
  - Hundreds of millions of people exposed to increased water stress
  - Up to 30% of species at increased for extinction, and significant extinctions around the globe
  - Increased damage from floods and storms, with about 30% of coastal wetlands lost
  - Increased mortality and morbidity from heat waves, floods, and droughts
  - Negative impacts on subsistence farmers and fishers
  - Farming productivity to decrease at low latitudes and potentially decrease at high latitudes
  - Changed distribution of disease vectors

B. Stopping Climate Change Will Be Expensive

The U.S. Can't Do It Alone

Global Atmospheric CO_2 Concentrations

Parts per million



Source: EPA (emissions) and MIT

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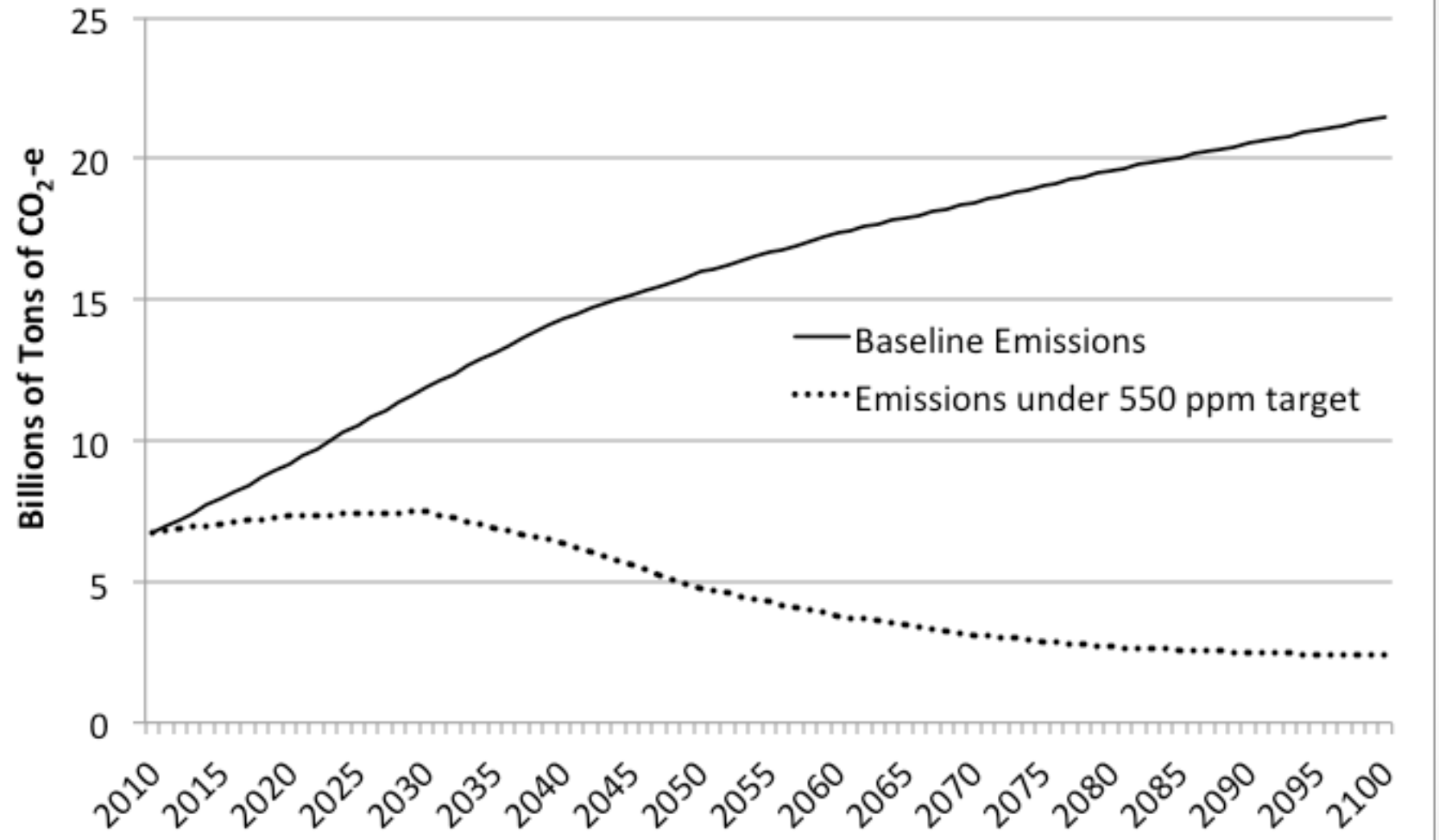
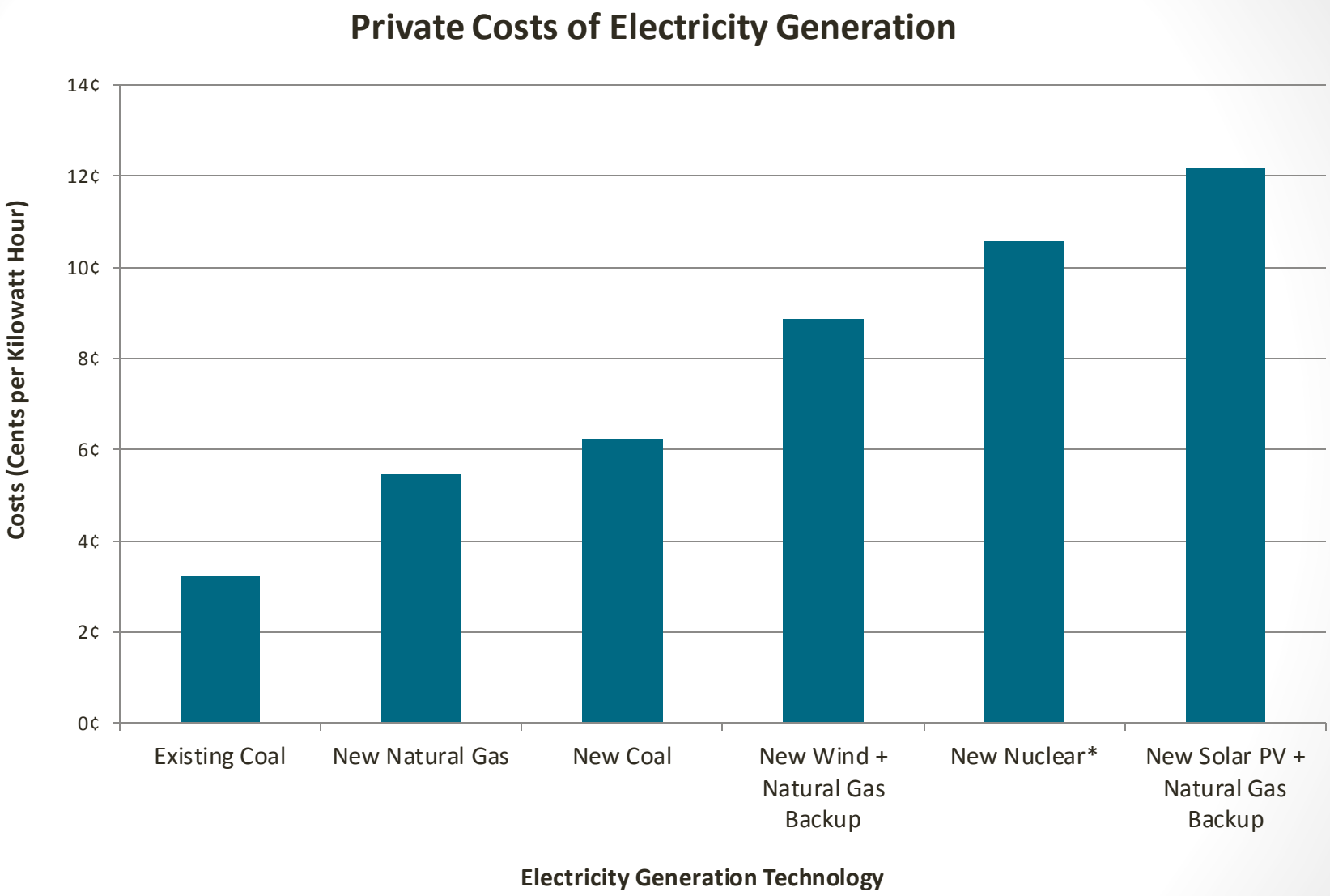
Figure 1: Chinese Emissions under Baseline vs. Mitigation Scenarios



Source: Authors' calculations based on Energy Modeling Forum estimates.

Fossil Fuels are Much Cheaper than the Alternatives



Inexpensive Fossil Fuels are Abundant

- New Drilling Techniques are Greatly Increasing the Supply of Natural Gas and Petroleum
- Coal Reserves:
  - U.S.: 263 billion short tons of recoverable reserves (at 2008 consumption pace, enough for 234 years)
  - China: 114.5 billion short tons of recoverable reserves (at 2008 consumption pace , enough for 38 years)
  - India: 62.3 billion short tons of recoverable reserves (at 2007 consumption pace, enough for 108 years)

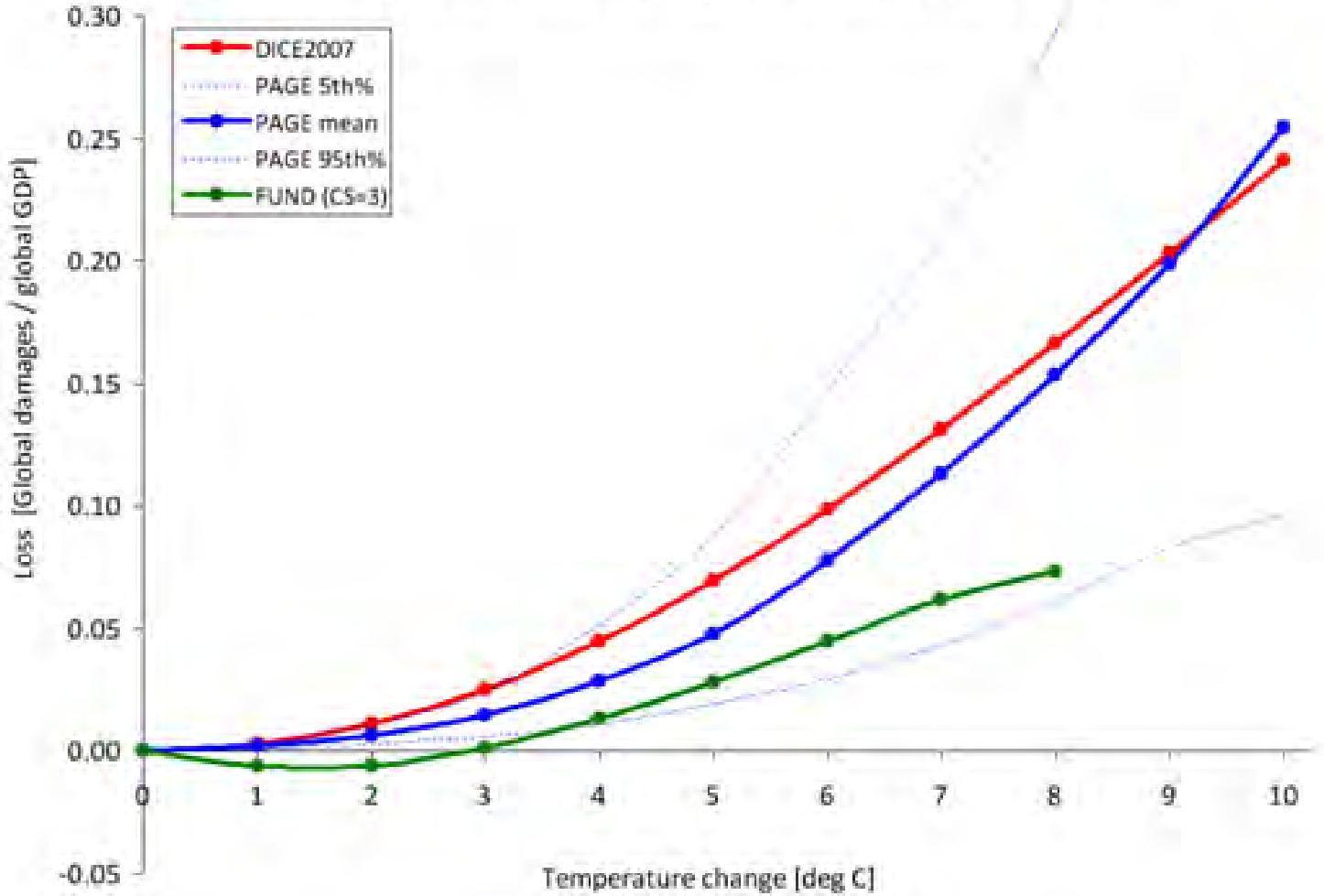
Alternative Wisdom

"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

-Thomas Edison

On the other hand, the Unabated Costs of Climate Change Are Not Small

Figure 1: Annual Consumption Loss as a Fraction of Global GDP in 2100 Due to an Increase in Annual Global Temperature in the DICE, FUND, and PAGE models



II. What Does Economic Theory Tell Us About Adaptation?

Takeaways

1. Full Cost of Adaptation Includes Compensatory Responses, as Well as More Conventionally Measured Outcomes

2. Impacts on Health/Crop Yields or other Conventionally Measured Outcome Could be Small But Total Costs Could Still be Significant. It depends on the Availability and Cost of Defensive Technology

3. Environmental Changes will Induce Directed Technical Change

A. Extreme Temperatures in the US

"Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US"

Deschenes and Greenstone
American Economic Journal: Applied Economics, 2011

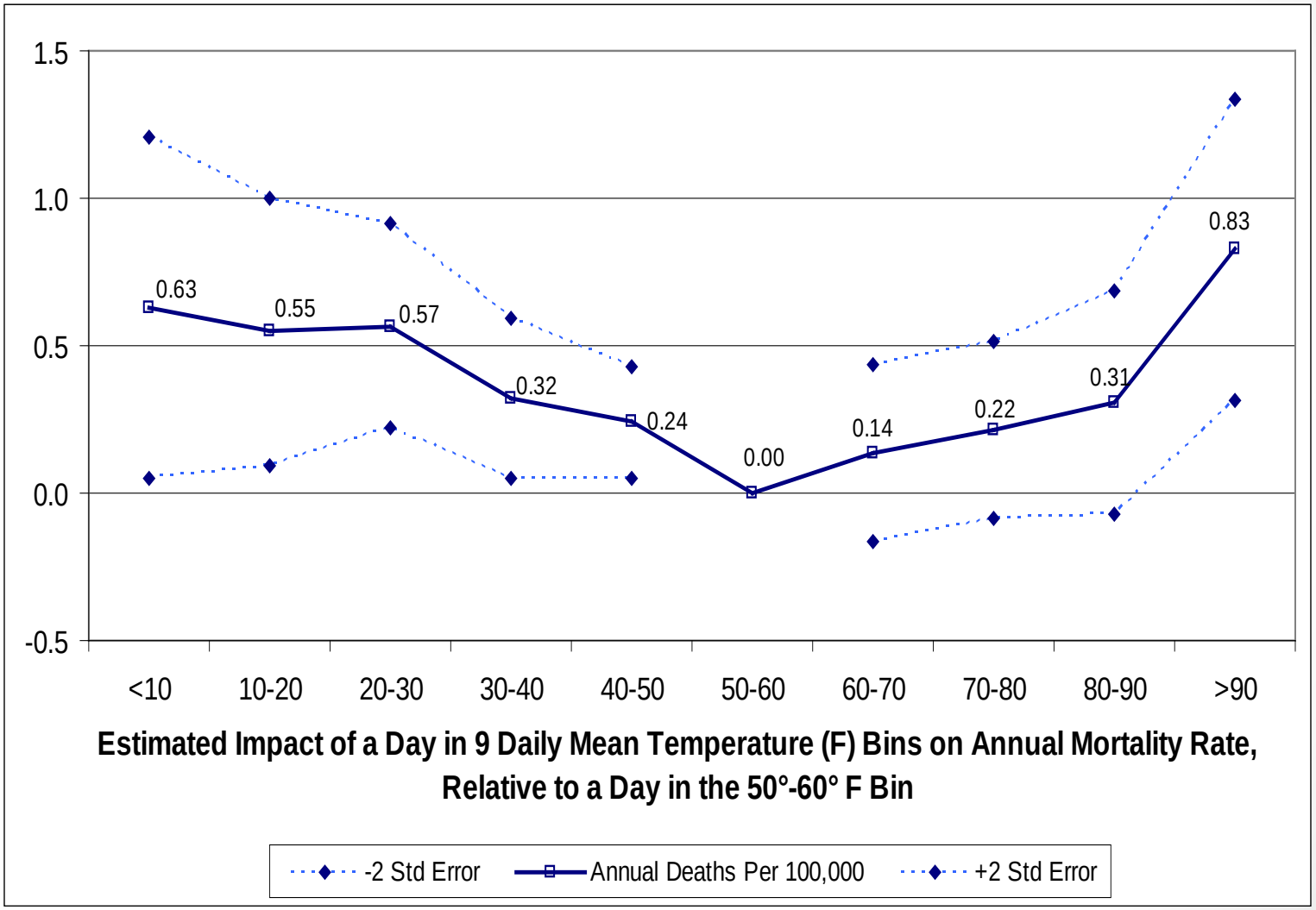
Questions

1. What are the Impacts of Extreme Temperatures in the US on Mortality?

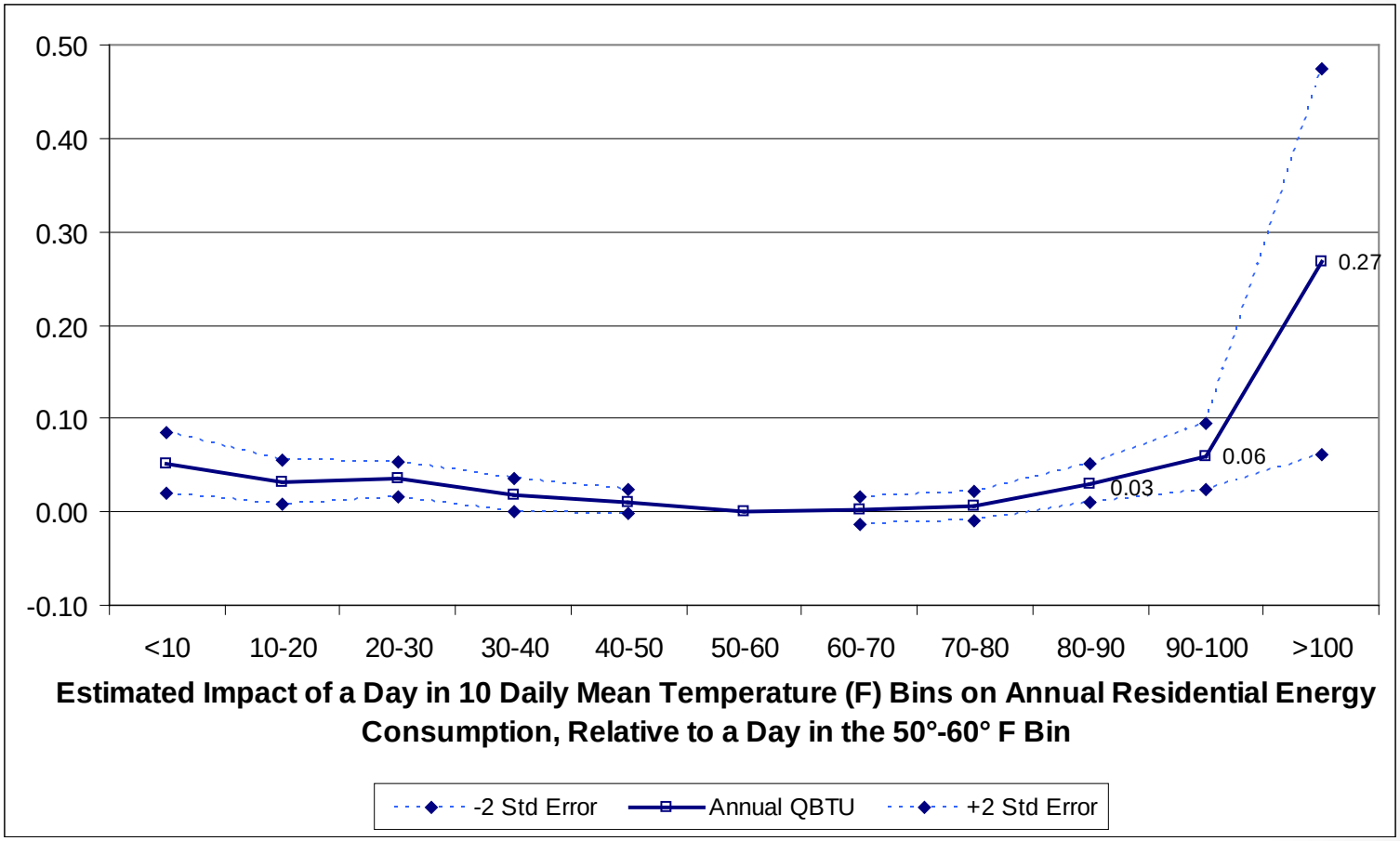
2. What are the Impacts of Extreme Temperatures on Adaptation?

3. Based on Short-Run Adaptation Only, What are the Costs of Extreme Temperatures on Climate Change?

Relationship Between Mortality and Temperature in the US

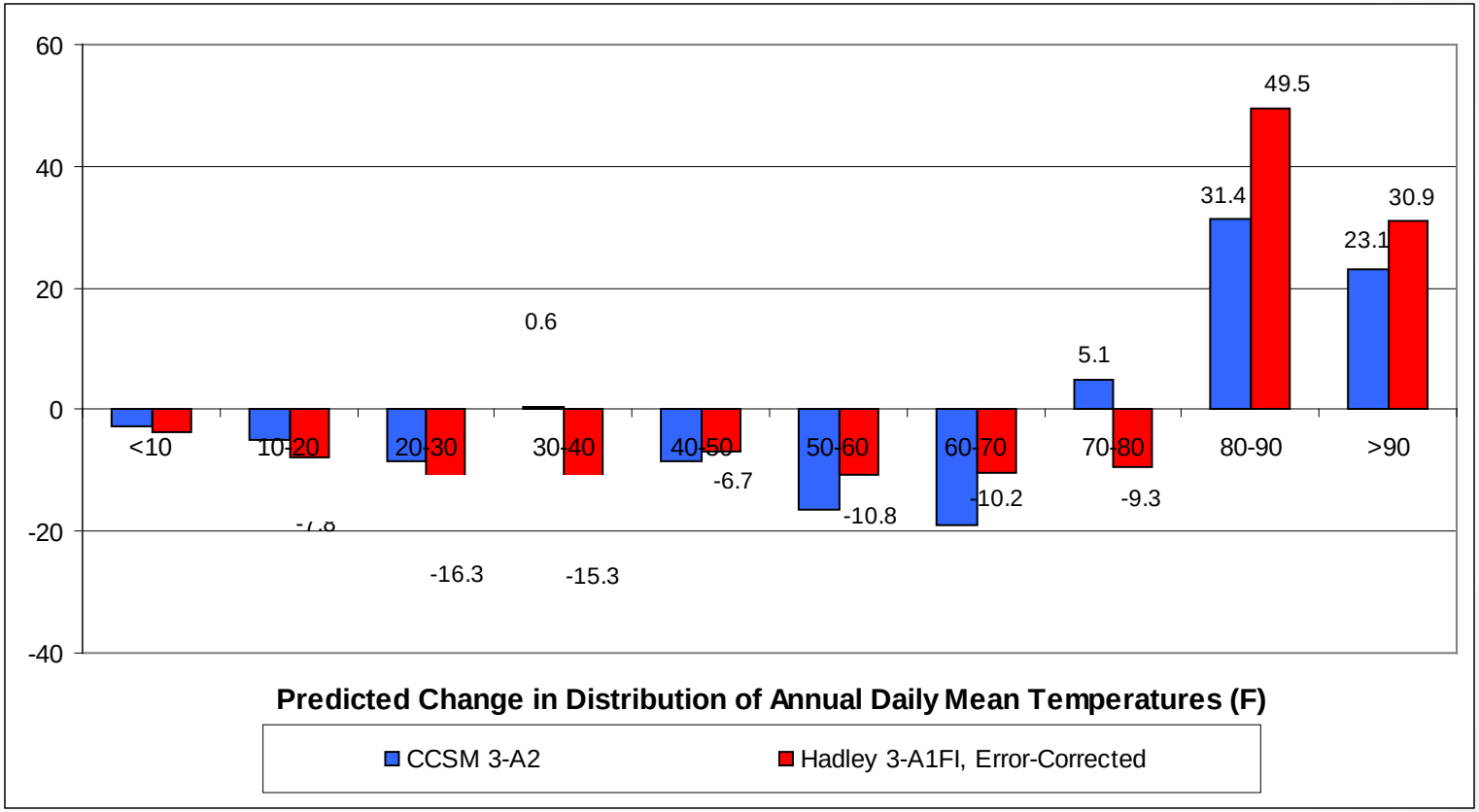


Relationship Between US Residential Energy Consumption and Temperature



Projected Climate Change Impacts

Predicted Change in Distribution of Temperature for 2070-2099, US



Summary of Findings and Interpretation, Assuming No Change in Adaptation Opportunities

- 3.0% increase in annual mortality rate by the end of the century

→ In last 35 years, US annual mortality rate has declined by about 1% per year

- 13% ($15 billion) Increase in Energy Consumption (Air Conditioning) in Response to Hot Days

- Highlights individuals' willingness and ability to engage in costly adaptation in US

B. Extreme Temperatures in India

"Weather and Death in India: Mechanisms and Implications of Climate Change"

Burgess, Deschenes, Donaldson, and Greenstone, 2011

Setting: India

- GDP per capita: $640

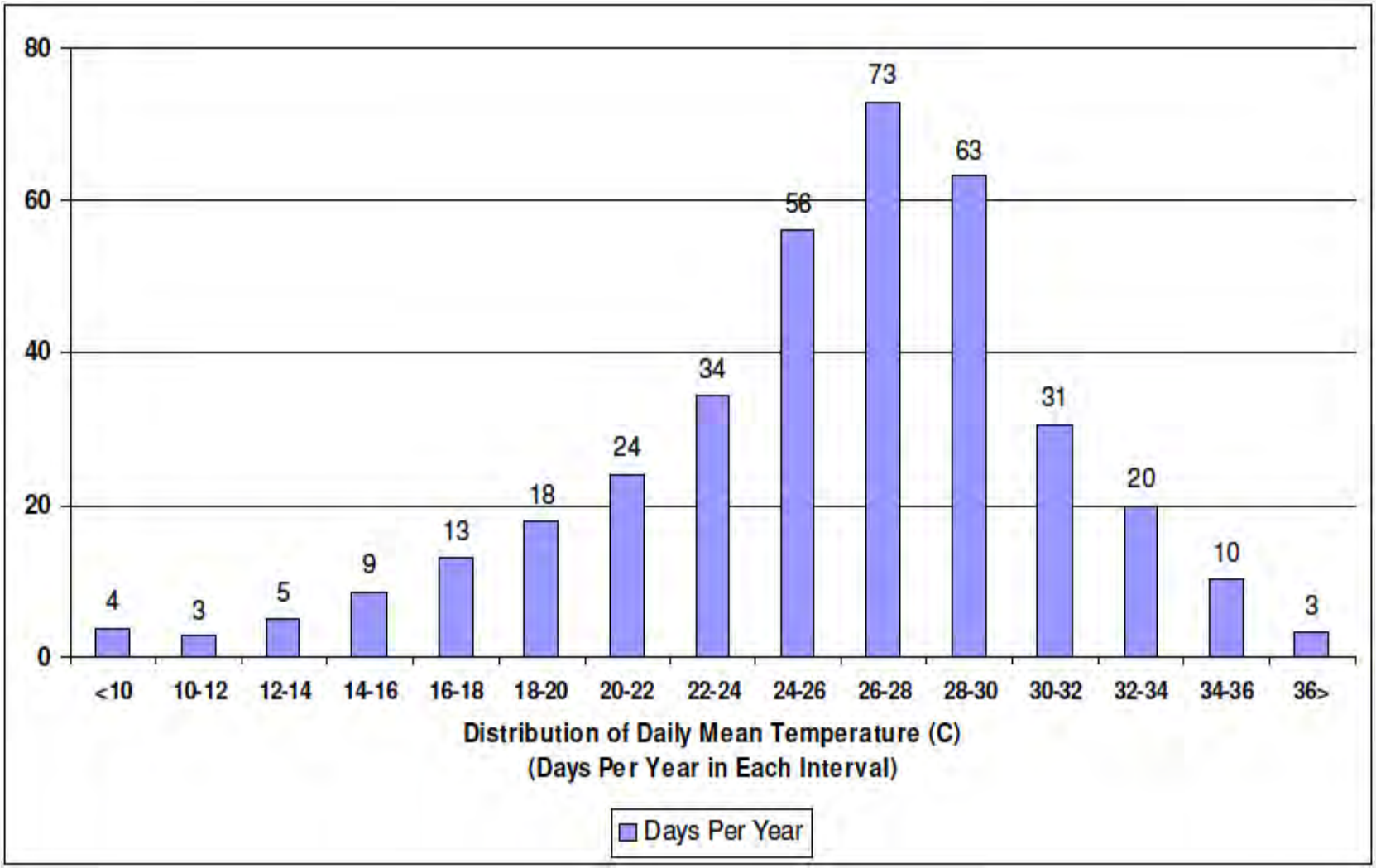
- Life expectancy: about 65, median age 25,
- Crude death rate: 8 per 1,000

- Agriculture accounts for 22% of GDP and 60% of employment

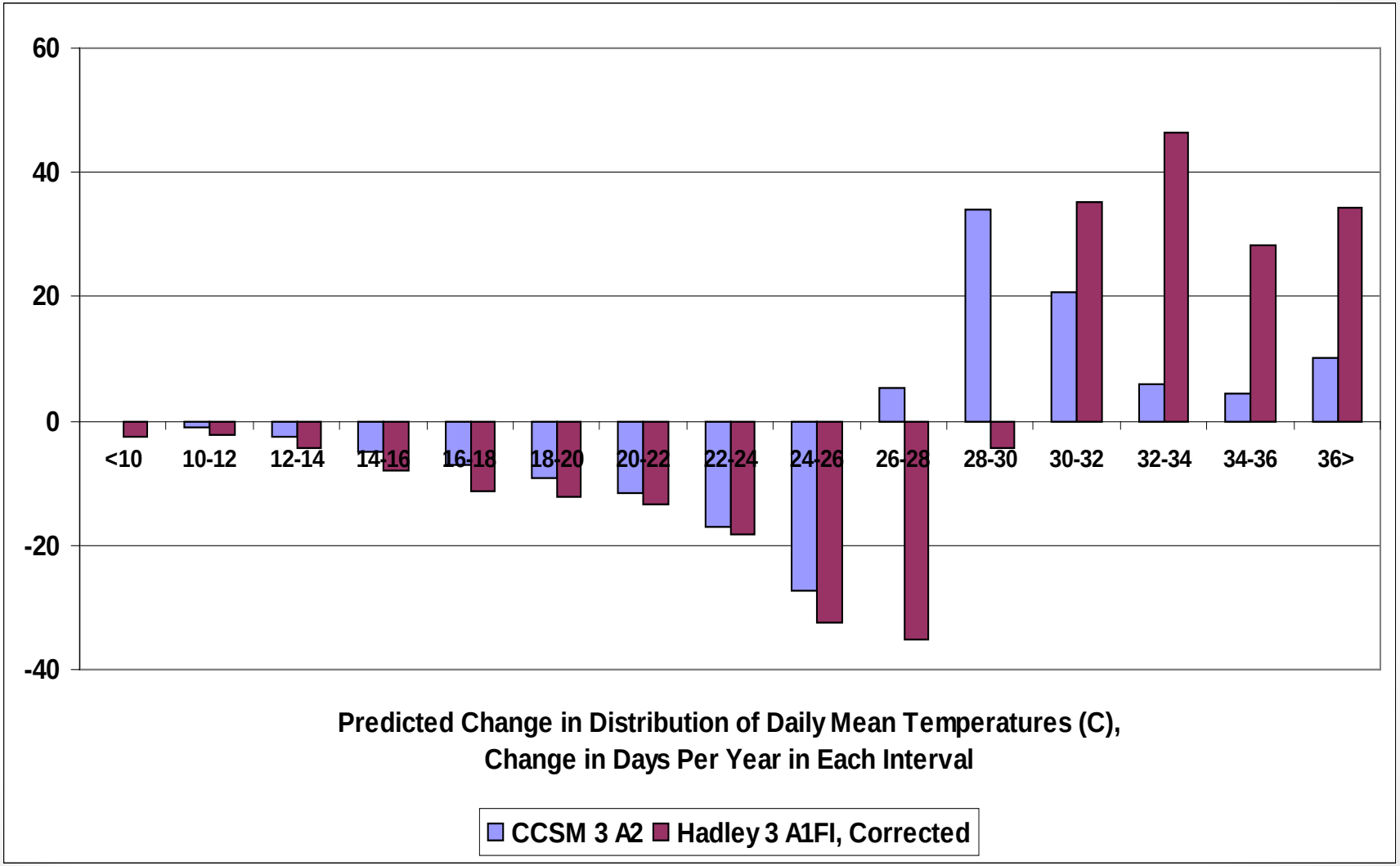
- **Rural / urban sectors:**
- 75% of population lives in rural sectors (<5,000)
- Higher poverty rates (39.4 vs. 22.5, 1983)
- Higher dependence of agriculture (income and food)

- $\Rightarrow$ Rural population's real income more exposed to weather shocks than urban population

Distribution of daily mean temperatures, 1957-200



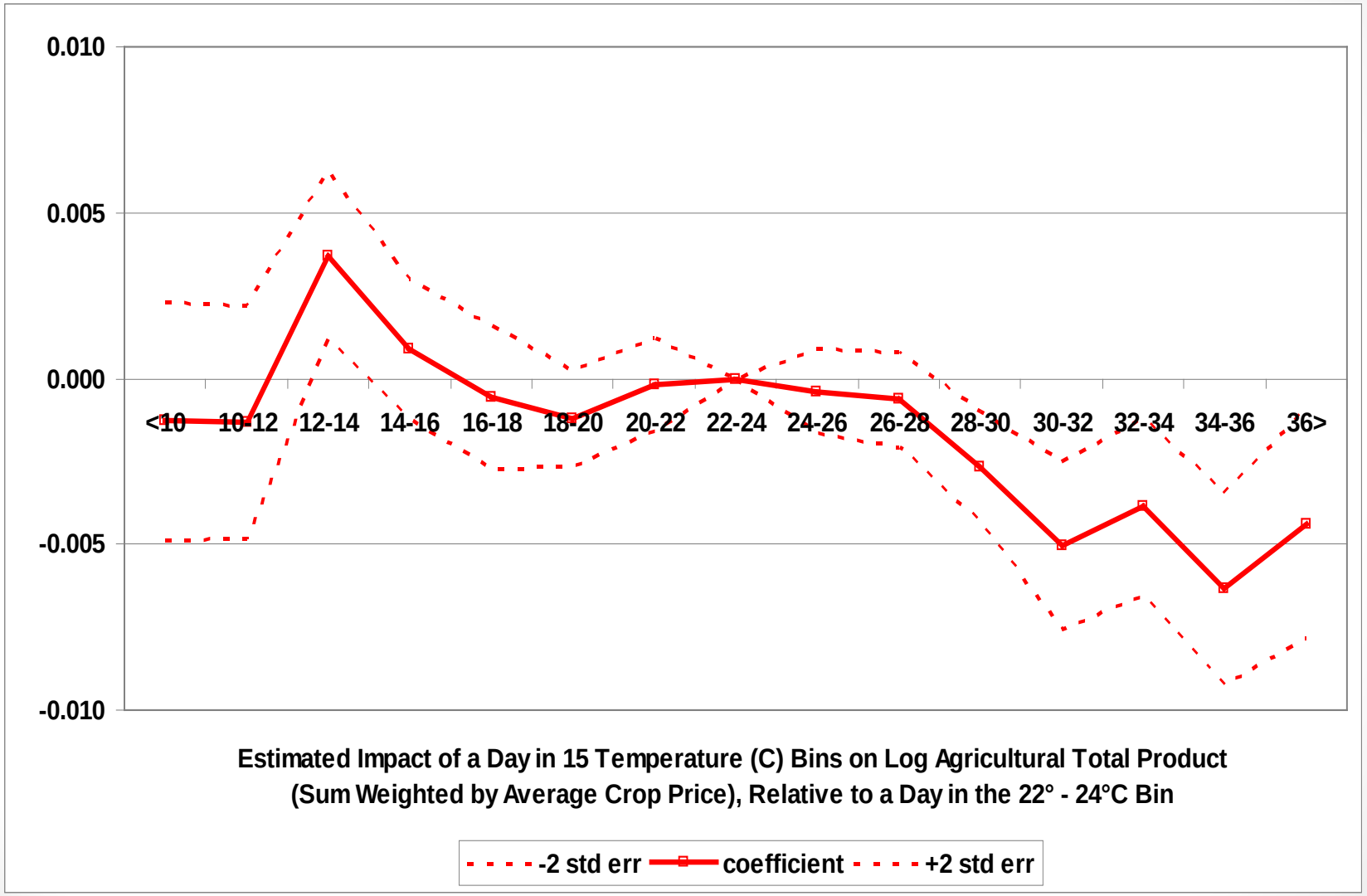
Predicted change in annual distribution of daily temperatures for 2070-2099, India



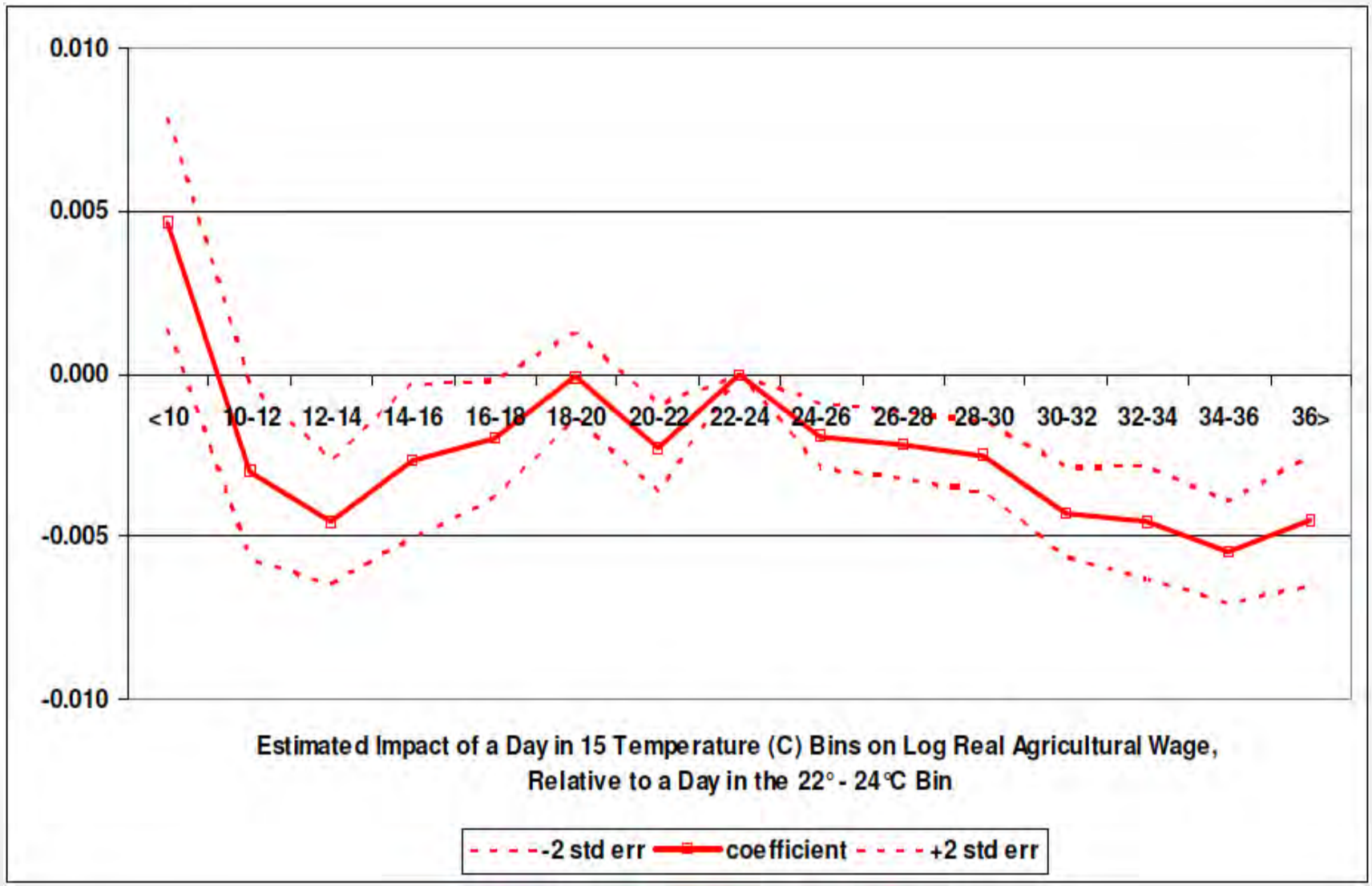
Impact of Weather Shocks in Rural India on Economic Outcomes

Temperature and Productivity: Rural Areas

Rural Productivity: Aggregate agricultural output per hectare

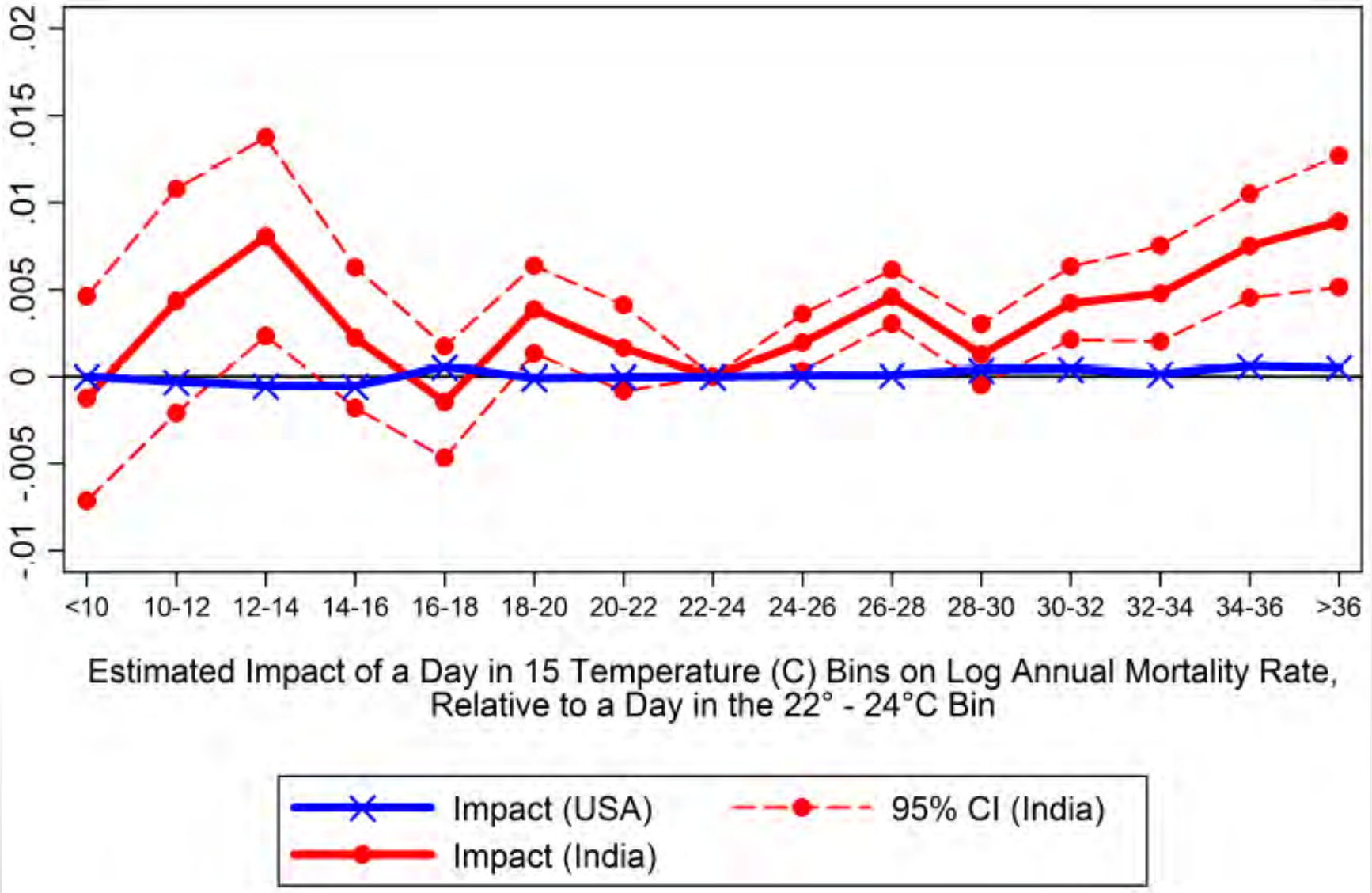


Estimated Response Function Between Log Agricultural Wage Rate and Daily Temperature



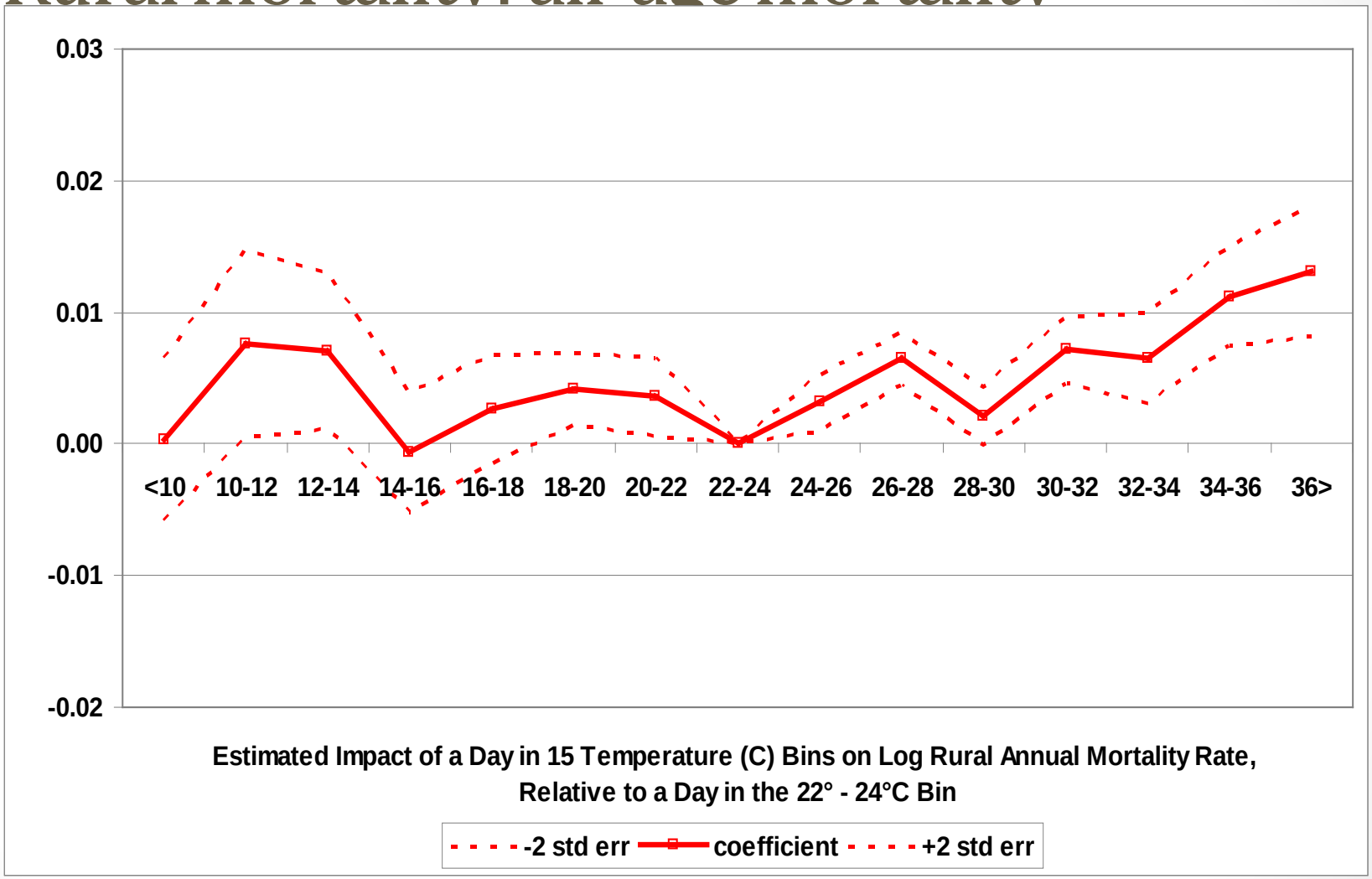
Impact of Weather Shocks in India on Mortality Rates

Unequal Adaptation? Relationship Between Log Annual Mortality Rate and Daily Temperature in India and US



Temperature and Mortality: Rural Areas

Rural mortality: all-age mortality



Summary of Findings and Interpretation, Assuming No Change in Adaptation Opportunities

1. In India, Hot Days Associated with
    a. Sharp Decline in Agricultural Output
    b. Sharp Decline in Rural Wages
    c. Sharp Increases in Mortality Rates

2. 46.0% increase in annual mortality rate by the end of the century, compared to 3% in the U.S.

3. Highlights India Currently has Fewer Adaptation Opportunities.

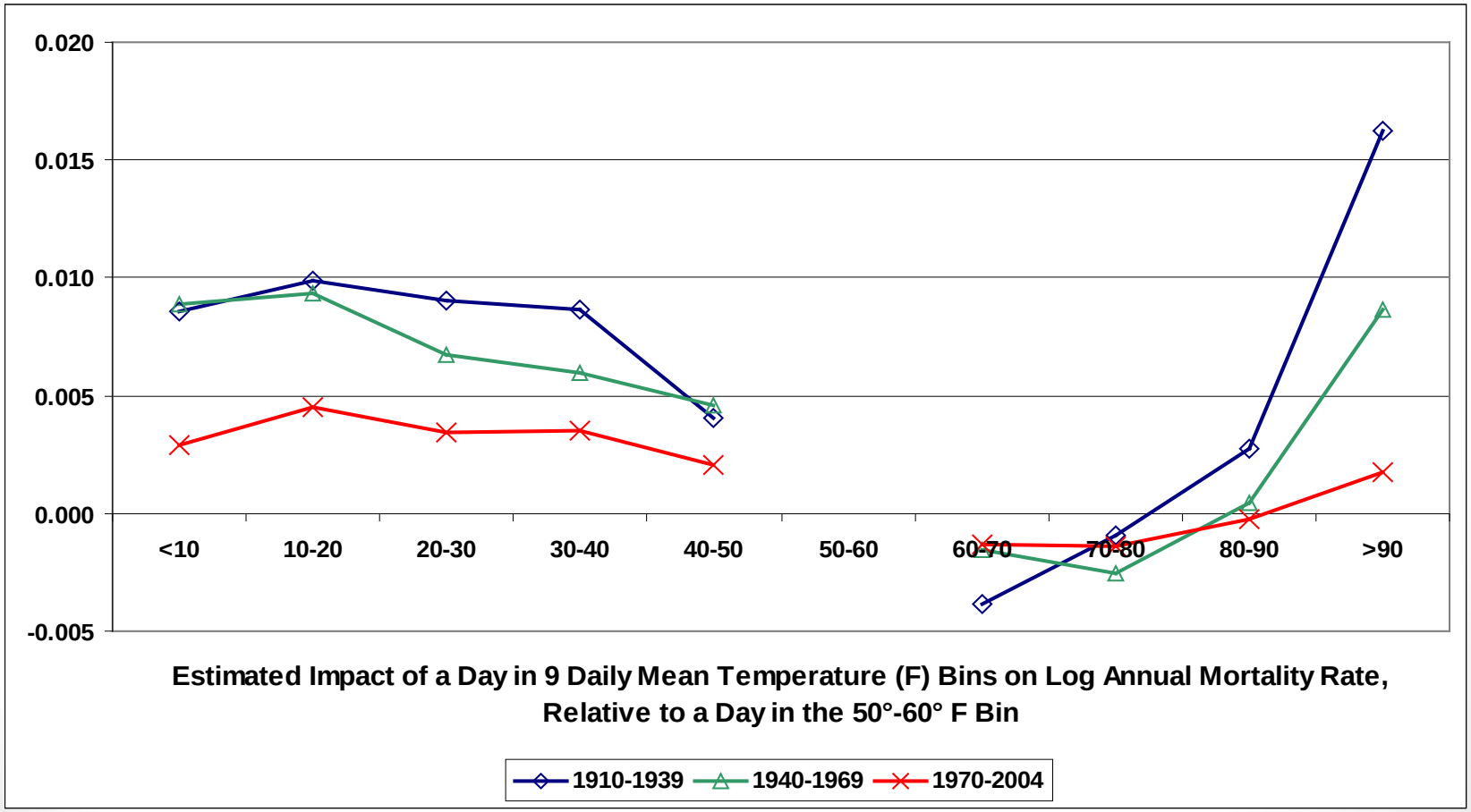
→ Tremendous Pressure to Grow Per-Capita Incomes to Get a Temperature-Mortality Response Function Similar to the U.S.

C. Long Run Historical Evidence from the US

Preliminary and Untitled
Barreca, Clay,
Deschenes, and Greenstone, 2011

Evolution of Temperature-Mortality Gradient in US

Figure 2: Estimated Relationship Between State-Level Log Annual Mortality Rate and Daily Temperatures, for Early, Mid and Late 20th Century



What Caused the Improvements in the US?

Active Area of Research. Potential Candidates Include:

1. Chlorinated Water Supply
2. Electrification, Air Conditioning
3. Hospital Access
4. Others

Concluding Thoughts

1. Climate Change is Projected to Lead to Really, Really Big Changes in our Environment

2. Mitigation is Challenging Politically and Economically

3. Adaptation will be a big part of Solution (by default?).

4. However Adaptation is Costly. Adaptation is Likely to be Unequal Across the Globe and the Income Distribution.

5. Empirical Evidence on History of Adaptation to Environmental Change is Nascent. Largely Focused on Relatively Short-Run Adaptations.

→ More Research is Necessary