Modelling the Risks of Climate Change

Presentation to the NAS/NRC Committee on
the Social Cost of Carbon
13 November 2015
by

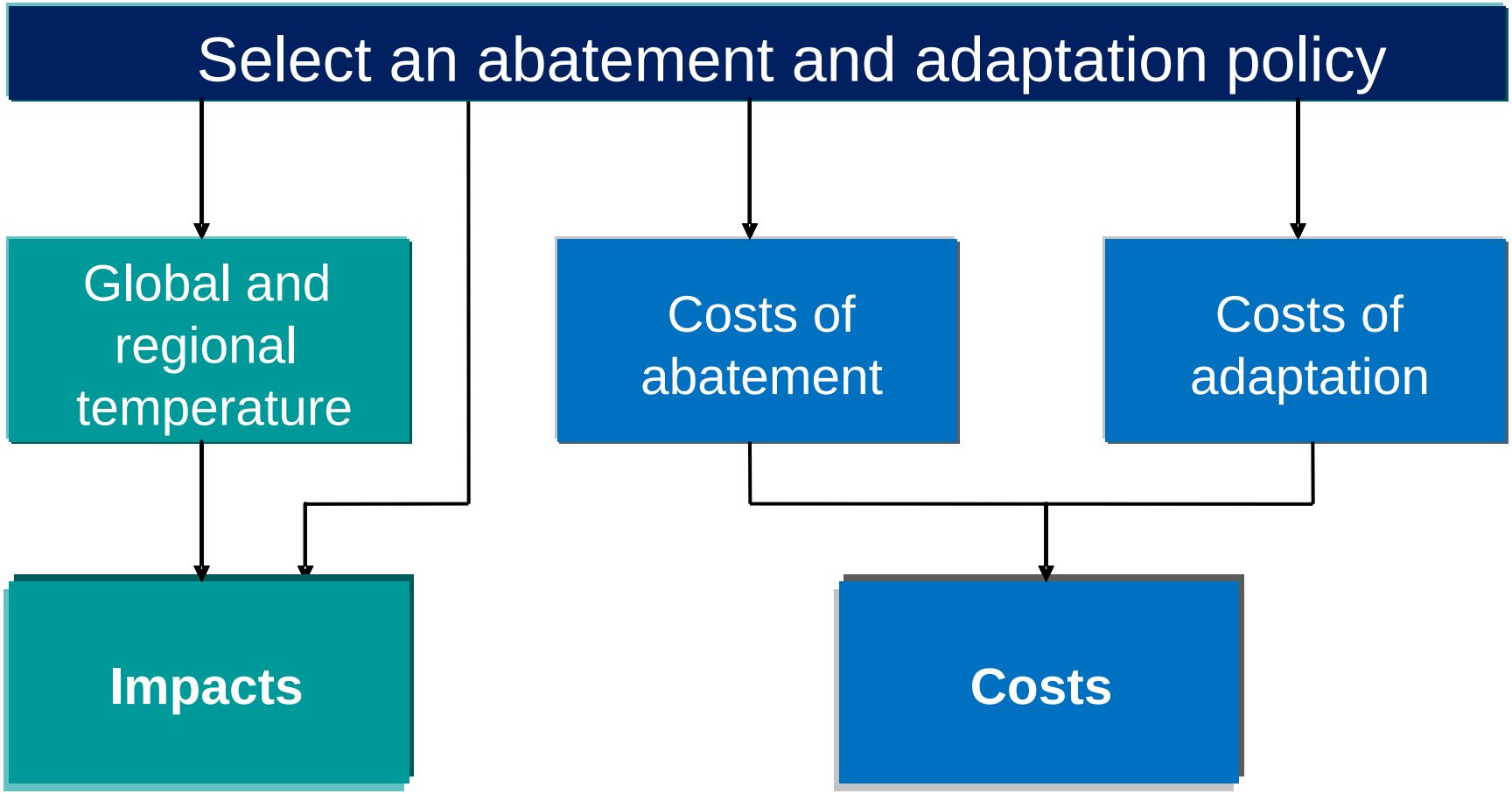
Dr Chris Hope
Cambridge Judge Business School, University of Cambridge
c.hope@jbs.cam.ac.uk
www.chrishopepolicy.com
@cwhope

UNIVERSITY OF CAMBRIDGE
Judge Business School

Plan of talk

- The PAGE09 integrated assessment model & the social cost of CO_2.
- Improving the estimates of the social cost of CO_2.

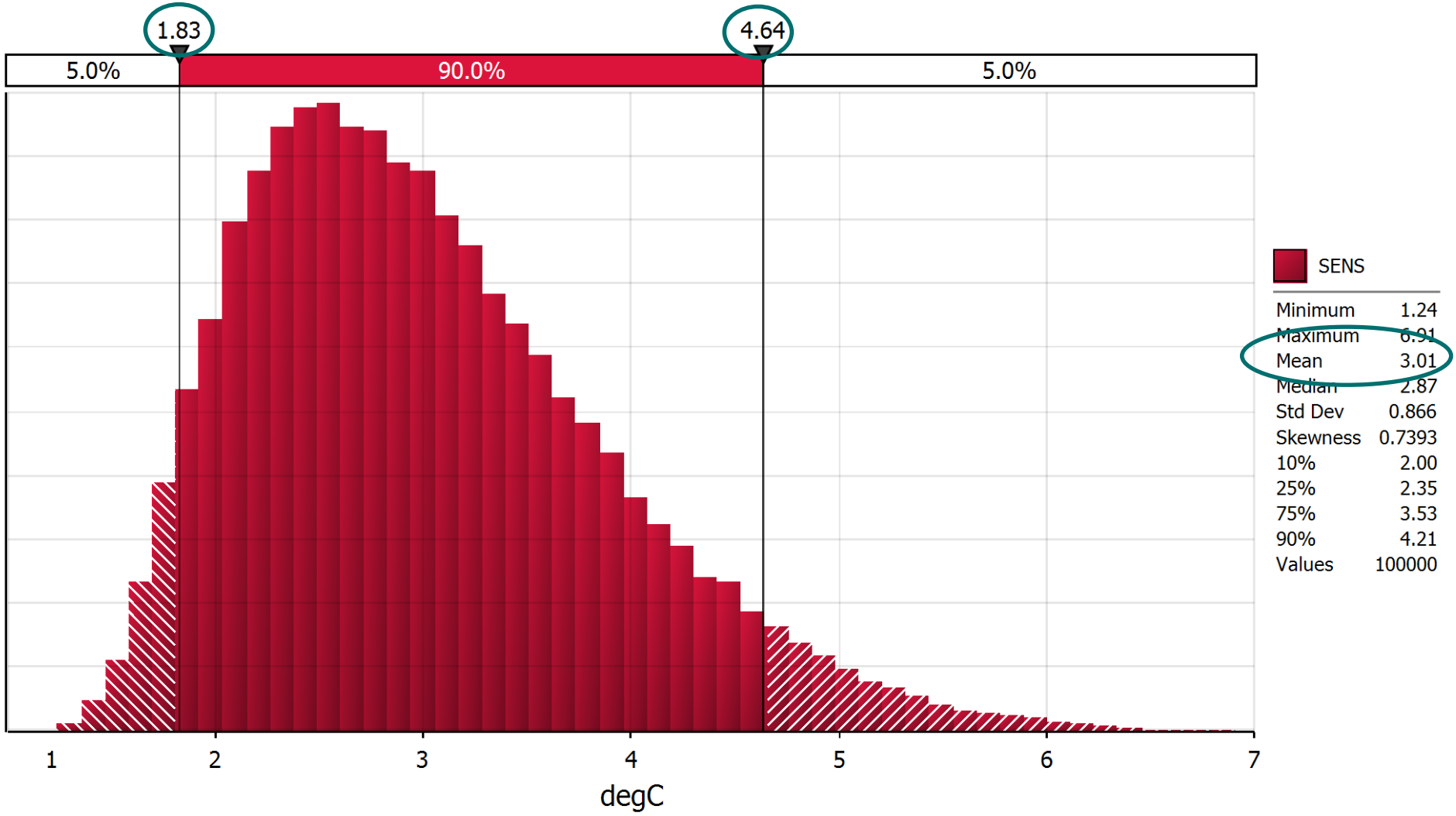
Structure of the PAGE09 model



The PAGE09 model

- Excel 2010 workbook with @RISK6 add-in
- Explicit treatment of CO_2, CH_4, N_2O, sulphates
- 8 regions
  - Including EU, US, China
- 10 analysis years
  - up to 2200
- 4 impact sectors
  - Sea level, economic, non-economic, discontinuity
- 112 uncertain inputs, 46 used in calculation of $SCCO_2$
- 100000 runs to calculate distribution of $SCCO_2$

Default climate sensitivity probability distribution



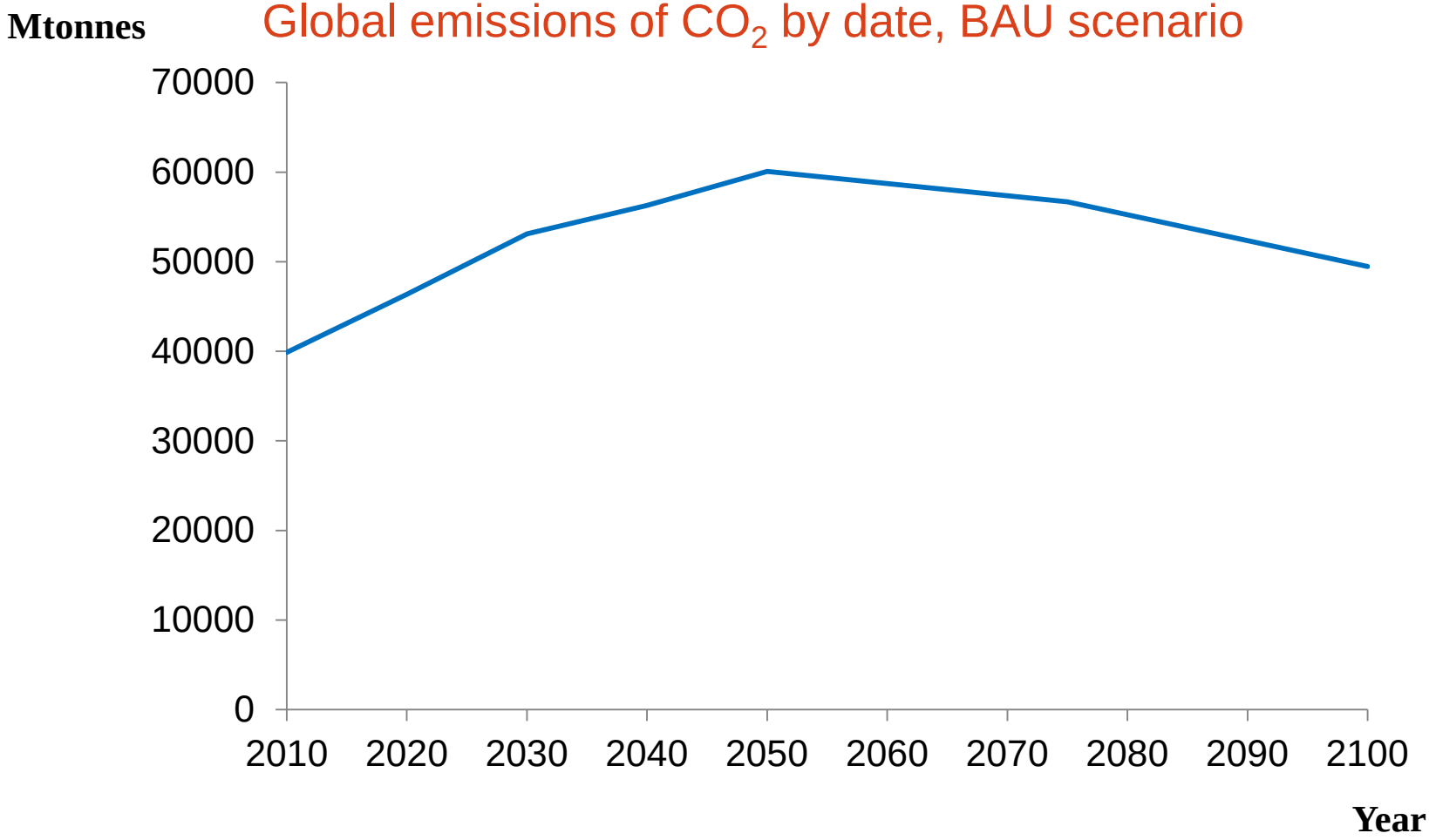
Source: 100000 default PAGE09 runs

CAMBRIDGE
Judge Business School

The social cost of CO_2 from the default model

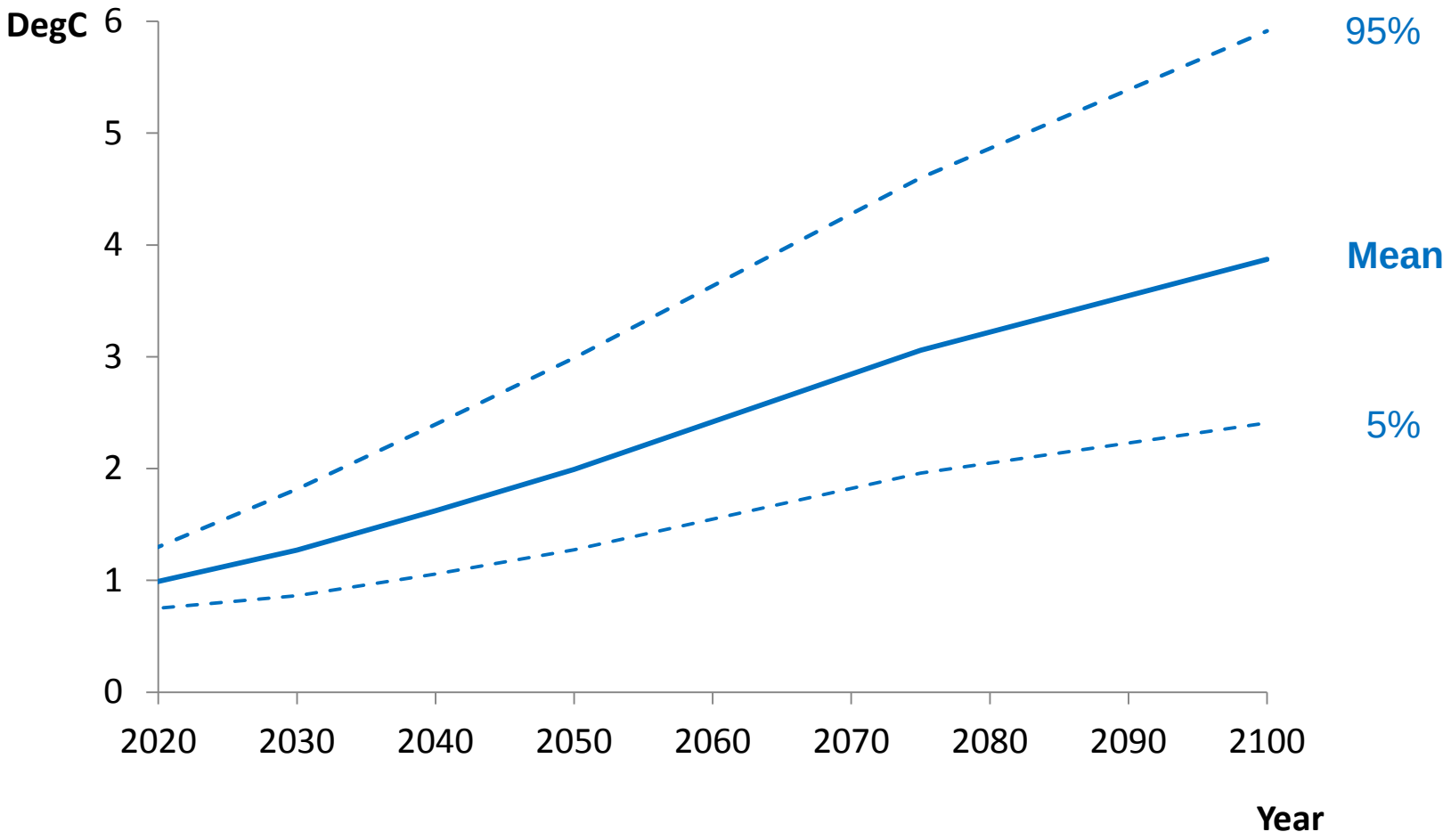
- Business as usual scenario: A1B.
- Moderate adaptation.
- Currency unit: $2005, PPP exchange rates, EU mean GDP/cap.

Global emissions of CO_2 by date, BAU scenario



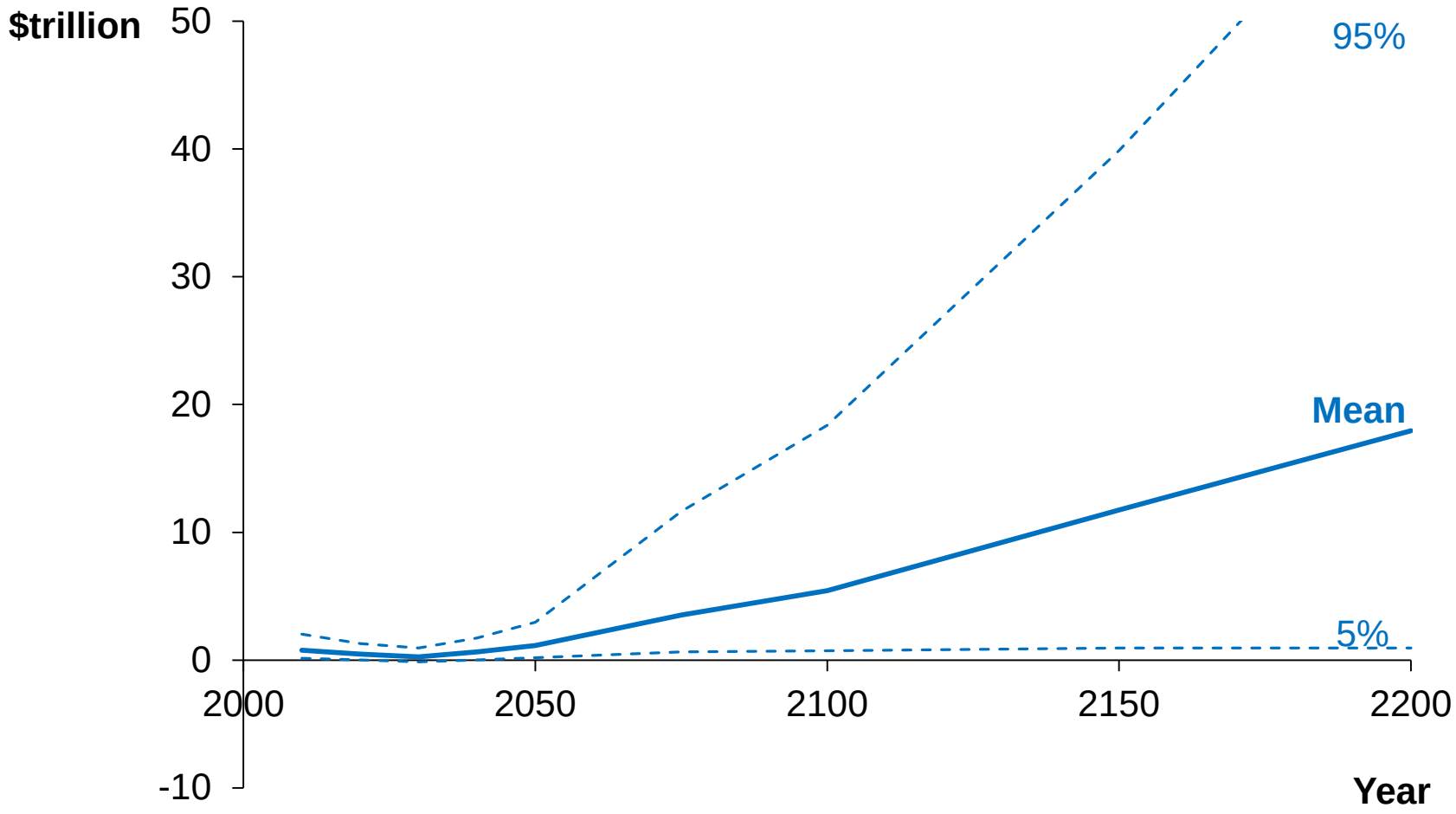
Source: PAGE09; A1B scenario

Global mean temperature rise by date, A1B scenario.



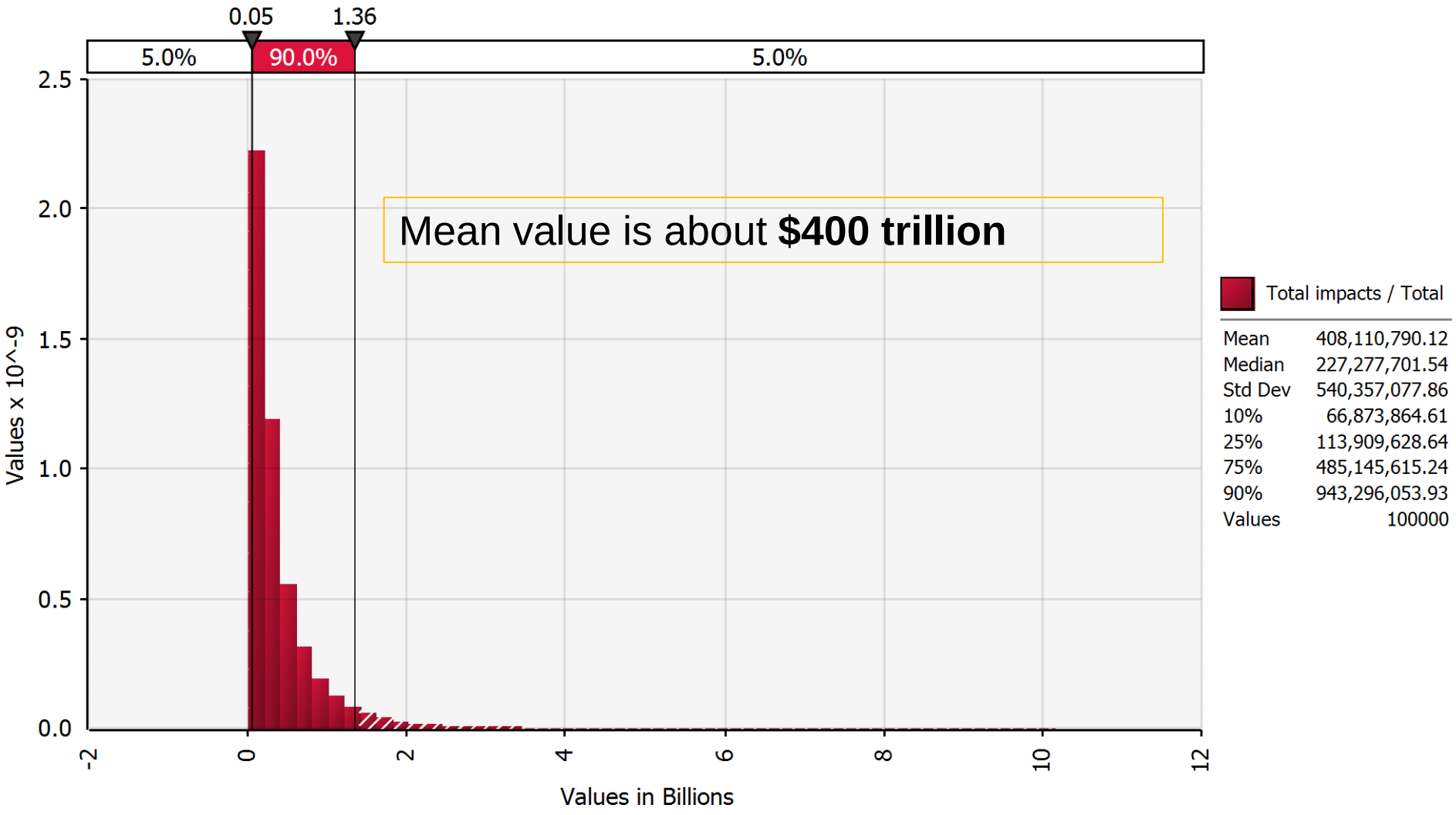
Source: 10000 default PAGE09 runs; A1B scenario

Global impacts by date, BAU scenario



Source: 10000 default PAGE09 runs, A1B scenario, moderate adaptation

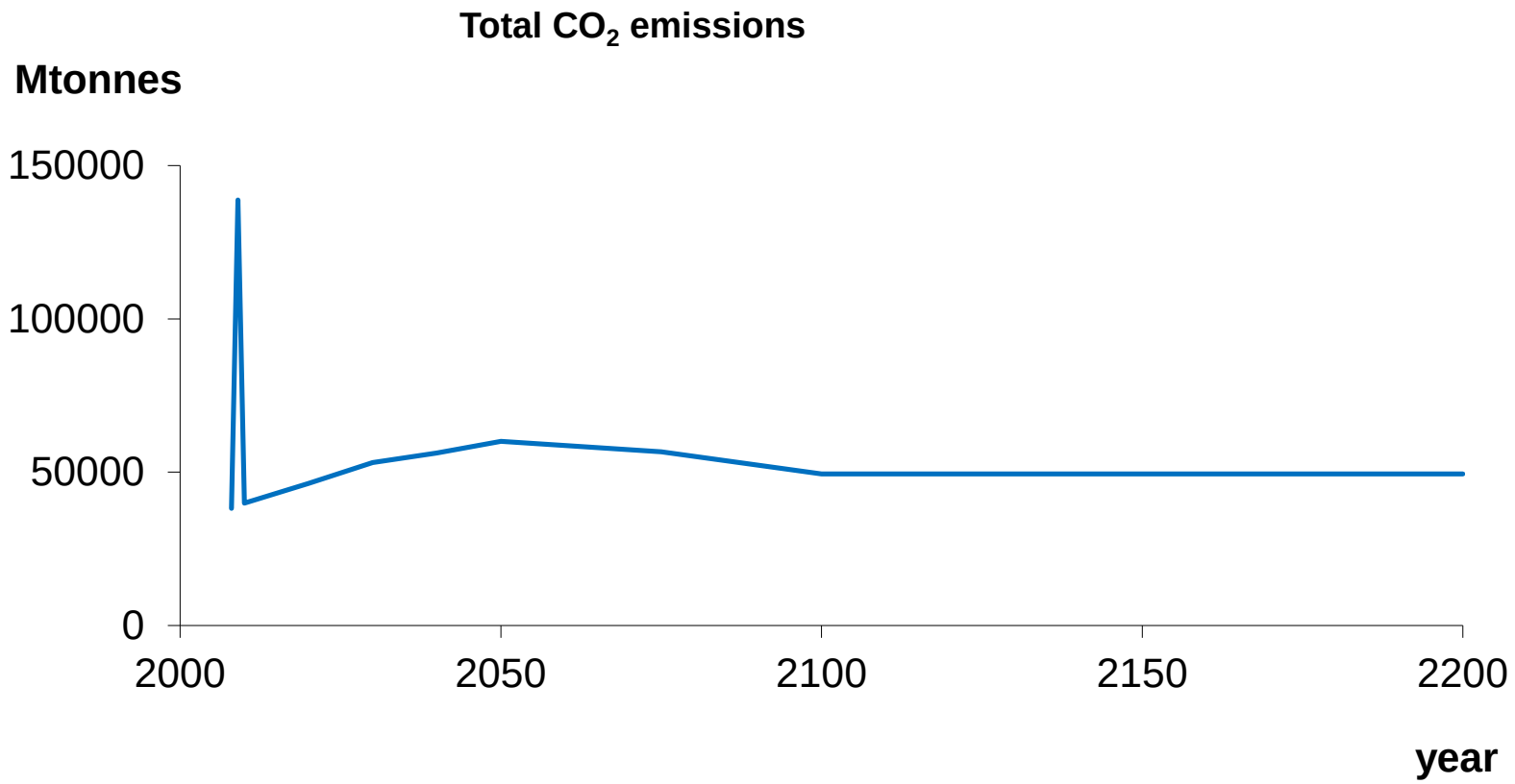
NPV of global impacts, BAU scenario



UNIVERSITY OF CAMBRIDGE
Judge Business School

Source: 100000 default PAGE09 runs; A1B scenario

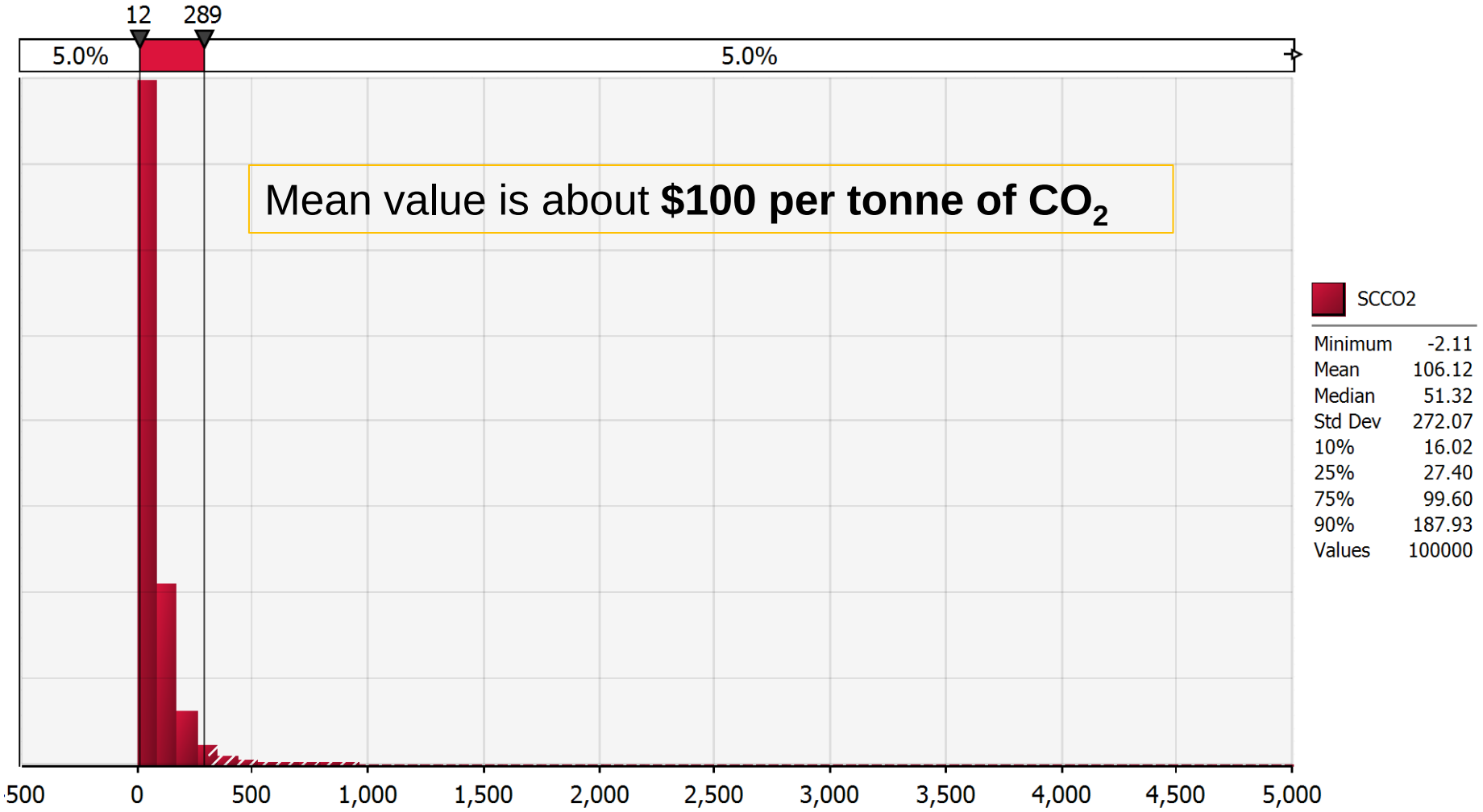
Calculating the social cost of CO_2



Calculating the social cost of CO_2

1. Find mean NPV of global impacts with spike of emissions
2. Find mean NPV of global impacts without spike of emissions
3. Subtract (2) from (1)
4. Divide by size of spike (100 billion tonnes of CO_2)

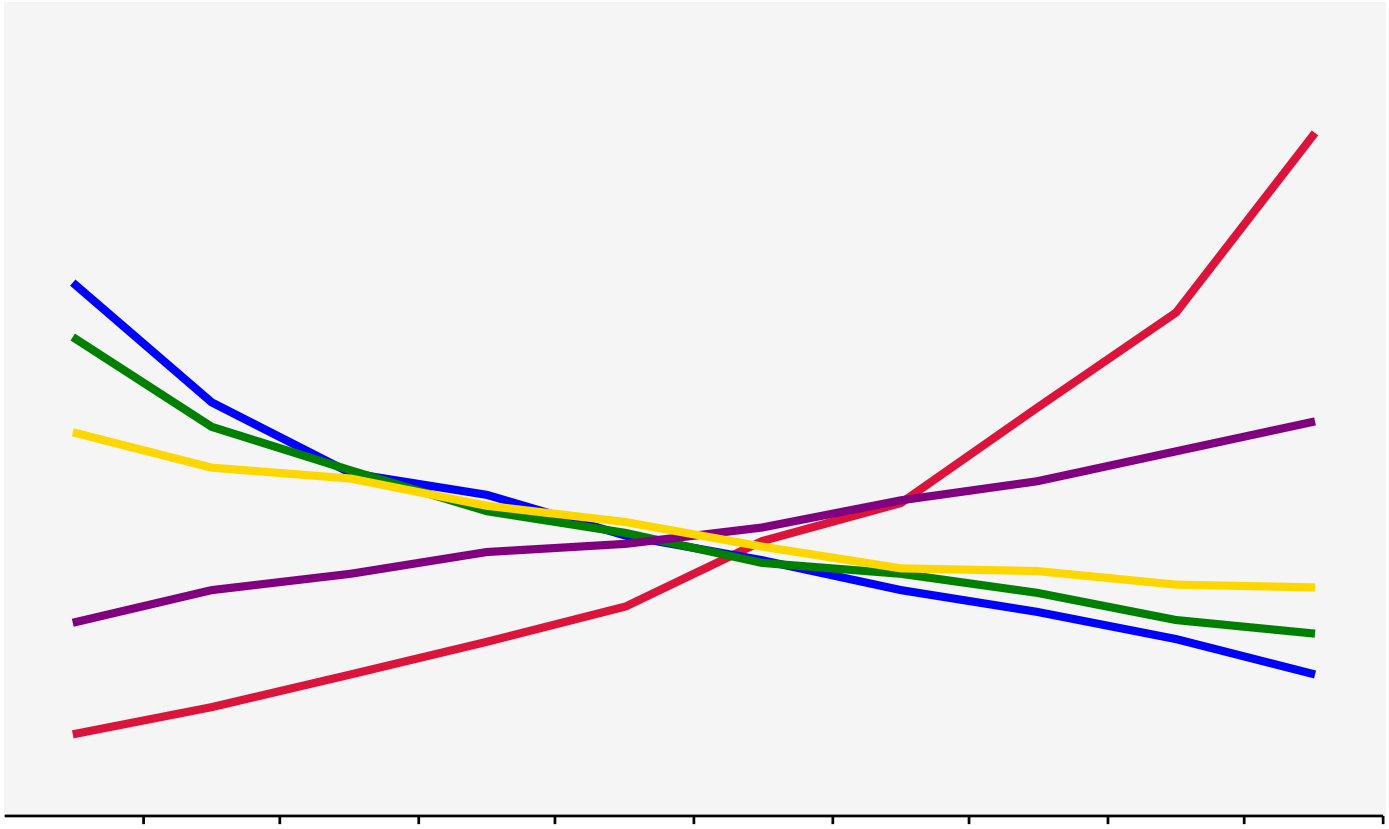
The social cost of CO_2



UNIVERSITY OF CAMBRIDGE
Judge Business School

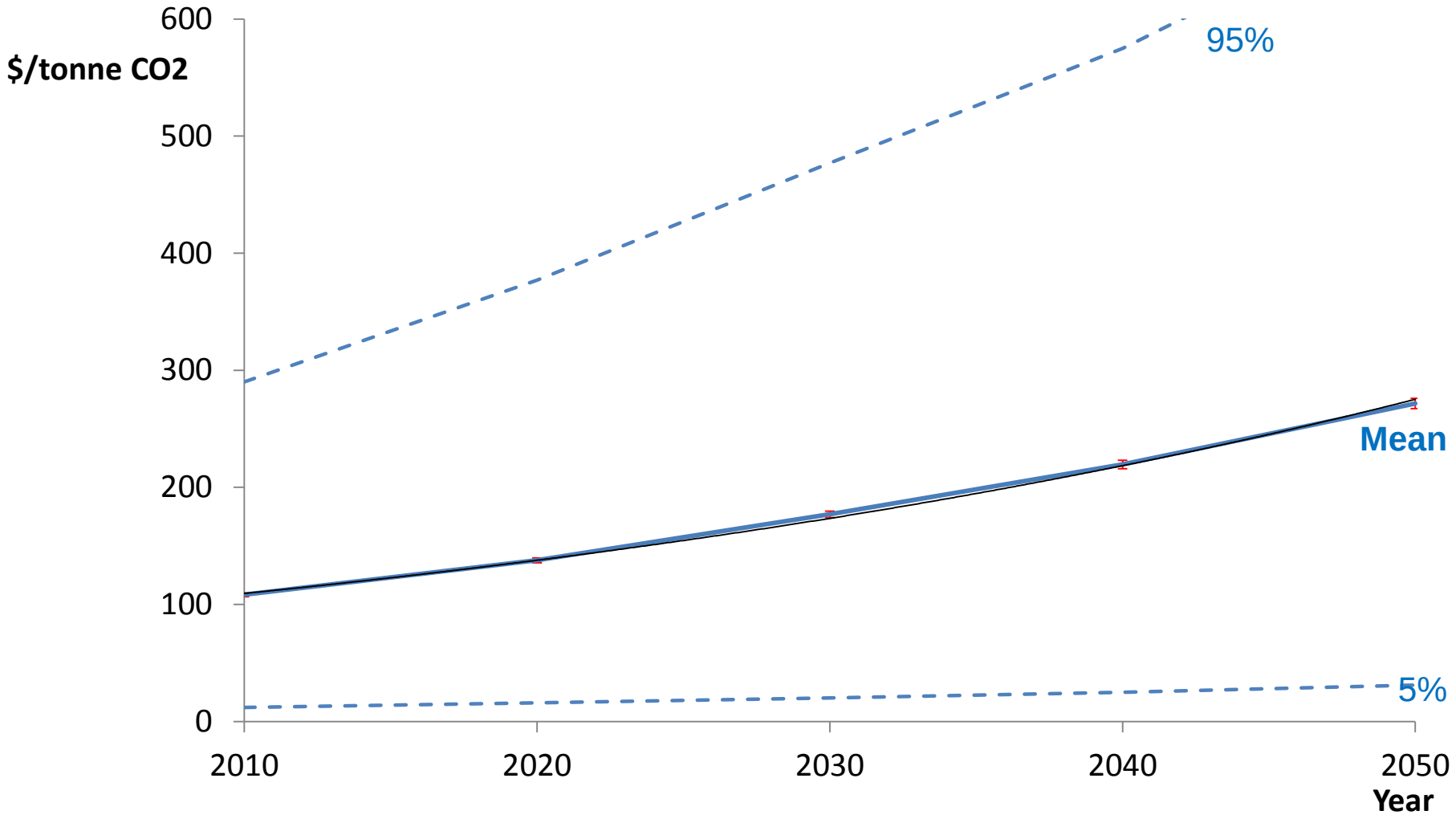
Source: 100000 default PAGE09 runs, A1B scenario, 2010

Major influences on the $SCCO_2$



UNIVERSITY OF CAMBRIDGE
Judge Business School

$SCCO_2$ by date, A1B scenario



Source: 100000 default PAGE09 runs, A1B scenario

Improving the estimates of the social cost of CO2

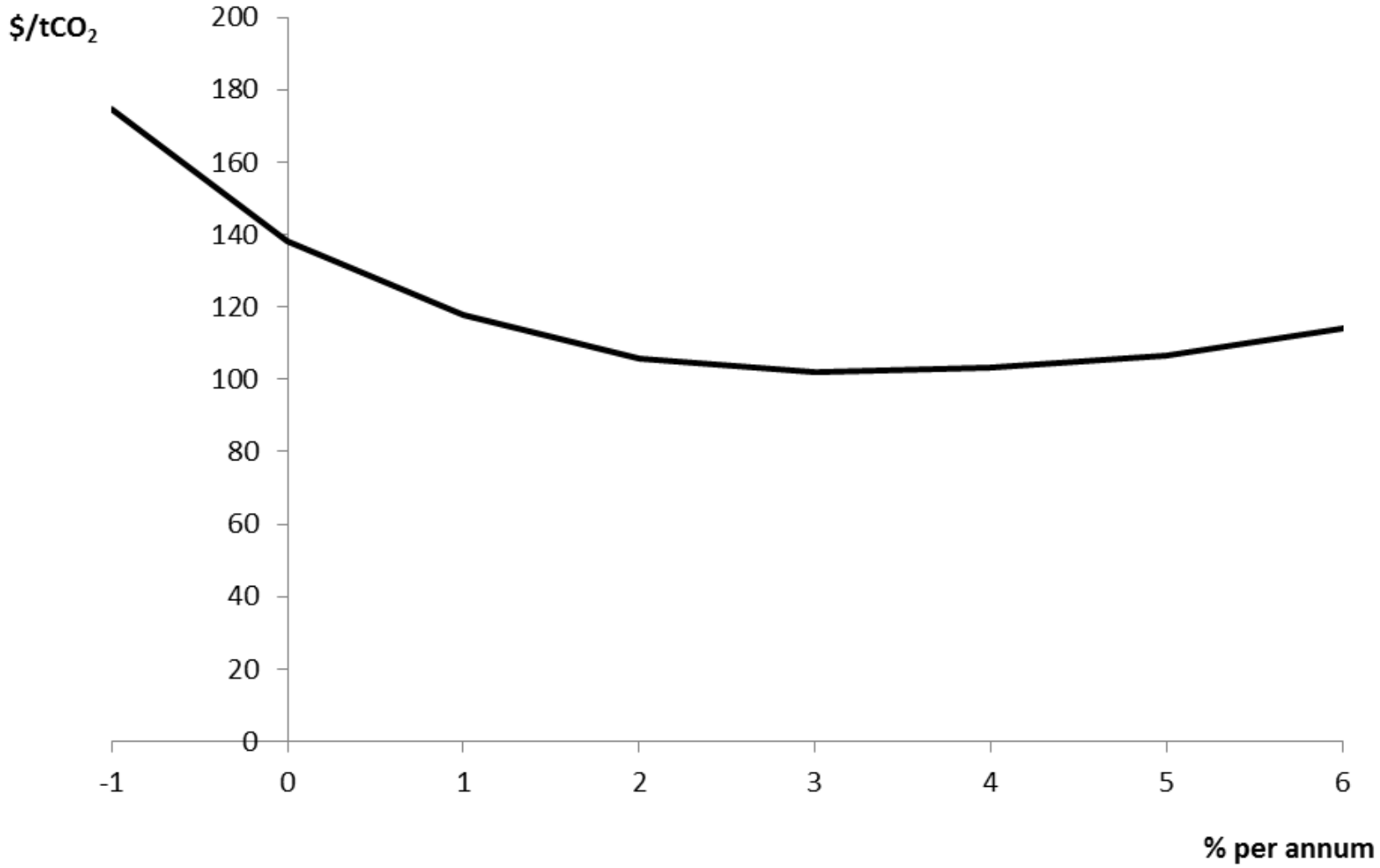
- Monitor, assess and use updated scenarios & input distributions.
- Maintain a strong focus on risks and uncertainty.

- Commission primary studies of an 8 degC world.
- Evaluate primary studies of migration and conflict.
- Evaluate feedbacks, especially in the Arctic.

- Consider including lasting damage.
- Consider including more than one discontinuity.

- Modelling individual damage categories has complications.
  - Number of correlations goes up as square of number of inputs.

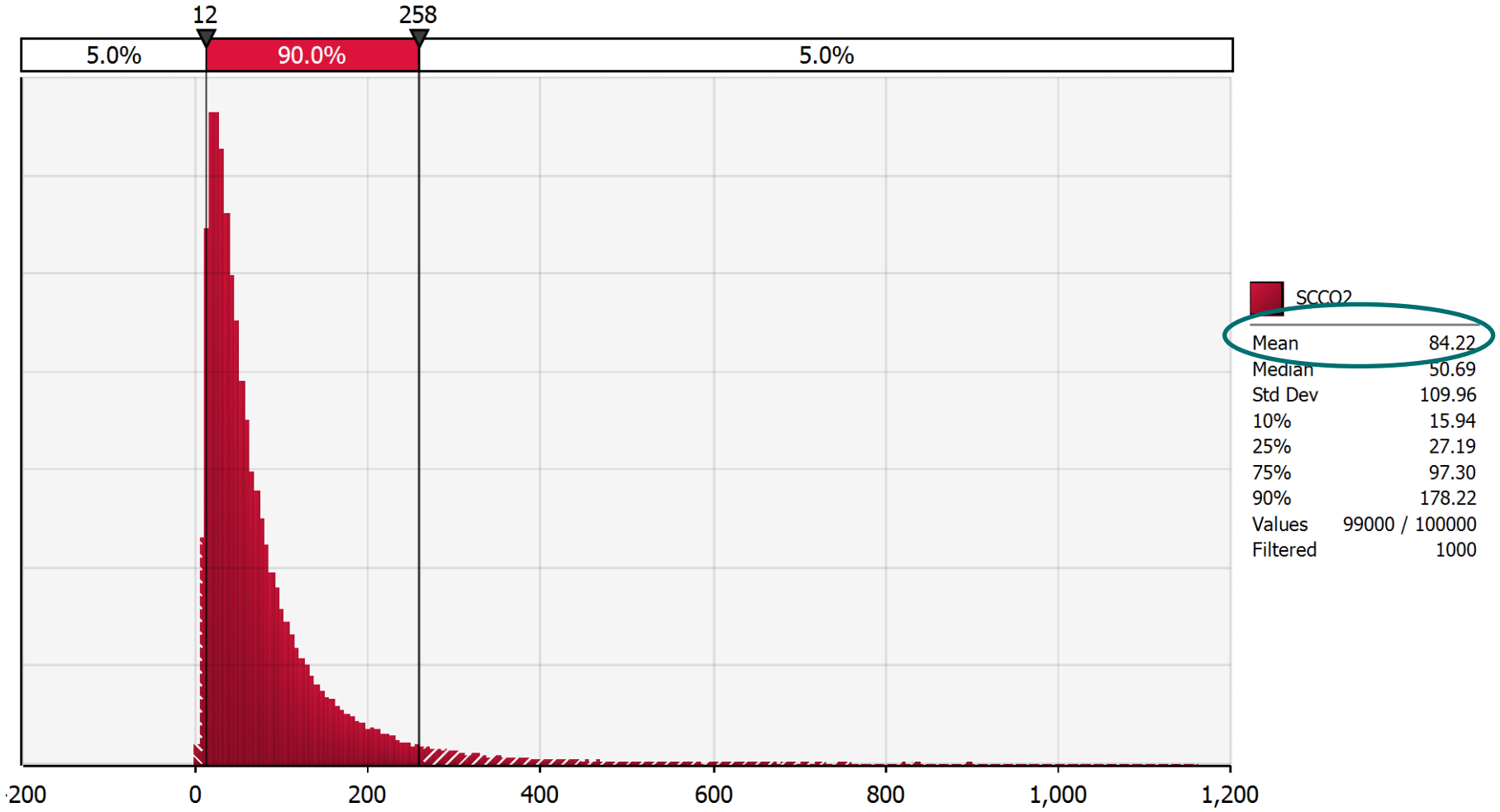
The mean social cost of CO_2 by GDP growth rate in annex 1 countries



UNIVERSITY OF CAMBRIDGE
Judge Business School

Source: 100,000 runs of the PAGE09 model.

The social cost of CO_2, excluding top 1% of runs



UNIVERSITY OF CAMBRIDGE
Judge Business School

Source: 100000 default PAGE09 runs, A1B scenario, 2010

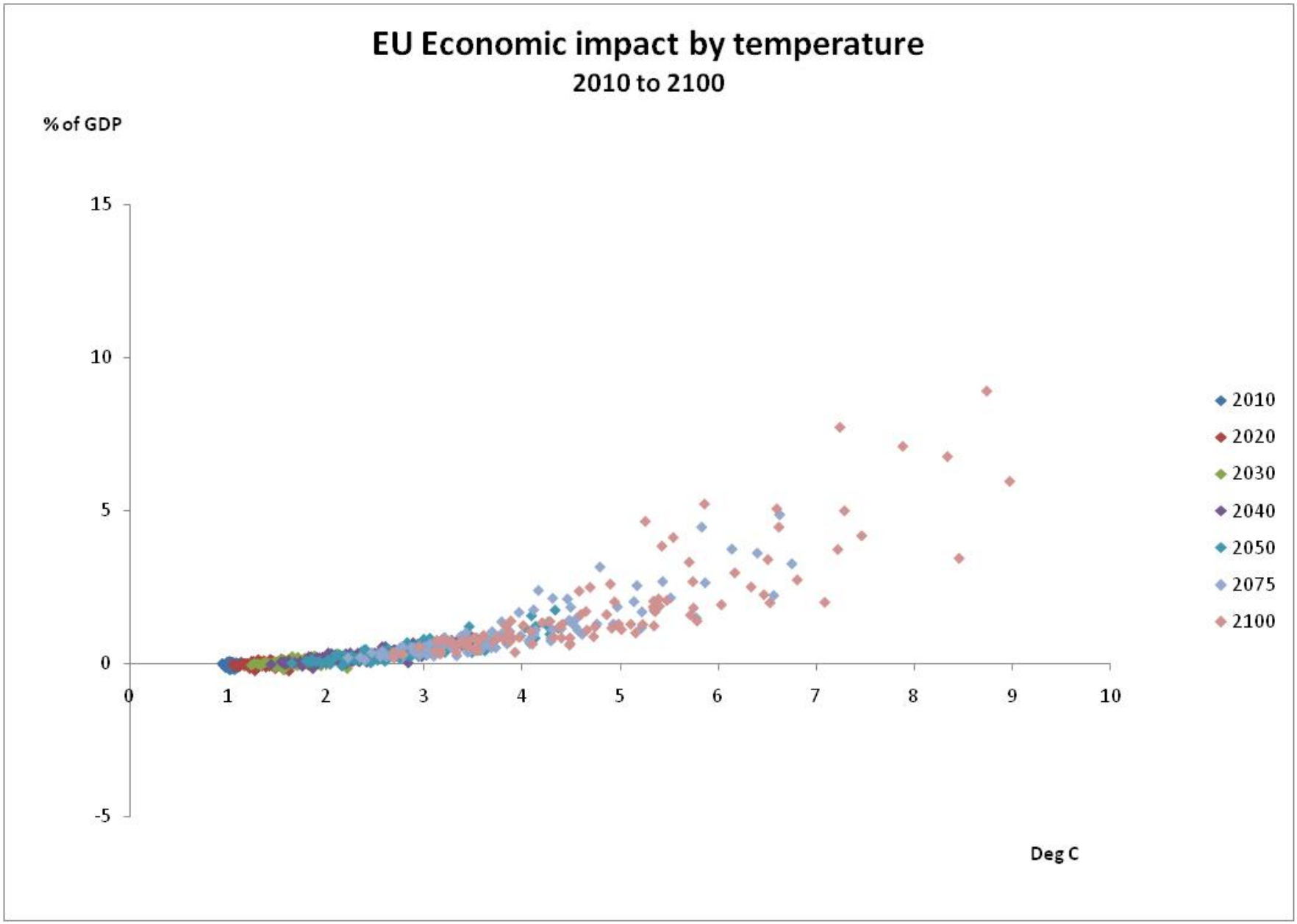
Improving the estimates of the social cost of CO2

- Monitor, assess and use updated scenarios & input distributions.
- Maintain a strong focus on risks and uncertainty.

- Commission primary studies of an 8 degC world.
- Evaluate primary studies of migration and conflict.
- Evaluate feedbacks, especially in the Arctic.

- Consider including lasting damage.
- Consider including more than one discontinuity.

- Modelling individual damage categories has complications.
  - Number of correlations goes up as square of number of inputs.



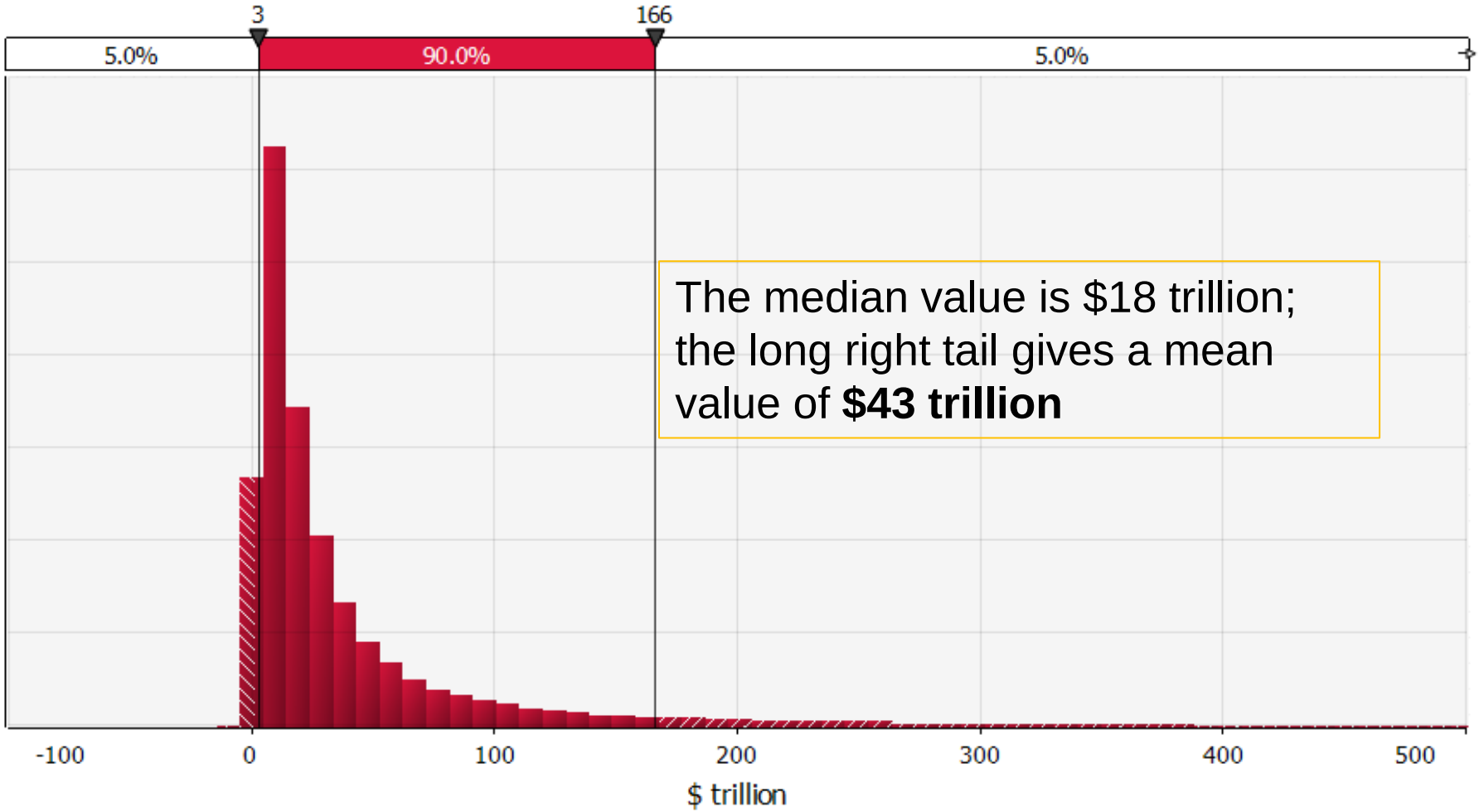
Source: 100 default PAGE09 runs; A1B scenario

CAMBRIDGE
Judge Business School

Impacts omitted from the default PAGE09 model

- Mass migration
- Conflict
- Unintended consequences of bio-engineering
- Ocean acidification
- CO_2 and CH_4 emissions from thawing permafrost

Net present Value (NPV) of extra impacts from permafrost CO_2 and CH_4 emissions



Source: 100000 PAGE09 runs; A1B scenario

Improving the estimates of the social cost of CO2

- Monitor, assess and use updated scenarios & input distributions.
- Maintain a strong focus on risks and uncertainty.

- Commission primary studies of an 8 degC world.
- Evaluate primary studies of migration and conflict.
- Evaluate feedbacks, especially in the Arctic.

- Consider including lasting damage.
- Consider including more than one discontinuity.

- Modelling individual damage categories has complications.
  - Number of correlations goes up as square of number of inputs.

A caution about timescales

- Including new input distributions can be done in a matter of weeks.
- Upgrade from PAGE2002 to PAGE09 included:
  - All 6 greenhouse gases,
  - better carbon cycle feedback,
  - latitude link to temperature change,
  - sea level modelled explicitly,
  - expected utility basis of calculation,
  - initial benefits for small temperature rise,
  - explicit link of impacts to GDP/capita,
  - lag in discontinuity impacts,
  - more realistic MAC curves,
  - limits to adaptation.
- This upgrade took 2 years.

UNIVERSITY OF
CAMBRIDGE
Judge Business School