Results from the PAGE09 model

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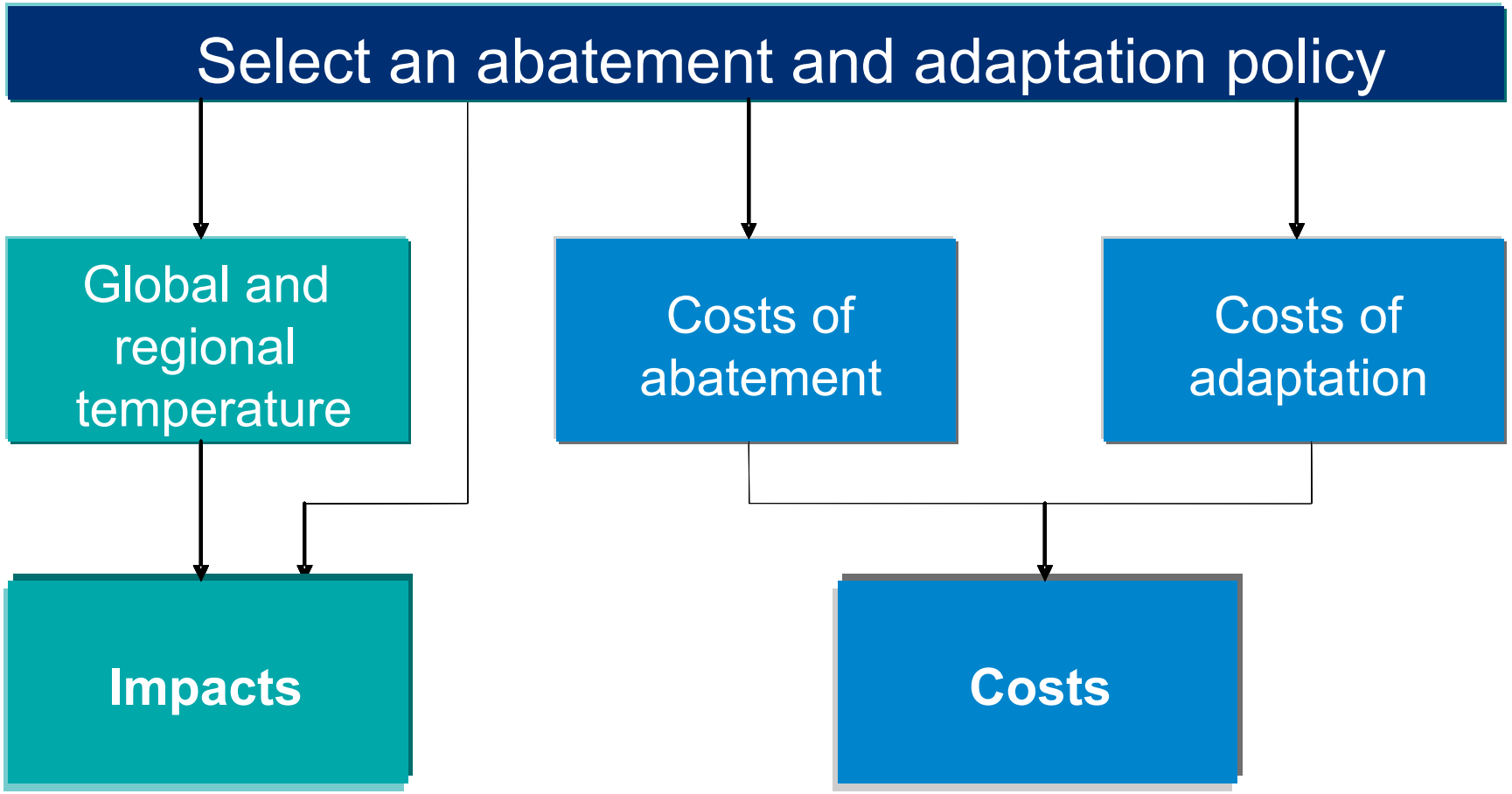
Plan of talk

- The PAGE09 model.
- Base scenario results.
- Results from experiments.
- Towards optimization.

The PAGE09 model

Structure of the PAGE09 model

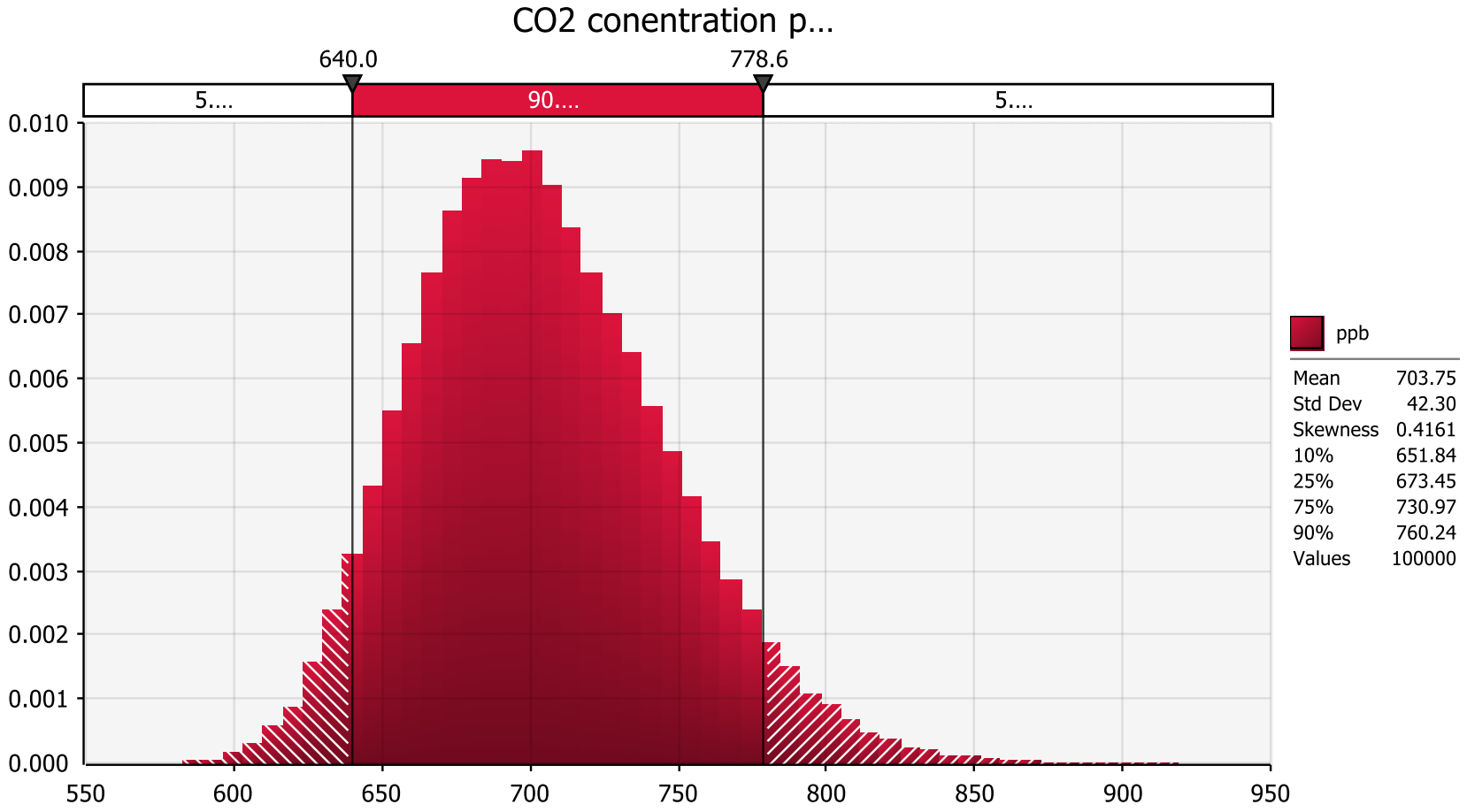


The PAGE09 model

- Excel 2010 workbook with @RISK 5.7 add-in
- 8 regions
  - Including EU, US, China
- 10 analysis years
  - up to 2200
- 4 impact sectors
  - Sea level, economic, non-economic, discontinuity
- 2 policies and their difference
- 112 uncertain inputs
- 100000 runs to calculate distributions of outputs

Base scenario results

CO2 concentration in 2100, base scenario



Source: 100000 PAGE09 runs; A1B scenario

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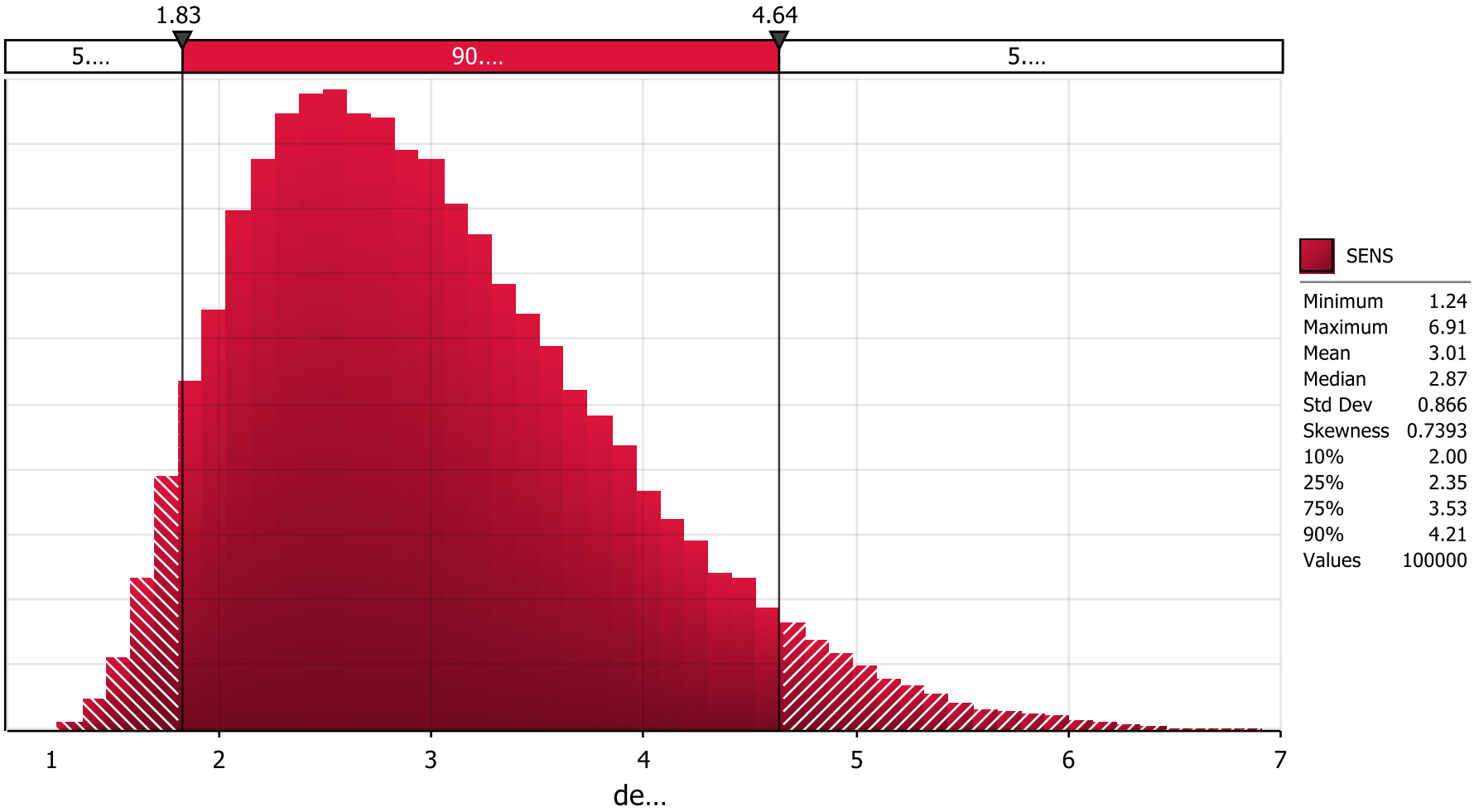
Climate sensitivity, base scenario



Source: 100000 PAGE09 runs, A1B scenario

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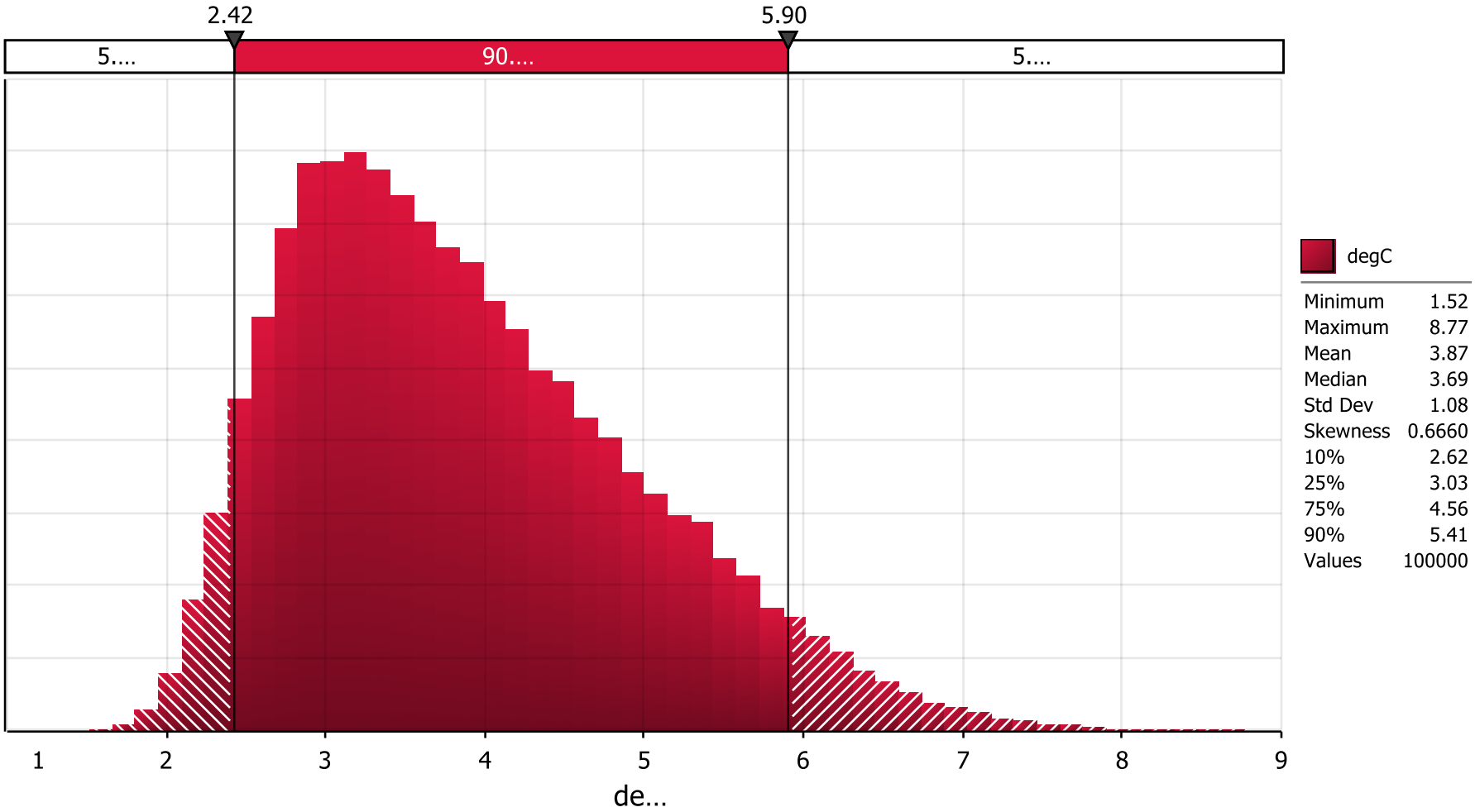
Global mean temperature rise in 2100, base scenario



Source: 100000 PAGE09 runs; A1B scenario

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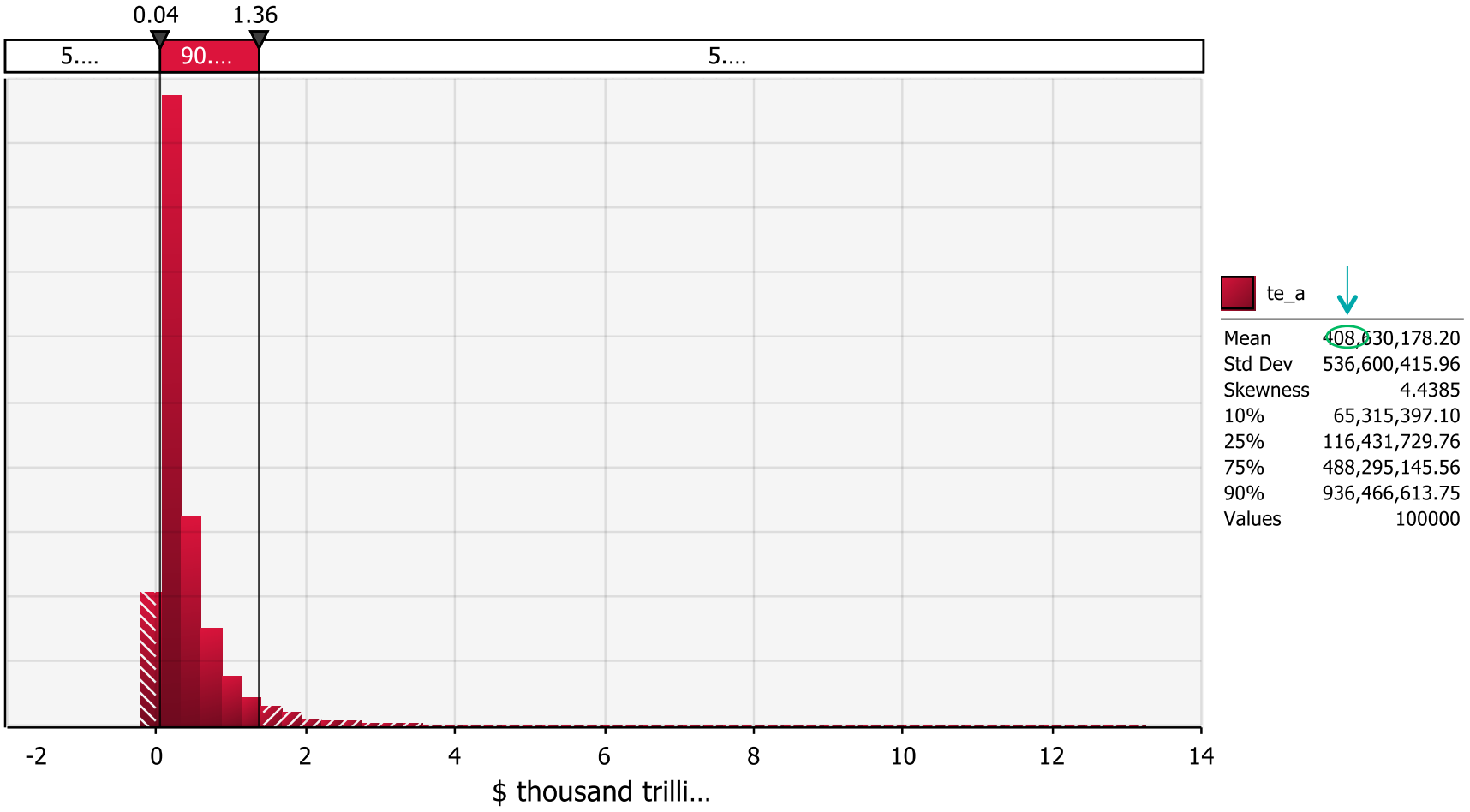
NPV of total effect, base scenario



Total effect = Impacts + abatement costs + adaptation costs

Source: 100000 PAGE09 runs; A1B scenario

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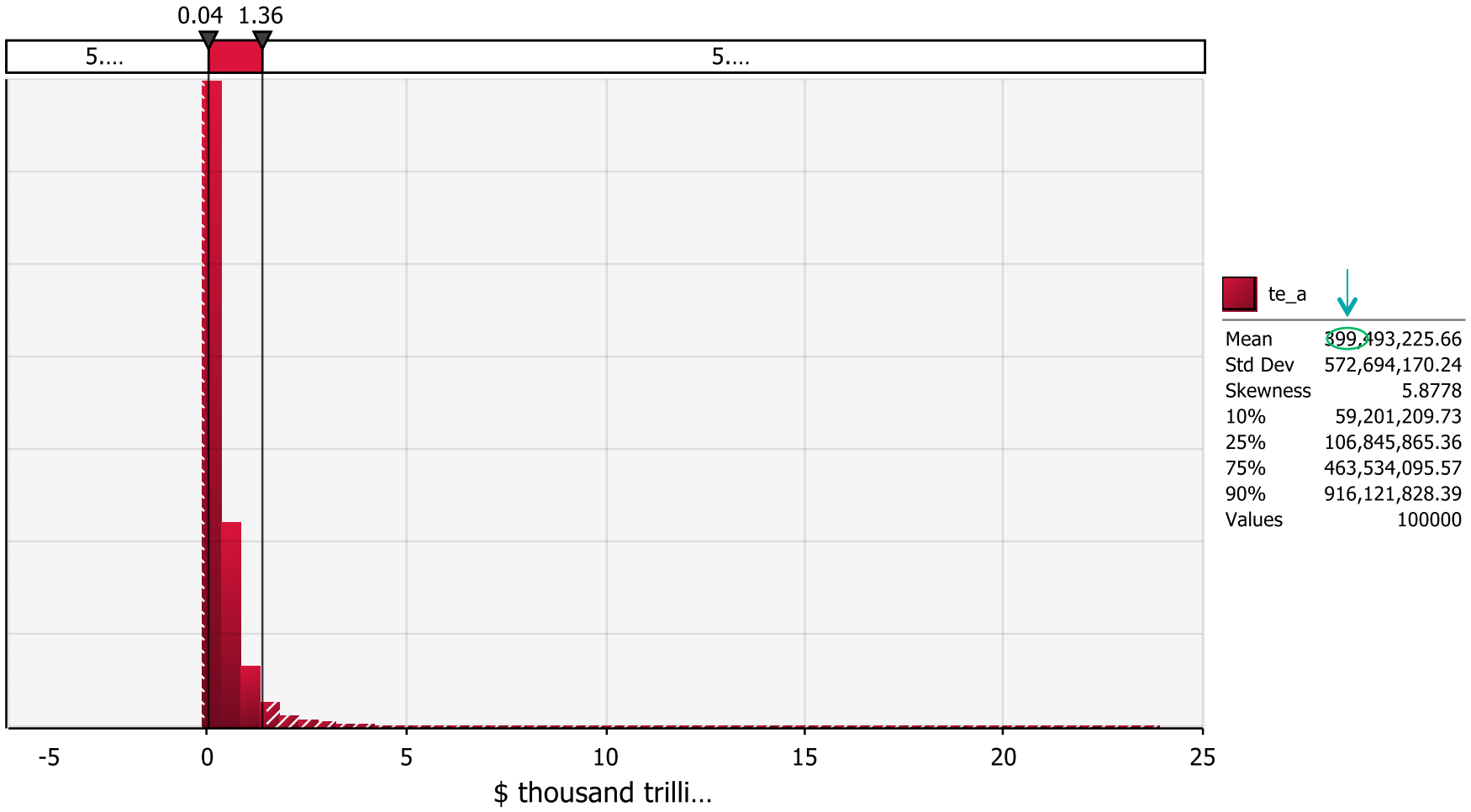
Results from experiments

Experiment c: Increased GDP growth of 0.5% per year

- GDP growth rate in all regions increased by 0.5% per year from 2020 to 2100
- Global GDP becomes $1200 trillion in 2100, vs $800 trillion in base scenario, an increase of about 50%. This persists through 22nd century.

NPV of total effect, experiment c



Source: 100000 PAGE09 runs

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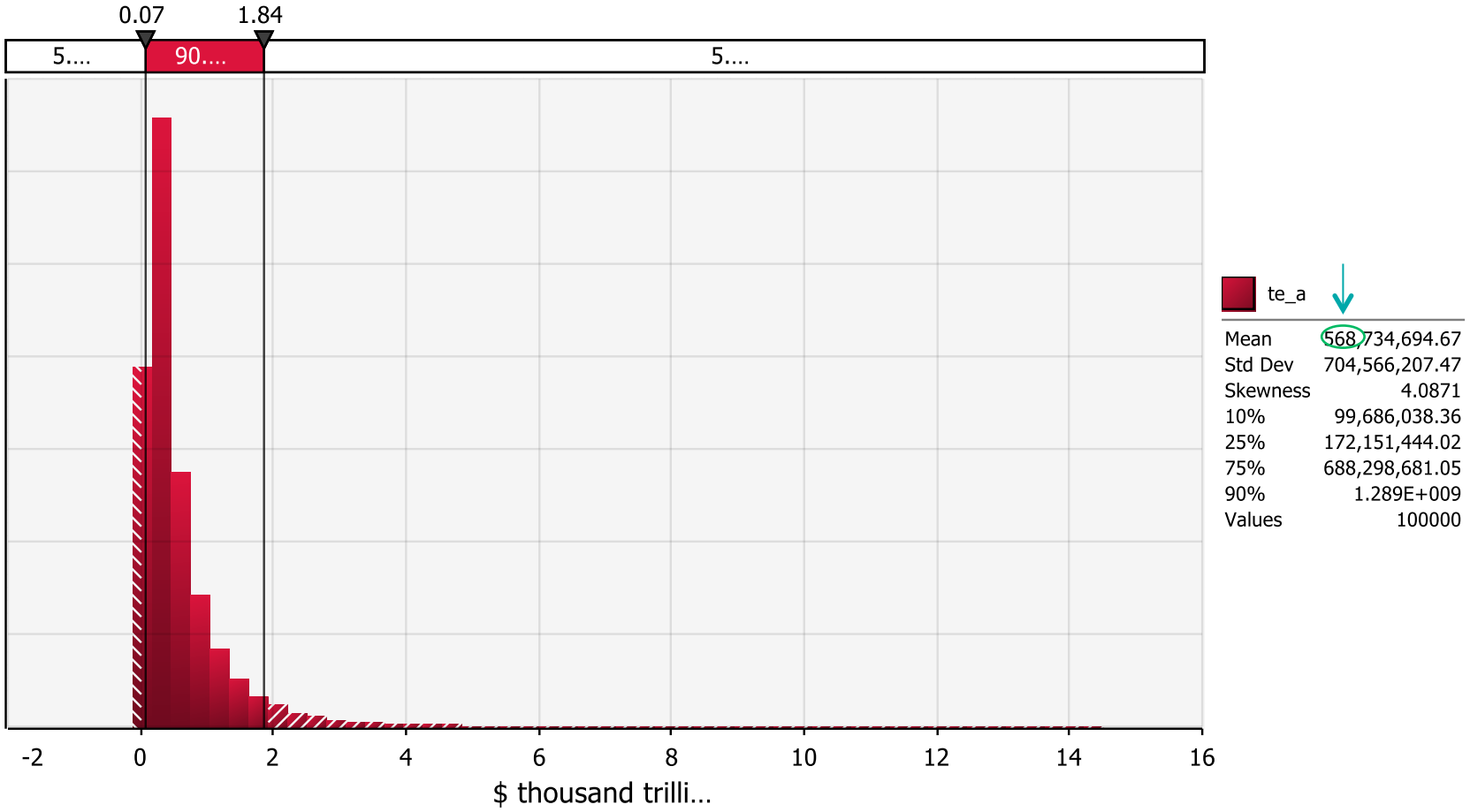
Explanation of result; experiment c

- GDP is not linked to emissions in PAGE09.
- Concentrations, temperature and sea level rise are the same as in the base scenario.
- The higher GDP leads to higher impacts as they enter the impact function as a % of GDP.
- The higher GDP leads to a lower valuation of the impacts, as the EMUC is greater than 0.
- The two effects would cancel out with an EMUC of 1.
- Mean EMUC in PAGE09 is 1.167, so the 2nd effect is slightly stronger.

Experiment e: Increased population growth of 1% per year

- Population growth rate in all regions increased by 1% per year from 2020 to 2050
- Global population becomes 12.8 bn in 2050, vs 9.5 bn in base scenario, an increase of about a third. This persists through the rest of the 21st and the 22nd century.

NPV of total effect, experiment e



Source: 100000 PAGE09 runs

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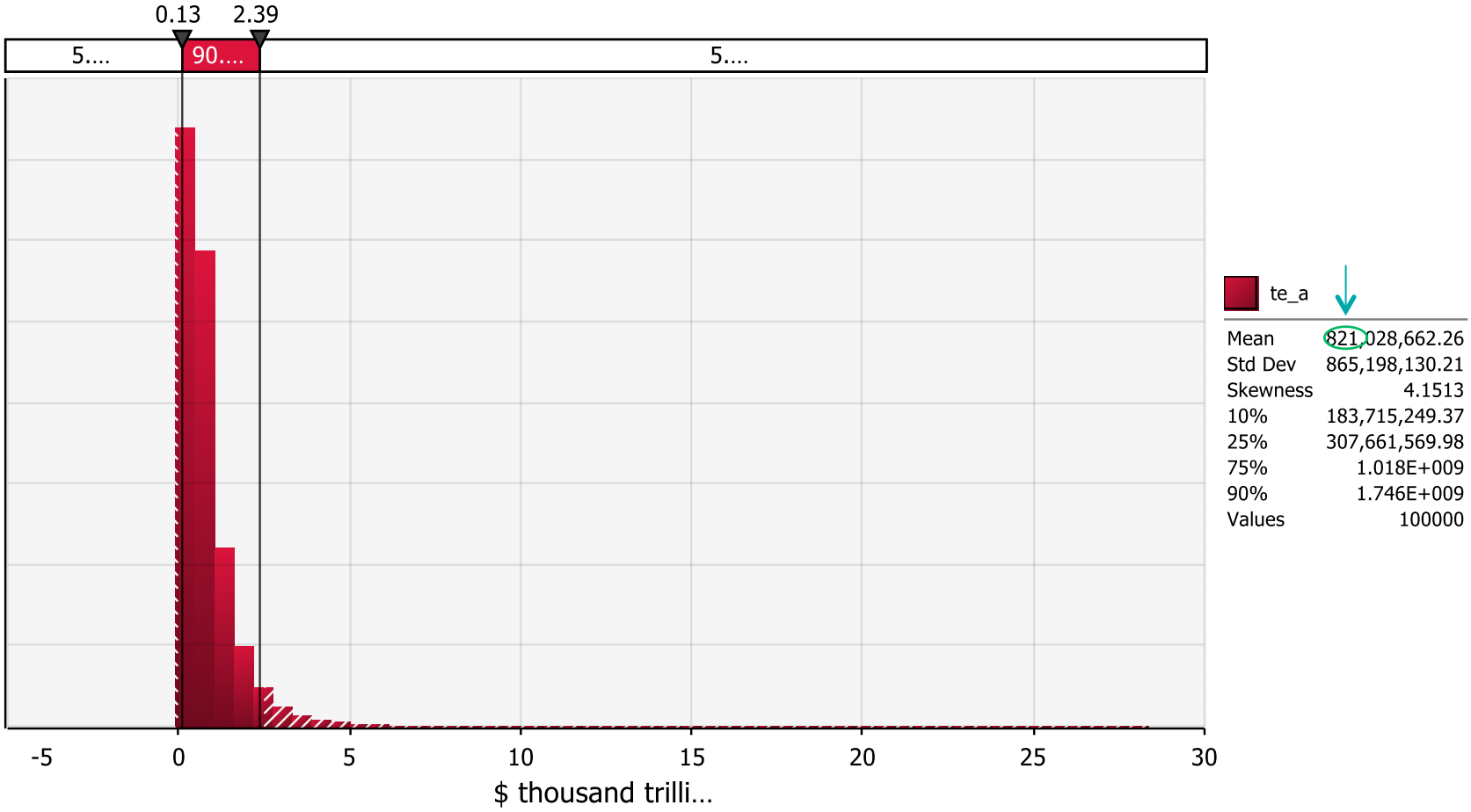
Explanation of result; experiment e

- Population is not linked to GDP or emissions in PAGE09.
- Concentrations, temperature and sea level rise are the same as in the base scenario.
- The higher population means people are poorer on average so the climate change impacts are valued more highly, as the EMUC is greater than 0.

Experiment d: Increased mean climate sensitivity by 1 degC

- Transient climate response increased from <1, 1.3, 2.8> to <1.7, 2, 3.1>
- This increases the mean of the climate sensitivity from 3.0 degC to 4.0 degC, and preserves the standard deviation of the climate sensitivity at 0.86 degC.

NPV of total effect, experiment d



Source: 100000 PAGE09 runs

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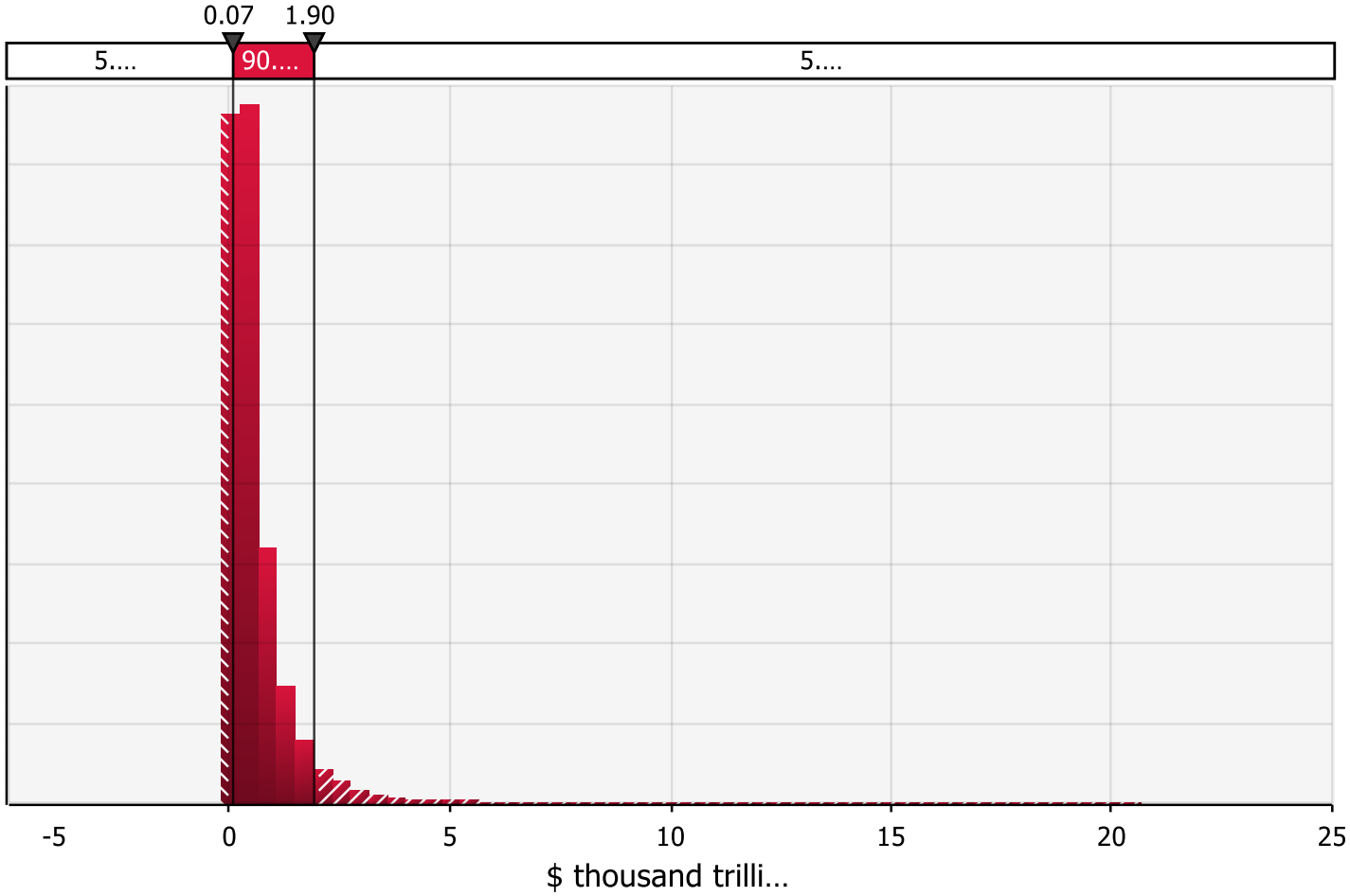
Explanation of result; experiment d

- Increased transient climate response leads to increased temperature change and sea level rise *ceteris paribus.*
- Higher temperature change leads to higher CO2 concentration via carbon cycle feedbacks which are included in PAGE09. Mean CO2 concentration in 2100 increases from 704 ppm in base scenario to 733 ppm.
- This increases temperature and sea level still further. Mean temperature rise in 2100 increases from 3.9 degC in base scenario to 5.3 degC.
- This leads to higher impacts and higher chance of discontinuity.

Variant experiment d: Increased mean climate sensitivity by 1 degC

- Climate sensitivity is derived from Transient Climate Response (TCR) and Feedback Response Time (FRT).
- SENS = TCR/(1-((FRT/70)*(1-EXP(-70/FRT)))) degC
- So an increased climate sensitivity can come from an increased TCR (experiment d), or an increased FRT (variant experiment d)
- Feedback response time increased from <10, 30, 65> years to <53, 55, 63> years.
- This increases the mean of the climate sensitivity from 3.0 degC to 4.0 degC, while increasing the standard deviation of the climate sensitivity only slightly to 0.93 degC.

NPV of total effect, variant experiment d



Source: 100000 PAGE09 runs

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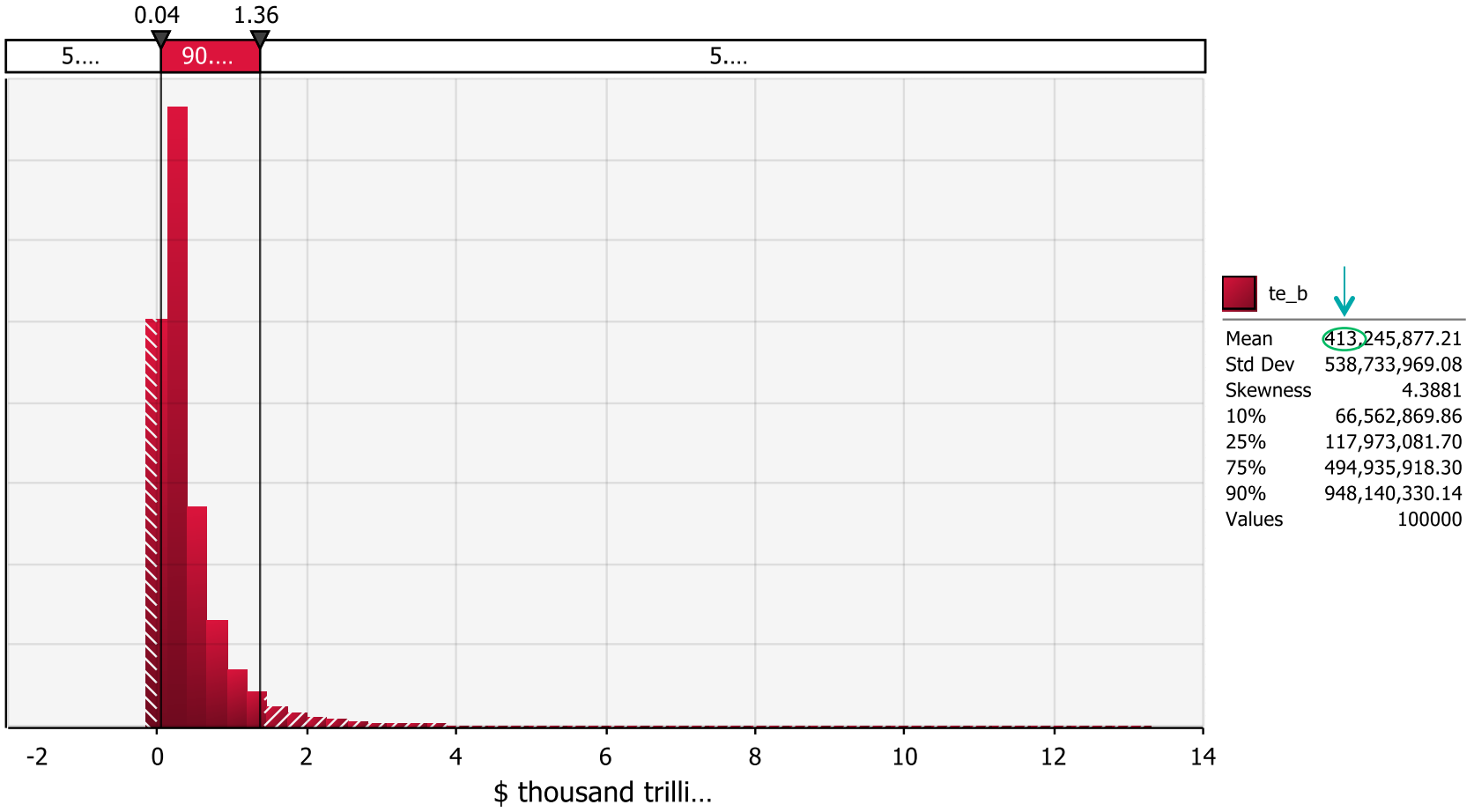
Explanation of result; variant experiment d

- Longer feedback response time leads to later temperature change and sea level rise compared to higher TCR.
- Mean temperature rise in 2100 is 4.4 degC, an increase from 3.9 degC in base scenario, but much lower than the 5.3 degC in the experiment d with higher TCR.
- This leads to lower impacts and lower chance of discontinuity in variant experiment d than in experiment d, with mean total effect of $591 trillion rather than $821 trillion.
- Conclusion: How the climate sensitivity is increased can have a big effect on the results.

Experiment a: Pulse of 50Gt in 2020

- Emissions of CO2 increased by 5 Gt for 10 year period centred on 2020.

NPV of total effect, experiment a



Source: 100000 PAGE09 runs

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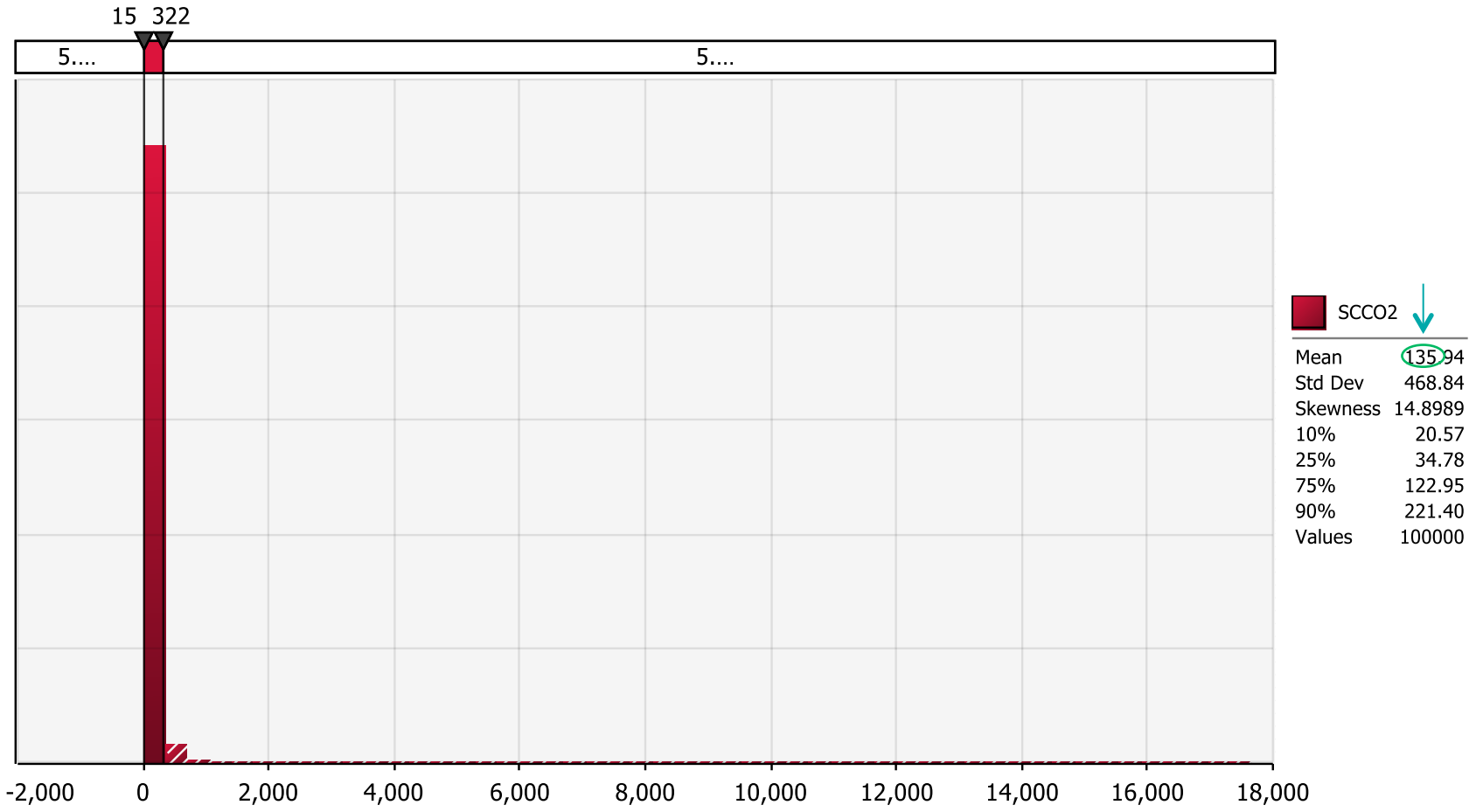
Explanation of result; experiment a

- Increased emissions of CO2 leads to increased temperature change and sea level rise.
- Higher temperature change leads to higher CO2 concentration via carbon cycle feedbacks which are included in PAGE09. Mean CO2 concentration in 2100 increases from 704 ppm in base scenario to 707 ppm.
- This increases temperature and sea level still further. Mean temperature rise in 2100 increases from 3.87 degC in base scenario to 3.89 degC.
- This leads to slightly higher impacts and higher chance of discontinuity.

The social cost of CO2 in 2020



Source: 100000 PAGE09 runs, A1B scenario

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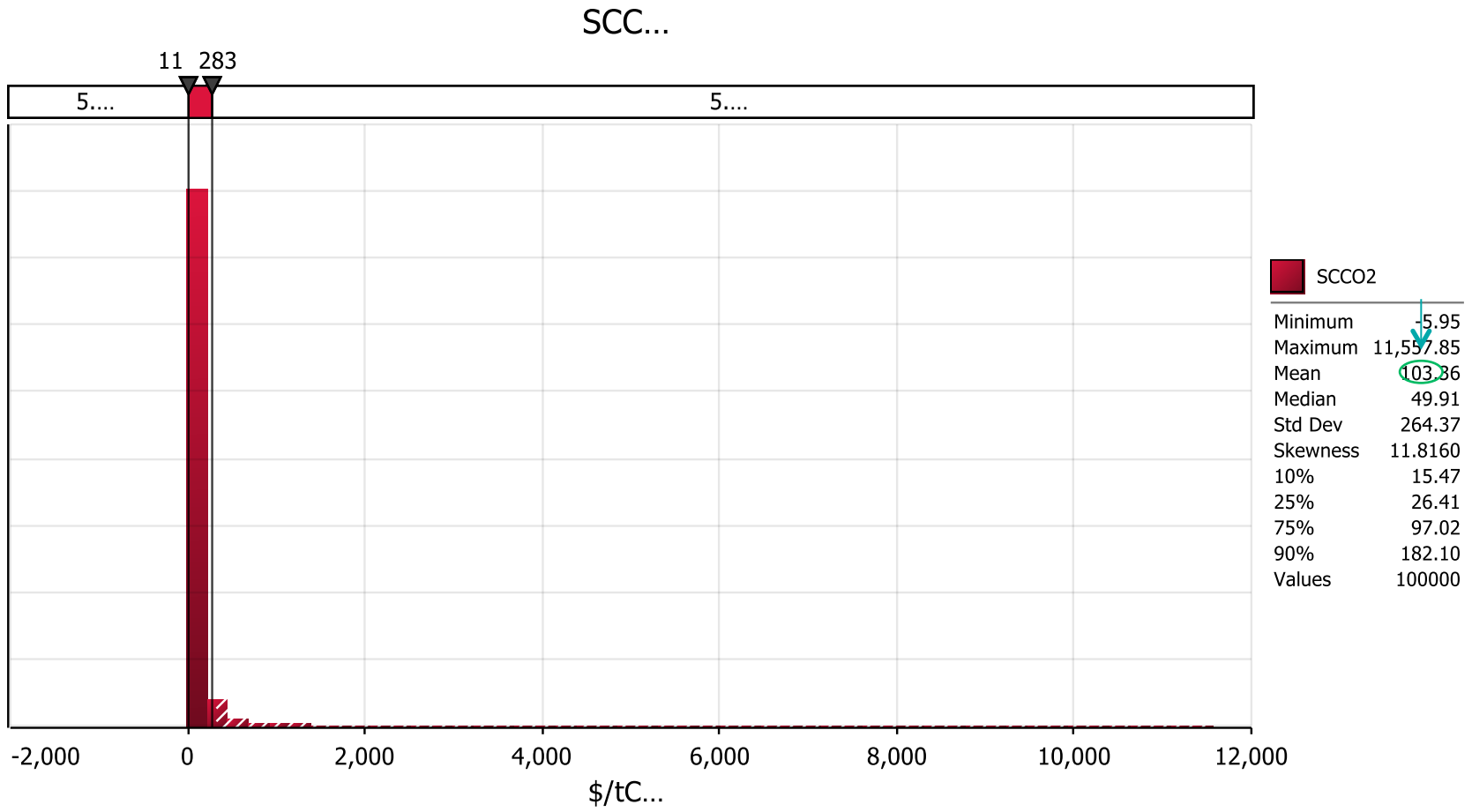
The social cost of CO2 in 2009; base scenario



Source: 100000 PAGE09 runs, A1B scenario

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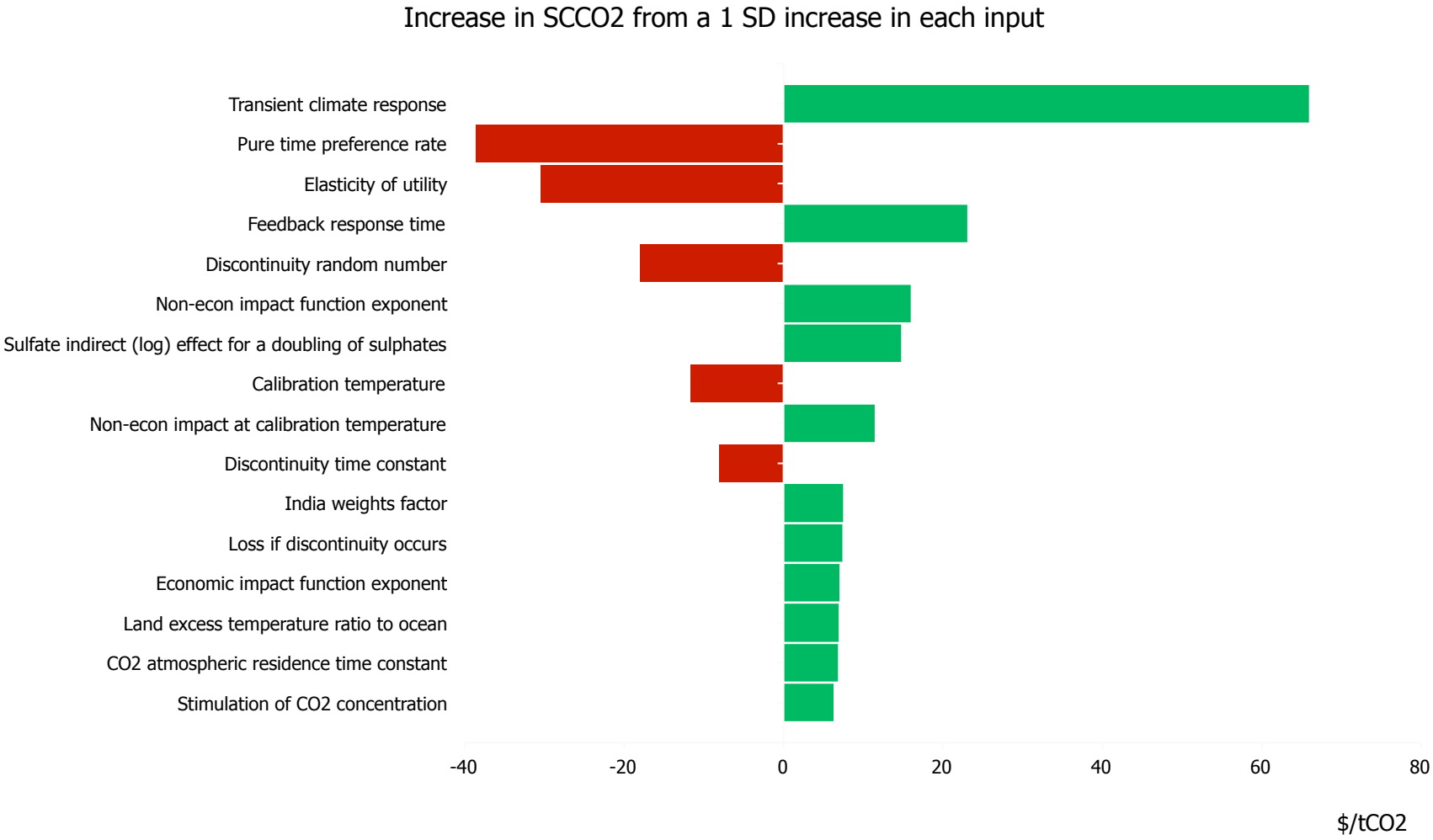
Mean SCCO2 in 2010, by experiment

Experiment	Mean SCCO2	
Base scenario	**106**	$(2005)/tCO2
Increased GDP growth	103	$(2005)/tCO2
Increased popn growth	150	$(2005)/tCO2
Increased sensitivity	215	$(2005)/tCO2

Source: 100000 PAGE09 runs; all mean values have standard errors of about $1/tCO2



Source: 100000 PAGE09 runs, A1B scenario

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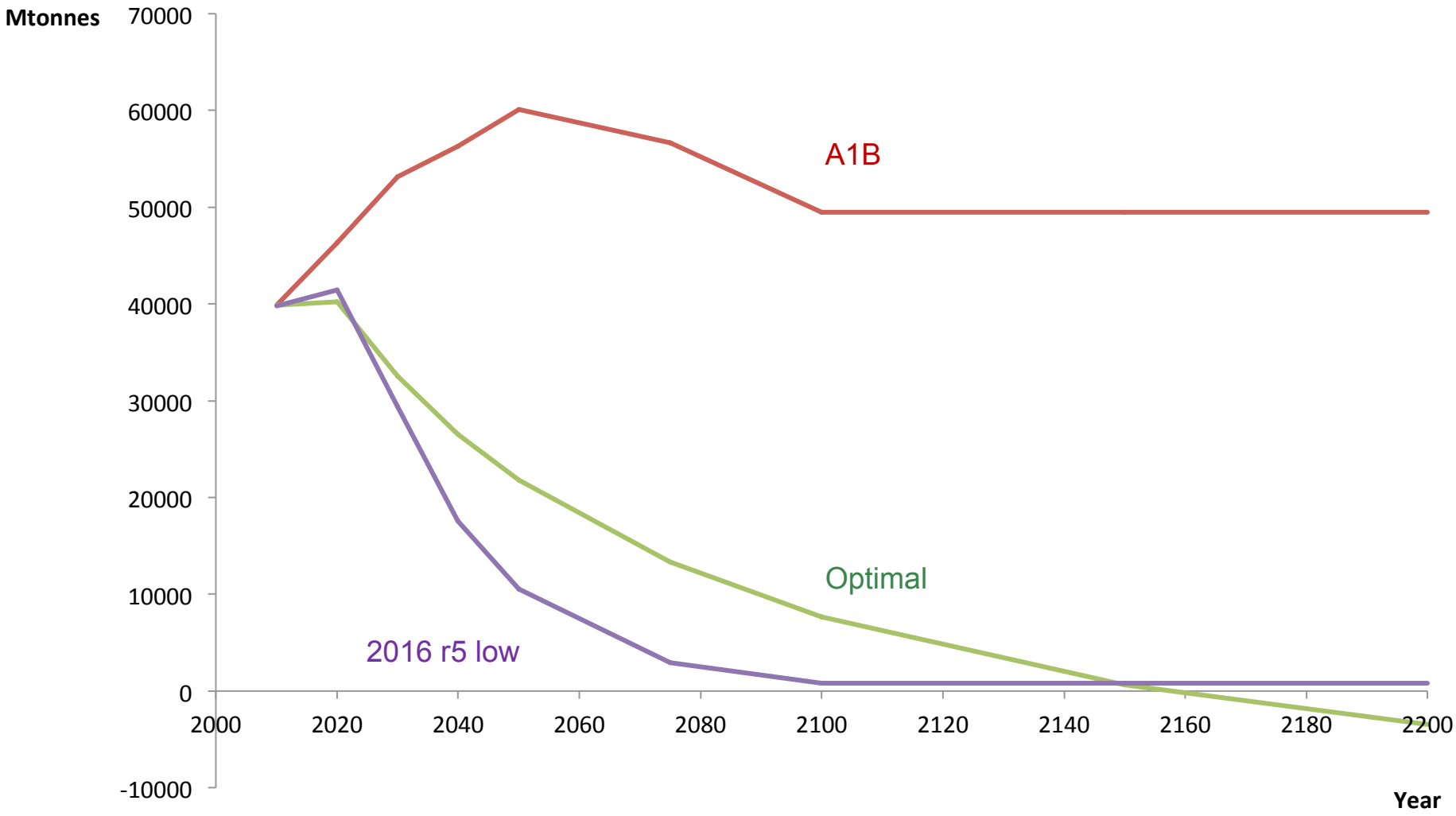
Towards optimal emissions

Emission paths over time



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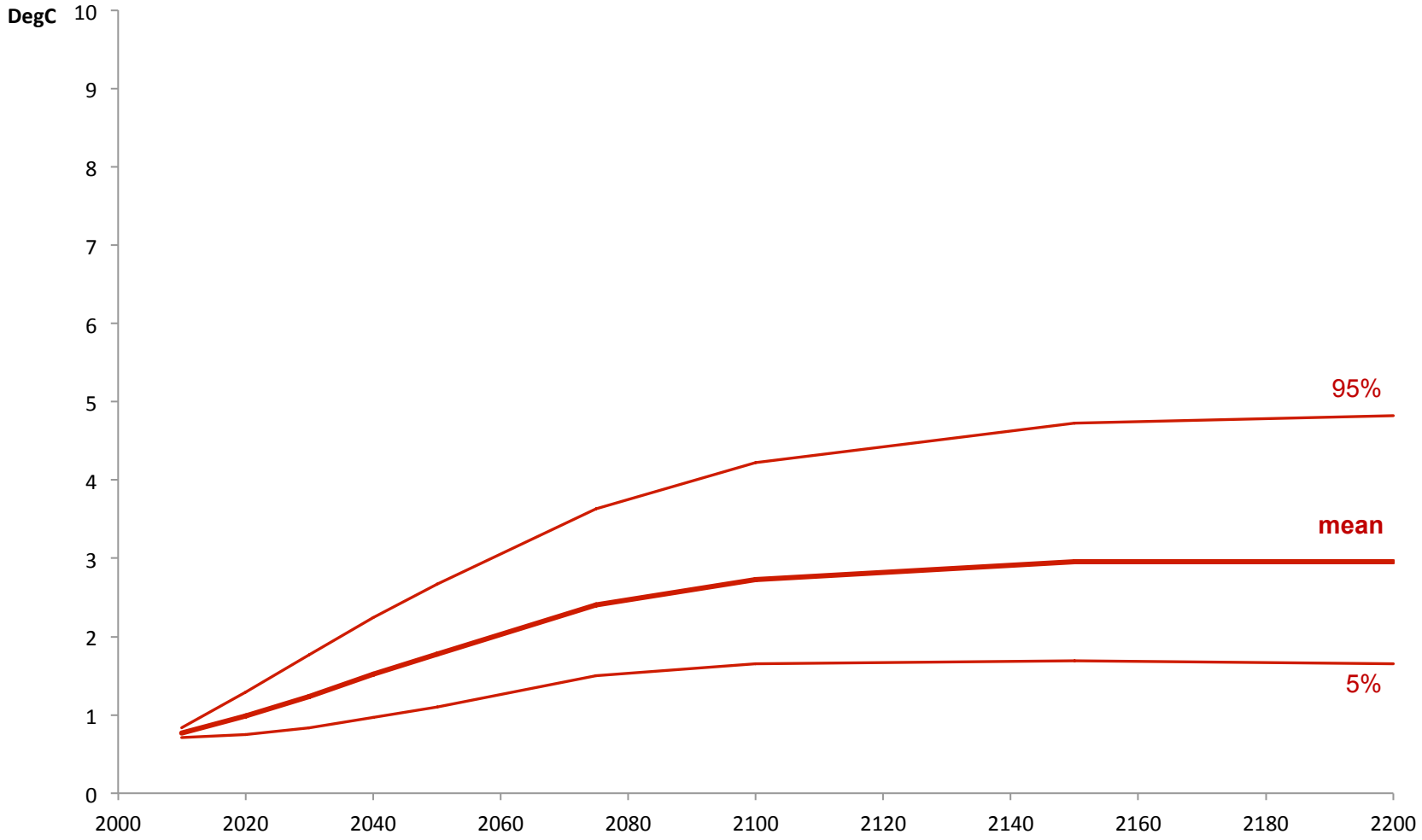
Global mean temperature rise by date, optimal emissions scenario



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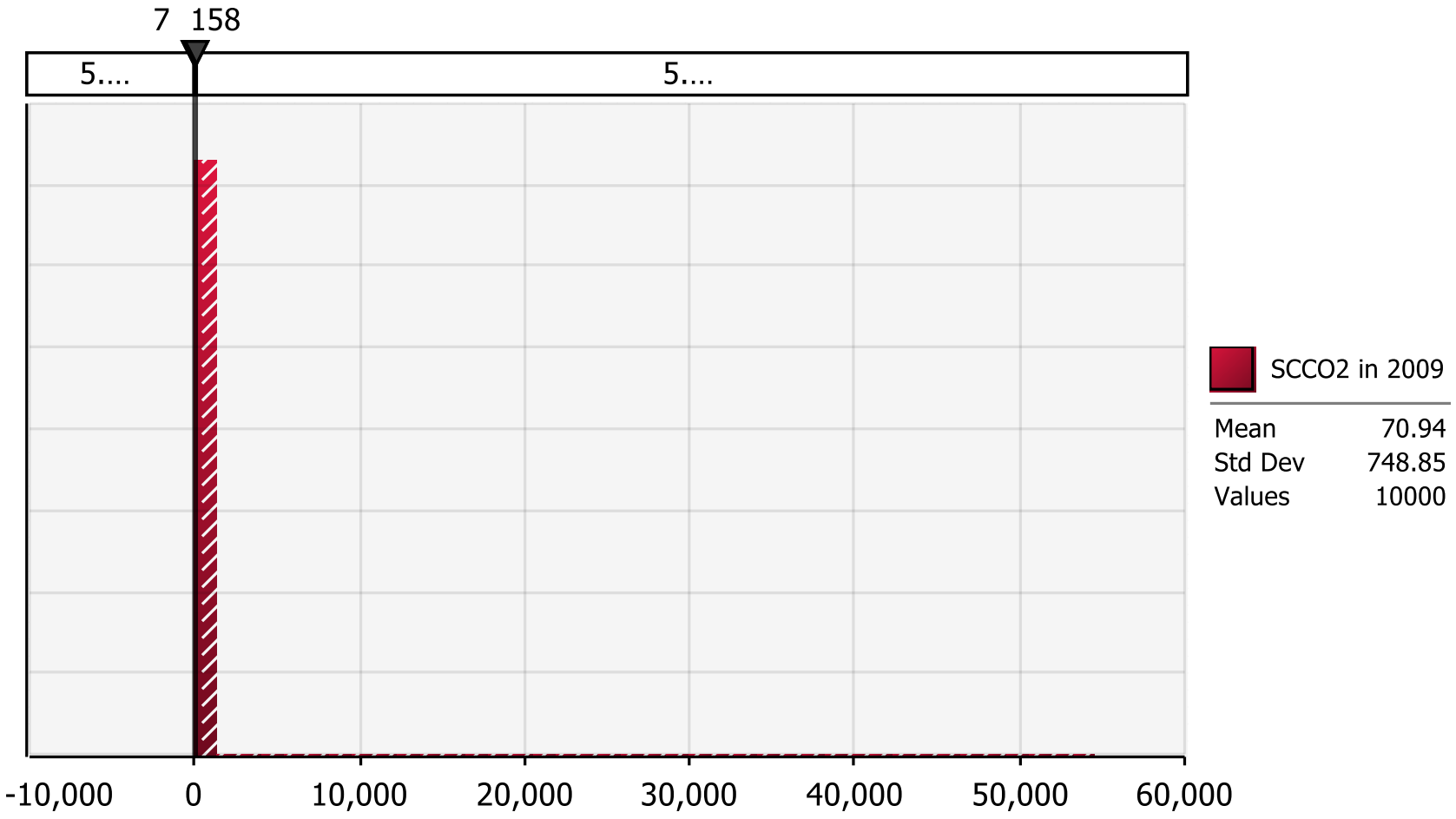
The social cost of SCCO2, optimal emissions scenario



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Thoughts for future modelling

- Specify link from GDP to emissions?
- More careful specification of climate sensitivity?
- Think about ‘optimal’ emission runs?