DISTINGUISHING BETWEEN PROACTIVE AND REACTIVE ADAPTATION TO CLIMATE CHANGE

Kelly de Bruin @ CERE, Umea, Sweden

Introduction

- Climate change policy options: mitigation and adaptation
- Integrated Assessment models are tools to analyse the effects of the economy on the climate and vice versa
- IAMs have many limitations but are good tools to understand the climate change problem and analyse its solutions
- Incorporate a more detailed description of adaptation in an IAM framework

Adaptation : introduction

- Adaptation refers to all strategies which alter economic and social infrastructure to better fit the new climate, in this way reducing the gross damages caused by climate change
- Can include many different options: use of air-conditioning, seawalls, agricultural adjustments, leisure adjustments, mosquito nets etc.

Adaptation : introduction

- Adaptation refers to all strategies which alter economic and social infrastructure to better fit the new climate, in this way reducing the gross damages caused by climate change
- Can include many different options: use of air-conditioning, seawalls, agricultural adjustments, leisure adjustments, mosquito nets etc.

Adaptation : in IAMs

- Adaptation is assumed to be optimal and implicitly included in the net climate change damage function
- Difficult to make adaptation explicit: lack of data, diverse, no common performance indicator
- PAGE, FUND, AD-DICE and AD-RICE

Adaptation : stock vs flow

- Adaptation has been categorised in many ways based on when and how adaptation occurs, and who adapts

We distinguish between 2 forms: **Stock** and **Flow**:

- Stock adaptation: investment costs are made to build up an adaptation capital stock which gives benefits later
- Flow adaptation: benefits and costs are simultaneous
- Stock adaptation: anticipatory, planned, public
- Flow adaptation: reactive, autonomous, private

Adaptation : stock vs flow

- Adaptation has been categorised in many ways based on when and how adaptation occurs, and who adapts

We distinguish between 2 forms: **Stock** and **Flow**:

- Stock adaptation: investment costs are made to build up an adaptation capital stock which gives benefits later
- Flow adaptation: benefits and costs are simultaneous
- Stock adaptation: anticipatory, planned, public
- Flow adaptation: reactive, autonomous, private

Framework (1)

- We base our analysis on DICE/RICE.
- Net damages in RICE were:

$$D_{j,t} = a_{1,j} \cdot TATM_t + a_{2,j} \cdot TATM_t^2$$

- We unravel these damages into residual damages (RD) and stock adaptation costs (IA) and flow adaptation costs (FAD) by defining a gross damage function, a residual damage function

Framework (2)

- We define gross damages as:

$$GD_{j,t} = \alpha_{1,j} \cdot TATM_t + \alpha_{2,j} \cdot TATM_t^{\alpha_{3,j}}$$

- Residual damages are reduced gross damages through adaptation:

$$RD_{j,t} = \frac{GD_{j,t}}{1 + Ptot_{j,t}}$$

Framework (3)

- Adaptation is given as a CES function of both stock and flow adaptation, i.e. we assume that stock and flow adaptation are imperfect substitutes:

$$Ptot_{j,t} = \gamma_j \cdot (\beta_{1,j} SAD_{j,t}{}^{\rho} + (1-\beta_{1,j}) \cdot FAD_{j,t}^{\rho})^{\eta/\rho}$$

- Where : $-\rho = \dfrac{\sigma - 1}{\sigma}$

- Stock adaptation can be build up over time through investments:

$$SAD_{j,t+1} = (1-\delta_k) SAD_{j,t} + IAD_{j,t}$$

Framework (4)

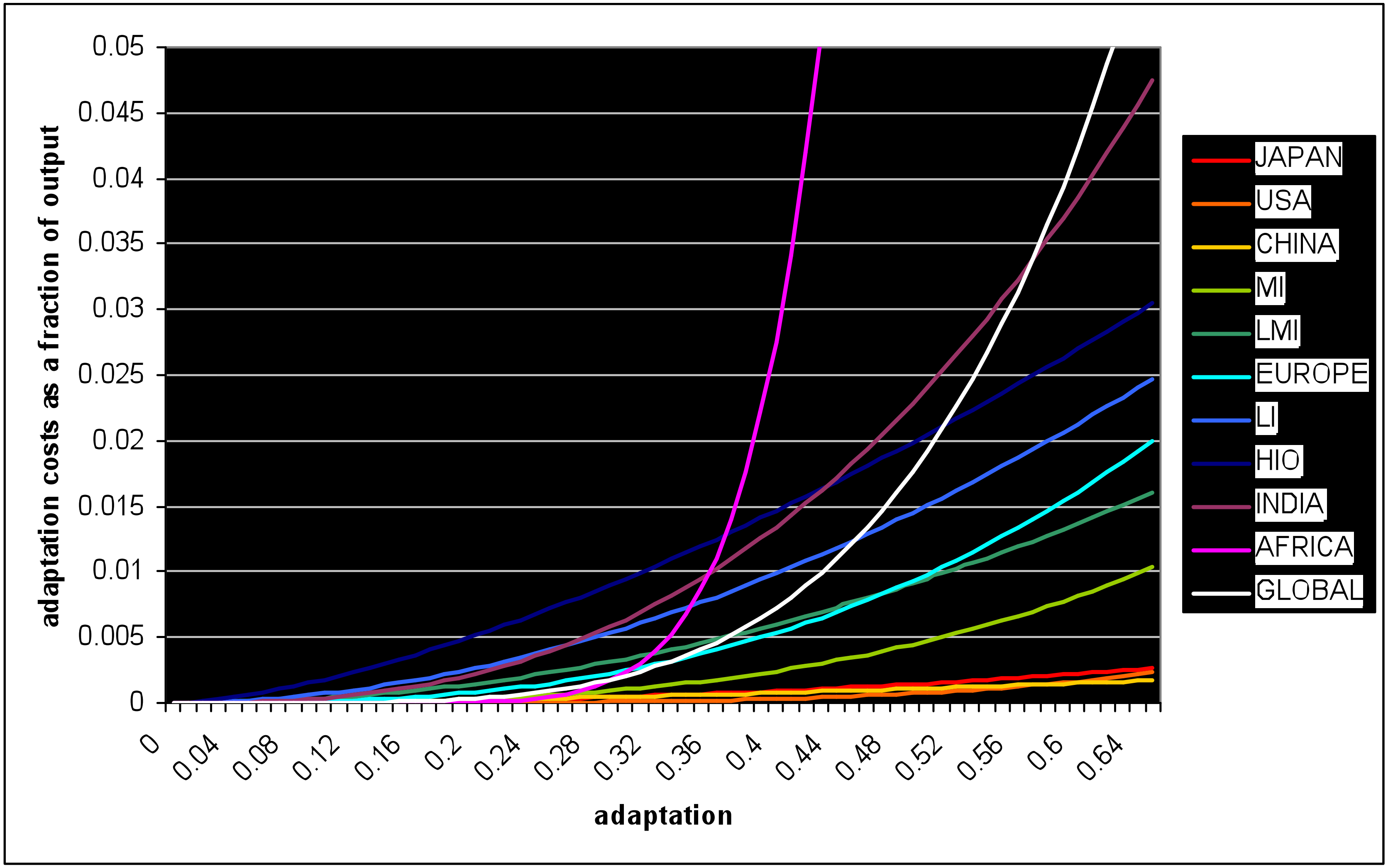
- Total adaptation costs consist of costs for flow and stock adaptation:

$$PC_{j,t} = FAD_{j,t} + IAD_{j,t}$$

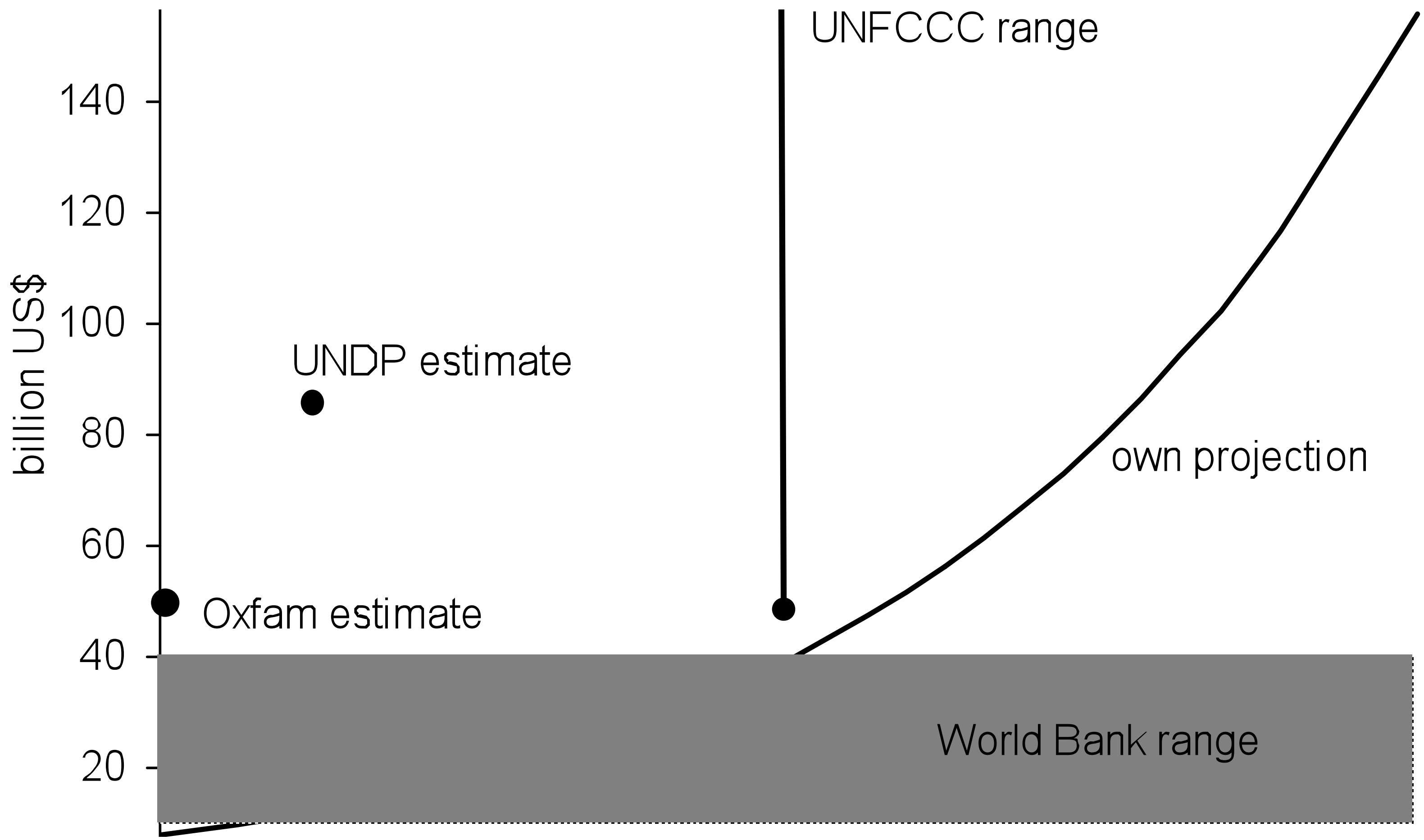
Calibration of AD-DICE2010

- Unravel net damages into residual damages and adaptation costs
- Use DICE/RICE damage categories
- Adaptation costs and benefits and potential are estimated for each category based on literature for both stock and flow (example: coastal (FUND), health (WHO), agriculture (T&S))
- Looking at the relative importance of the different impact categories over temperature change we can get an idea of how the importance of stock and flow adaptation will change over temperature change.
- Summarised in regional and global adaptation cost curves

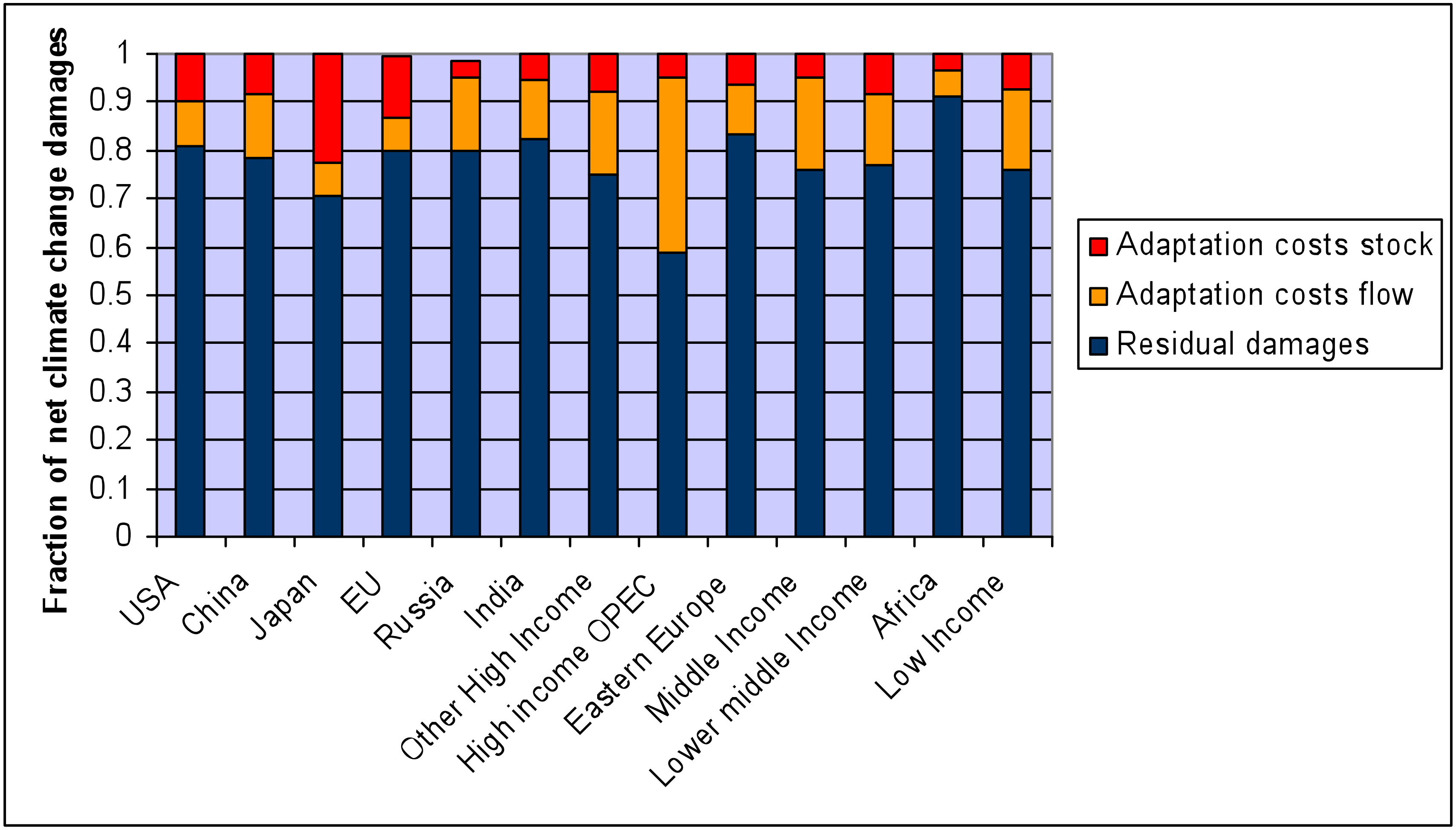
Results : adaptation cost curves



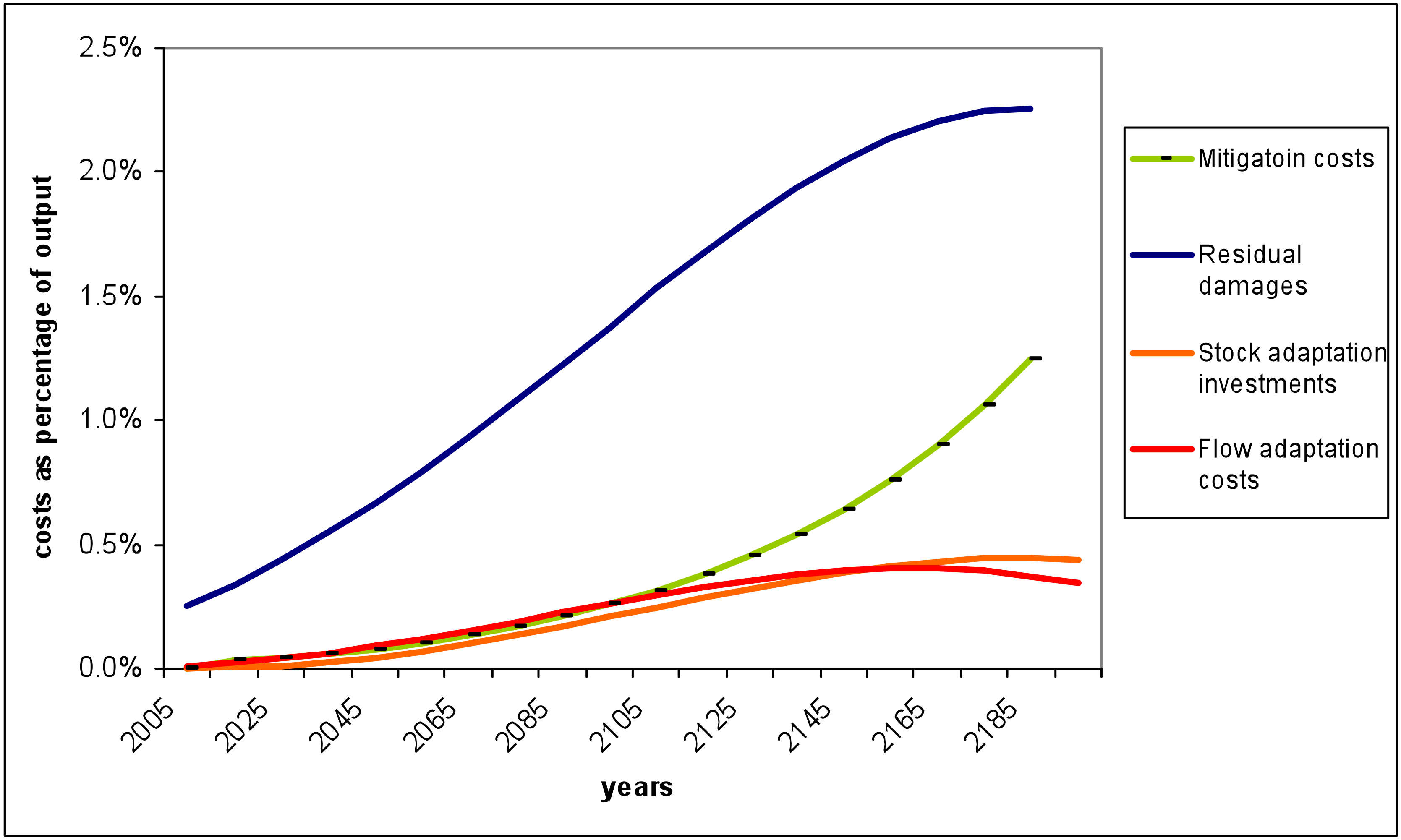
Results : adaptation costs



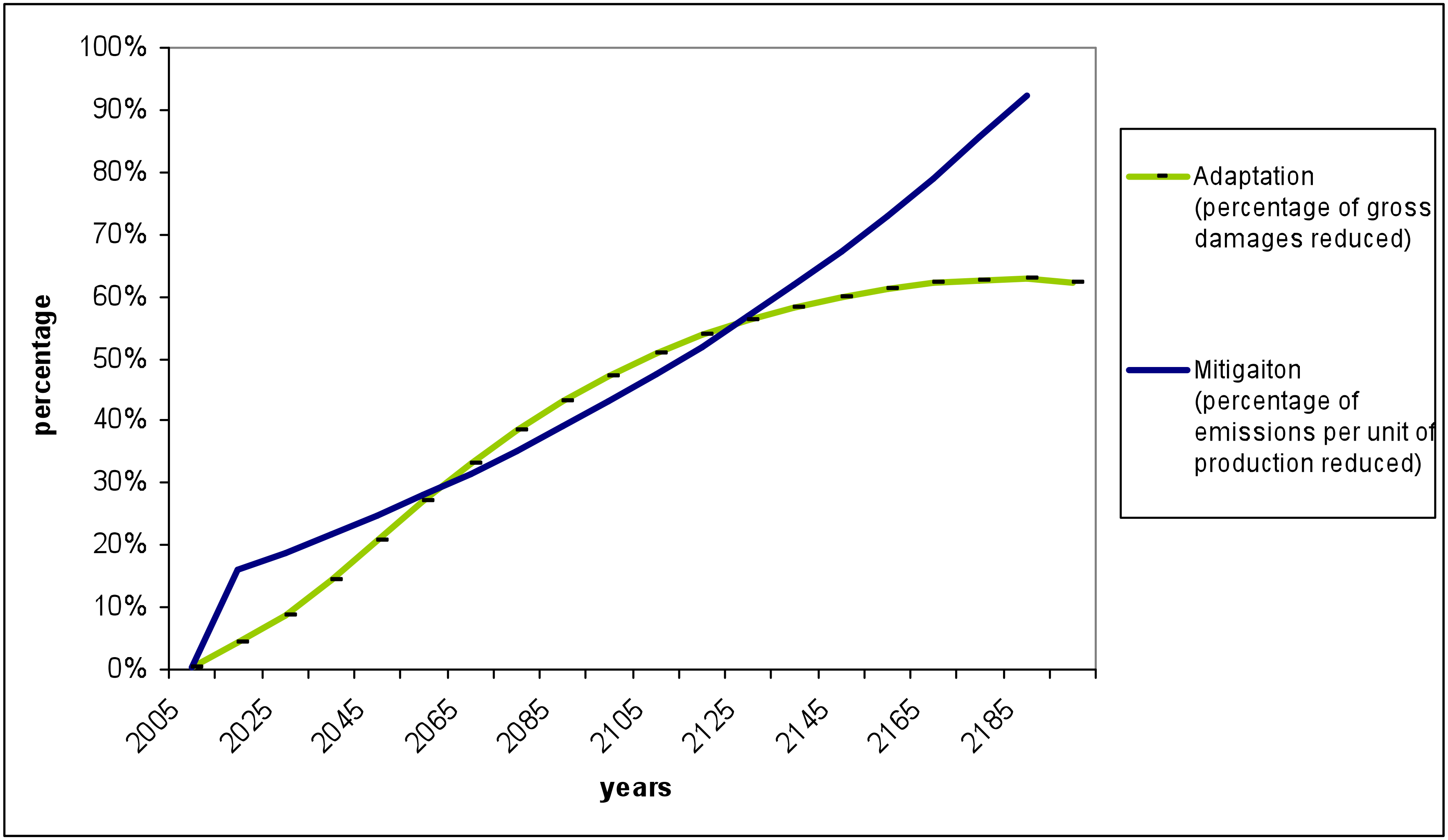
Results : regional climate change costs



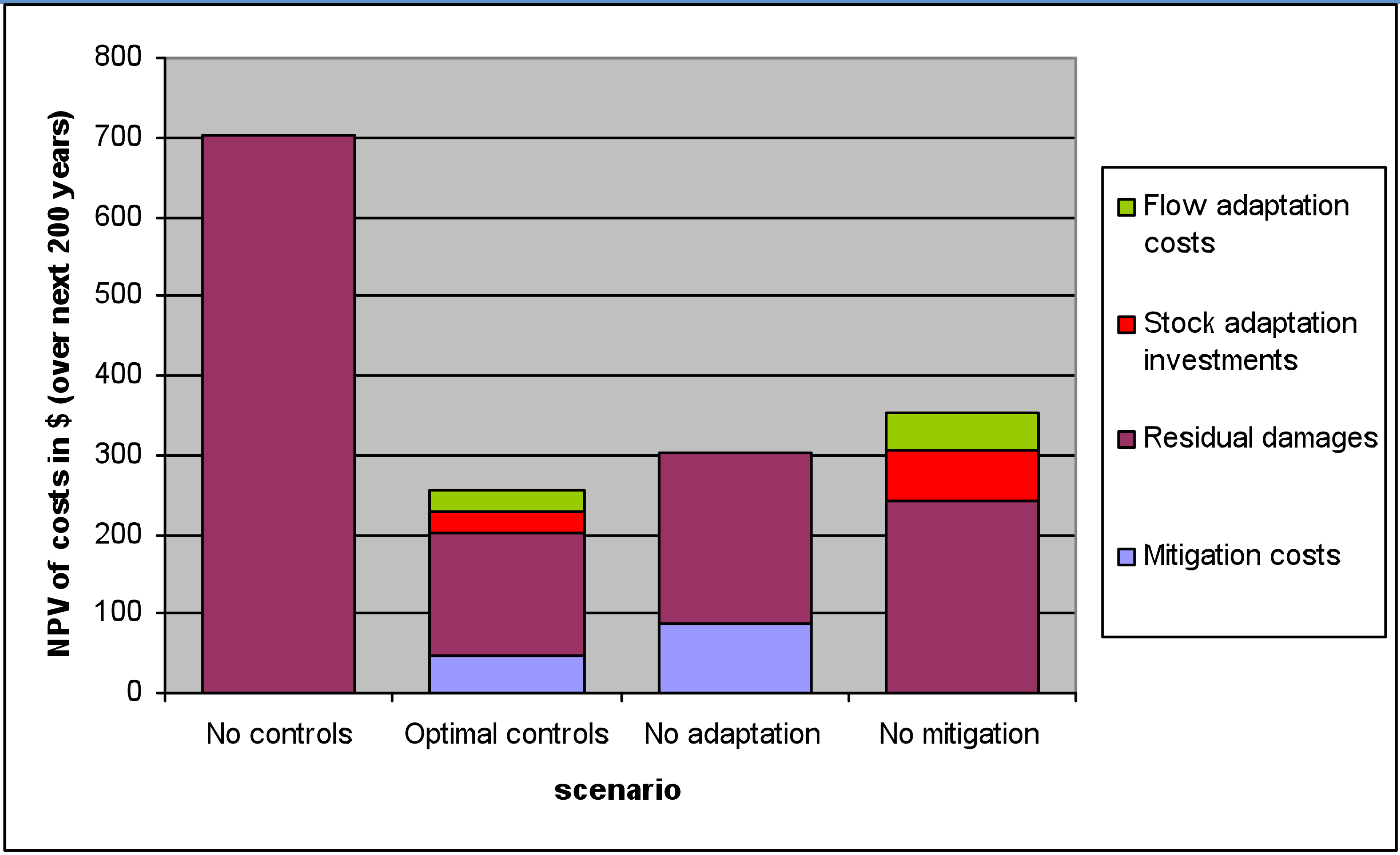
Results : global climate change costs over time



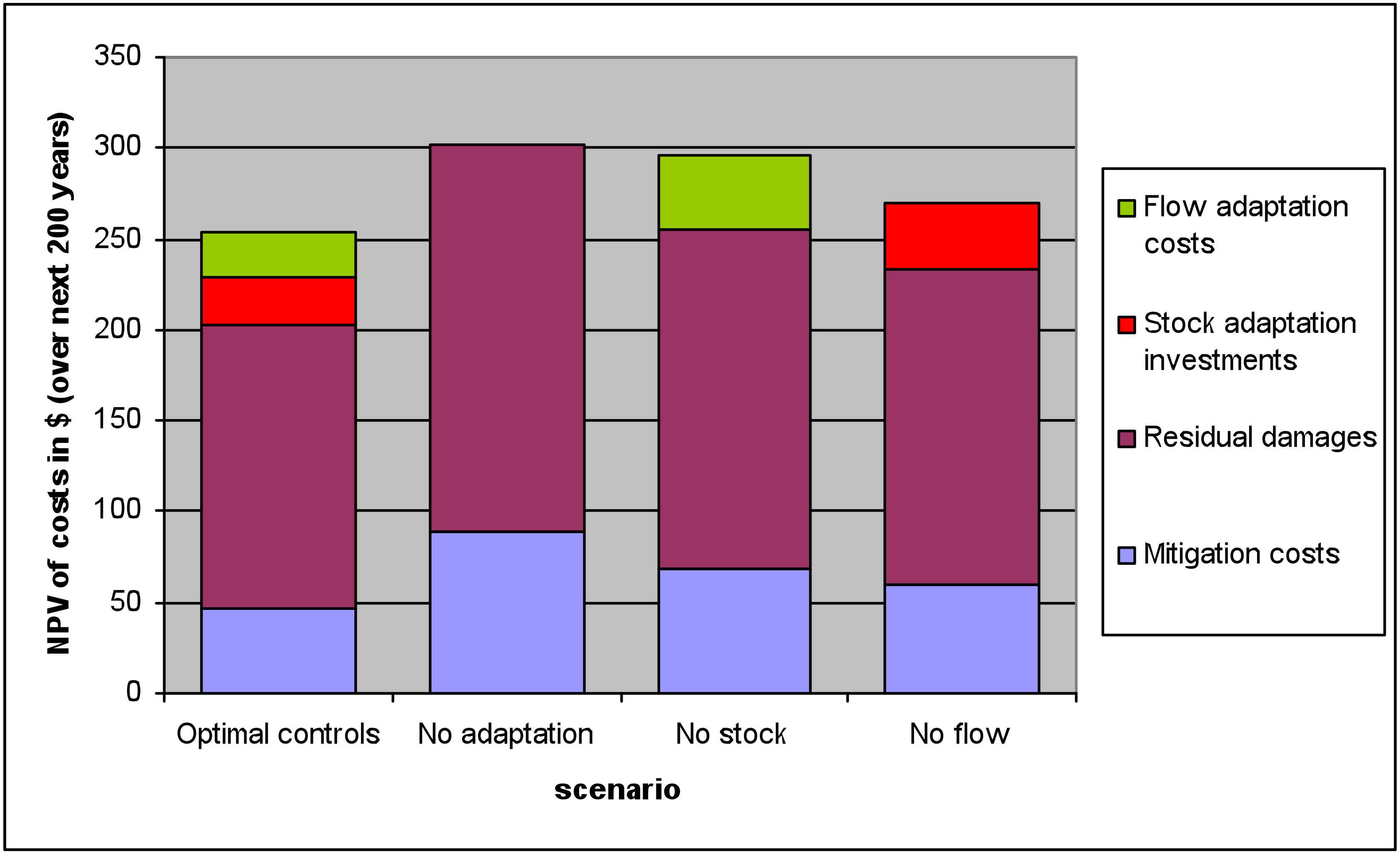
Results : adaptation and mitigation



Results : NPV of climate change costs in reference scenarios



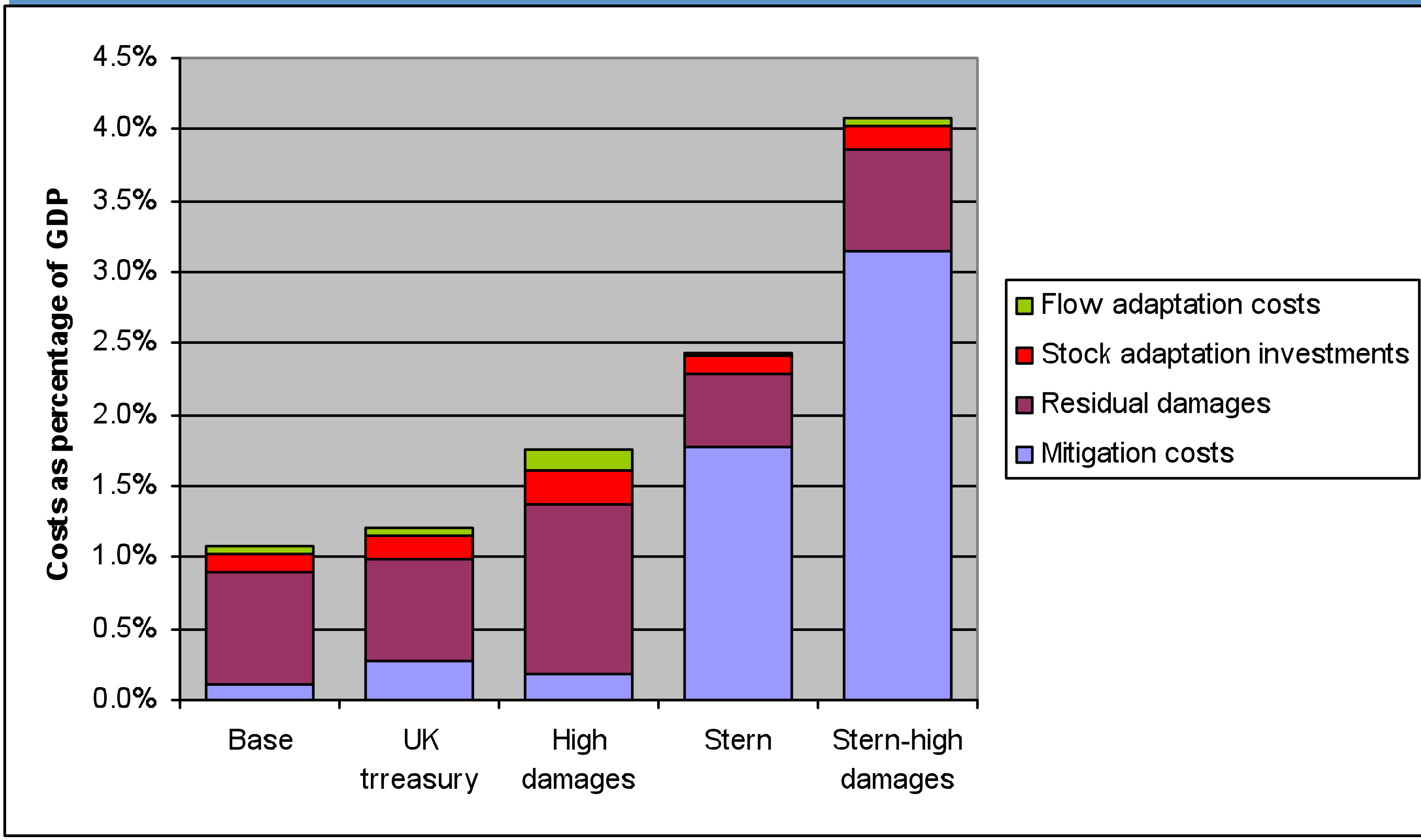
Results : NPV of climate change costs in adaptation scenarios



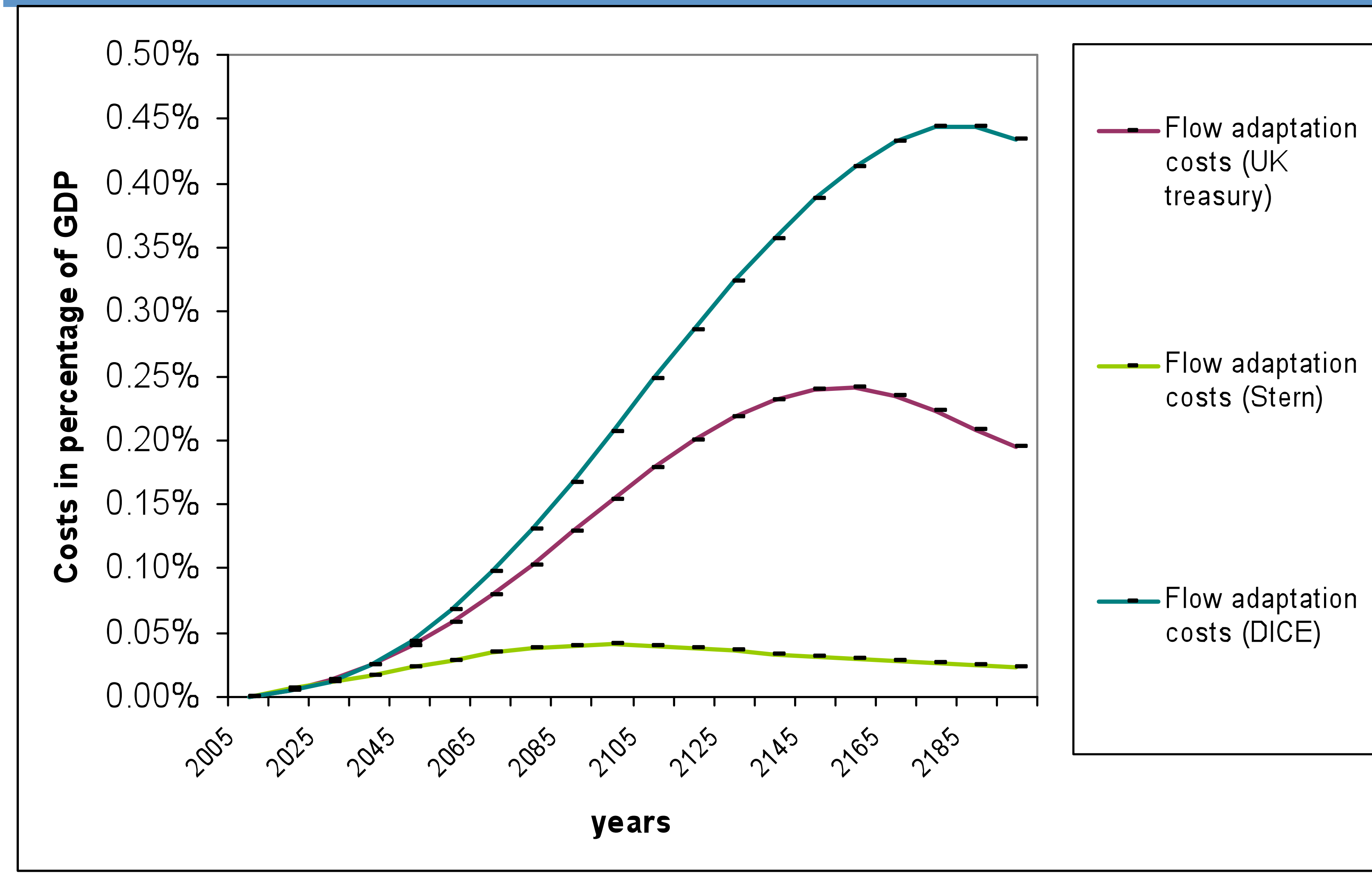
Sensitivity Analysis

- Large controversy over discount rate
- Main determinant of results
- How do adaptation and mitigation decisions react to changes in discount rate?
- DICE (high), UK treasury (middle) and Stern (low)
- Damages may be underestimated (Hahneman estimates twice as much)

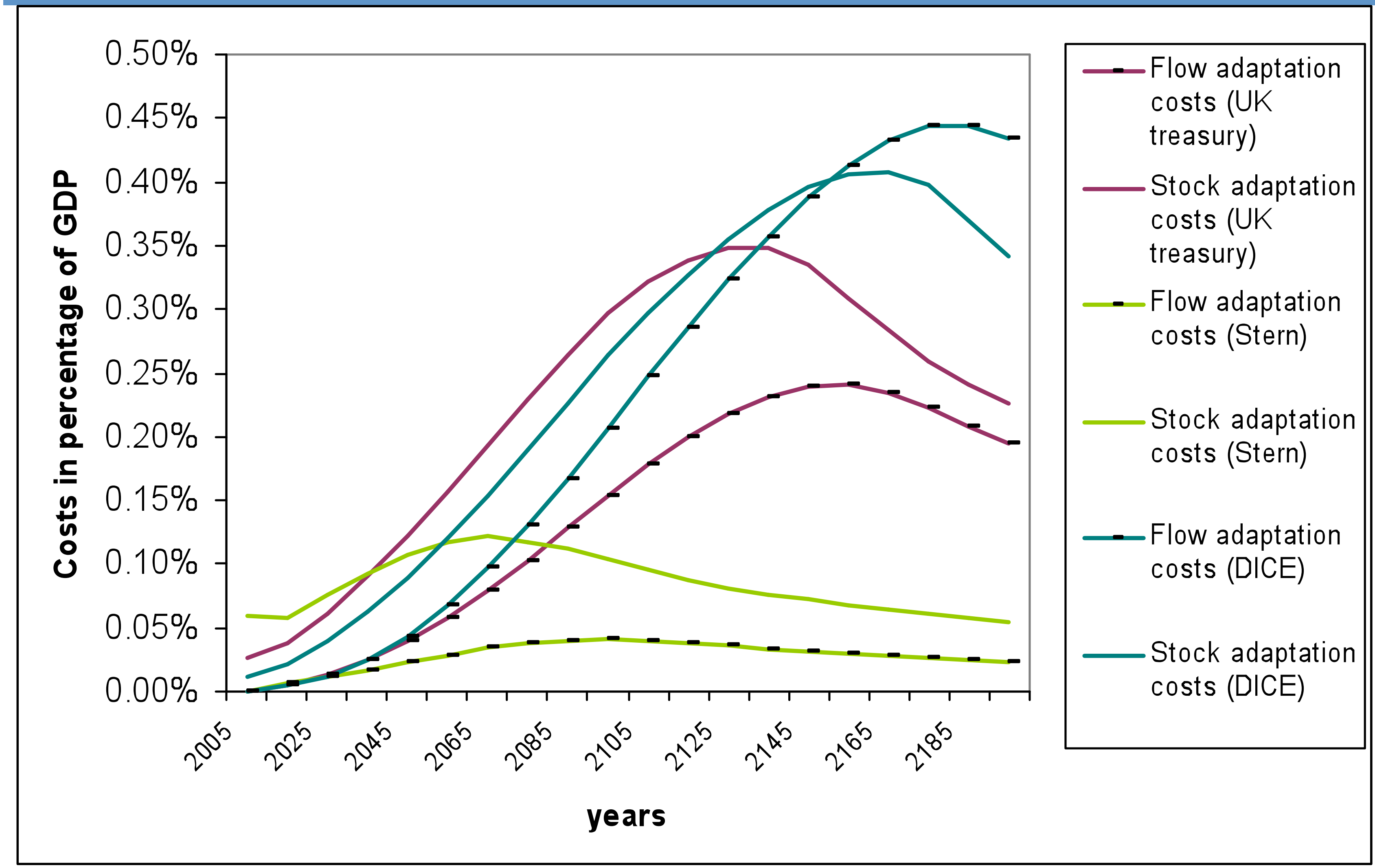
Sensitivity Analysis : discount rate



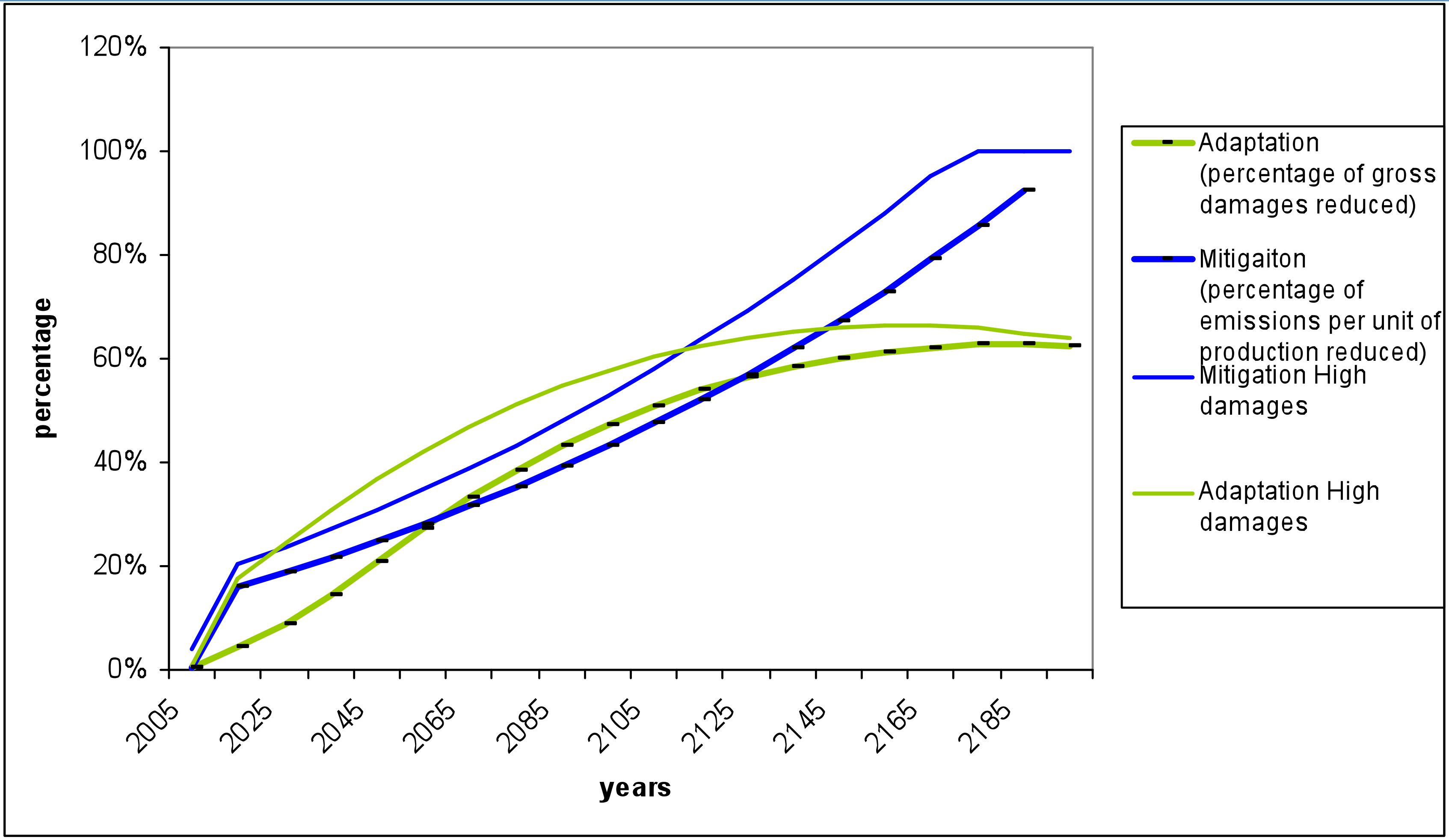
Sensitivity Analysis : discount rate



Sensitivity Analysis: discount rate



Sensitivity Analysis : damages

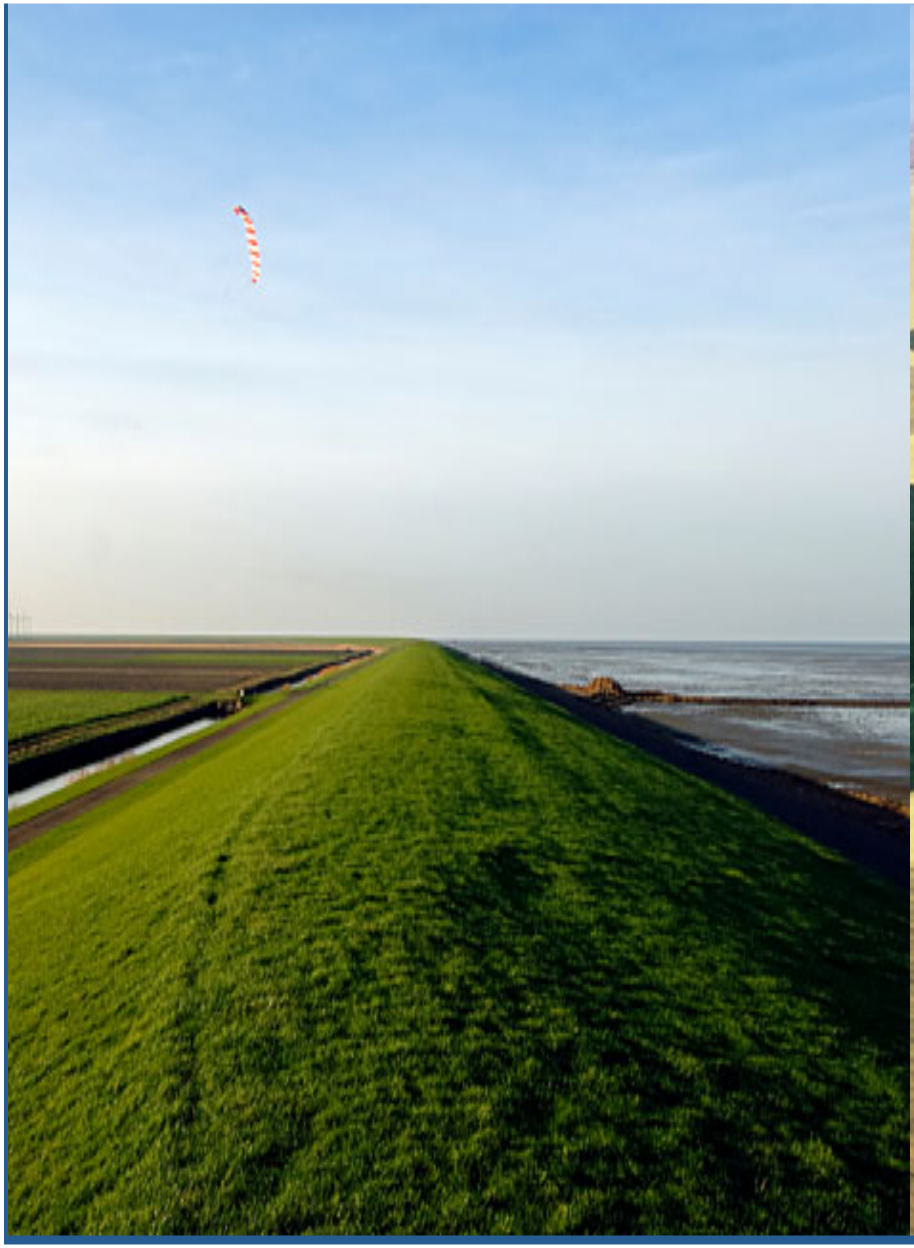


Conclusions

- Anticipatory adaptation ("stock adaptation") and reactive adaptation ("flow adaptation") are of similar order of magnitude
  - But variation across impacts and regions is large: adaptation is very diverse
- Different adaptation reacts differently to changes in the discount rate
- Stock and flow adaptation are imperfect substitutes, but restrictions on the one can be (partially) compensated at low cost by increasing the other
- Stock adaptation is a better substitute for mitigation than flow adaptiion

Further work

- Better consistent regional and sectoral damage estimates are essential!
- Improved calibration of regional and sectoral adaptation cost curves
  - Once we (roughly) know the impacts
  - Better insight into trade-offs between stock and flow adaptation
  - Better insight into impacts of policies on different impact sectors
- Stylised top-down modelling can illustrate interactions between mitigation, stock and flow adaptation



Thank you

Kelly de Bruin @ CERE, Umea, Sweden

Damages

- Several attempts to monetarise the impacts of climate change, most notably that of Nordhaus and Boyer (DICE/RICE model), Tol (FUND model), Mendelsohn
- The estimates of Nordhaus and Boyer are most often used in the literature and have been applied to several IAMs (MERGE, PAGE, WITCH etc.)
- My work has used several IAMs but focuses on the DICE and RICE models