

Overall assessment

This paper is strongly recommended for publication, because it

(a) describes in detail how the new version of PAGE which was used in the Stern review has been updated. It is very important that the economic and policy community understand the underlying changes to the model that result in new policy relevant information, and also that it is shown that the new calibrations are consistent with the latest literature.

(b) describes a new and important result, the contribution of Annex 1 versus the Rest of the World to the social cost of carbon, in an analysis which takes account of the uncertainties in the representation of impacts modelling, and in particular, the uncertainties in the relative weighting factors assigned to impacts in different world regions. This is a highly policy relevant result.

I recommend some modifications to improve the paper before publication. Importantly, the key results about the regional split of the SCC are given currently as mean values, and the author should extract also the ranges from the modelling results and show these in the paper and the abstract (see detailed comments). In particular, it should be made clear whether adaptation is or is not included in these figures, and whether this is an 'optimal' or some kind of maximum feasible level.

I would also like to see how the results vary with or without the inclusion of adaptation, which is much better represented in the new version of PAGE than it was in the previous version. This last addition is not essential for publication, but the paper would be much improved if this was included.

Slightly more detailed comments about how to make the modifications are given below.

Finally, the large number of minor comments are matters of clarification and suggestions for improvements to wording as the reviewer would like to help the author communicate the work as clearly as possible.

Detailed comments (these largely describe the above recommendations in more detail)

Abstract: Since PAGE is a probabilistic model, give ranges as well as single values for the numbers that you quote in the abstract. It is important, because PAGE is doing a good job of reflecting its uncertainty in estimating how impacts vary across regions, but this is not reflected in the abstract. What are the assumptions about adaptation in these headline figures? If you can derive the figures with and without adaptation (See below) include them in the abstract.

'Sea level rise impacts rise less than linearly' where have the values of the exponent come from, or did you simply choose them to make the outcome match that of Warren et al 2006 once you had incorporated Ackerman's value for economic and non-economic impacts? If so that is reasonable.

Page 8: adaptation and deBruin. Discuss whether to model 'optimal' levels of adaptation or 'maximum feasible' levels of adaptation. Which did you choose here? What did deBruin base their optimisation upon? Balancing adaptation costs and damage costs? Or adaptation costs and mitigation costs, and is this a global study or EU study? I also find the phrase 'residual damages without adaptation' confusing. Residual damage is usually used to describe that which remains after

mitigation, after adaptation, or after a combination of both - please clarify. The fact that adaptation is included as a choice in the model, as a variable value rather than just on/off, is very positive.

Page 11. The reader would like to see Figures 4 and 5 plotted with and without adaptation, so that we can perhaps assume, that reality might be somewhere between the two. Also it's important to know if the adaptation applied is the 'optimal' level calculated by DeBruin, or the maximum feasible adaptation (the maximum being defined by both physical and economic and social constraints). Are there any estimates of adaptation costs, since shouldn't these be added to the NPV of damages, and should they not contribute to the SCC? They are expenses that would not have been incurred without climate change. If I am right on this point, then the values of SCC with adaptation should be stated to be conservative. This point could be discussed and mentioned as a candidate for future work, perhaps.

Pp14-16 The reader would like to see the adaptation policy variable shown in Figure 7. Or, if only simulations were with adaptation 'on' and 'off', please show what Figures 6 and 7 are like with/without adaptation, currently you do not explain whether adaptation occurs in these Figures but presumably so as a default.

Page 17-18 Please give uncertainty ranges on the data shown here and match with summary findings in abstract. Only the mean results are quoted here. The min and max values in these tables would be very interesting to see.

Page 17-18 What would these tables look like in the absence of adaptation? Or supposing, there was adaptation in the Annex 1 and not in the RoW? These might be questions for future work but if you can easily include the results here, please do. At least in the abstract please explain whether the results assume adaptation or not and in Annex 1 or RoW.

Page 6: the assumption that only one discontinuity occurs seems over optimistic. You might want to add that this may be so and say that future work will explore the potential for multiple discontinuities.

Should there be a conclusion?

Minor Comments

On Abstract:

Since the abstract should be readily understood standalone, here is how it can be misunderstood if one does not read the rest of the paper. Suggest make edits so it stands alone.

Abstract: Sentence 2: reword, since 'scientific' encompasses the other three (impact, emission, adaptation) Suggest say 'The factors which are most influential in determining the value of the SCC emerging from the latest default version of the model, PAGE09 v1.7, are described. These include the input emissions, adaptation assumptions, and the representation of climate change and its impacts'.

What is meant by 'the scientific and economic impact results'? What results? Values of SCC? Or something else? What scientific impact results? Suggests PAGE is outputting impacts in physical quantities, which I'm sure it's not.

'Aims to' Rather, say that using a probabilistic climate model, xx, the scenario has a yy% probability of constraining annual global mean temp rise to below z C.

'Today's mean social cost'. The reader can think you are talking about a measured amount in the real world. Reword to say, 'The model finds that the value of the SCC today is about \$100

Last part: 'impacts in annex 1 from annex 1 emissions' and 'impacts in RoW from RoW emissions'. I know what you have done mathematically, but this doesn't make sense stand alone because impacts can't be assigned to a particular emitting country – all the CO2 from everywhere causes all the impacts. Hence suggest reword as follows: If the damage in Annex 1 countries is apportioned according to the ratio of emissions in Annex 1 to those of the RoW, and similarly for the RoW emissions, then the Annex1 emissions' effect on impacts in Annex 1 countries contributes to less than 10% of the SCC value. In contrast, 45% of the SCC value comes from damages in RoW countries apportioned to RoW emissions. Just over 10% of the value arises from impacts in Annex 1 apportioned to emissions in the RoW.

Question: presumably then, 35% of the SCC value is due to impacts in Annex 1 countries apportioned to emissions in the RoW. I think this is worth emphasizing in the abstract, as it is quite an interesting result too.

BAU scenario: in the abstract, say what the BAU scenario is.

On Introduction:

Para 3: as above re 'scientific, impact, emission and adaptaton' suggest reword to match suggested reword in abstract.

Para 5: economic and non-economic would seem to encompass everything. So need to reword as follows: 'impacts due to gradual changes in climate, in (i) economic sectors (ii) non-economic sectors, and also those arising from rapid changes in climate which may occur in response to feedback processes in the earth system (reference Lenton's paper) which are termed 'discontinuities'. Impacts from sea level rise are treated in a separate category. However, presumably sea level rise then has both economic and non-economic impacts, but presumably this category includes both types of impacts then?

Question: what about sea level rise impacts that are discontinuities, like melting of Greenland Ice Sheet? Which category are they in? Are they included?

Page 3. Effects of sulphates.

'Not easily understandable' I'm not sure this matters. What matters is whether it was correct, and whether the new version is more accurate ...the overall numbers are unchanged since PAGE2005. Can you be clearer about the changes since PAGE 2005?

Page 4. Carbon cycle feedback, para 2. 'Carbon cycle feedbacks with mean values in 2100 of about 95ppm' Not sure what the units of 'carbon cycle feedback are, as this is a process, but they might be ppm per ton C ... suggest reword to, 'the carbon cycle feedback thus simulated produces CO2 concentrations which are enhanced by approximately 95ppm by 2100 ...' etc. Edit rest of para 2 in like mind. You list Warren et al 2010 in the reference list, suggest that you explain that the changes to the representation of carbon cycle feedback addresses the issue raised about overestimated CO2 concentrations in the older version of PAGE that was noted in that paper.

On impacts section

Title 'sea level, economic and non-economic' is OK if wording is changed where the impact categories are explained on page 1. Next sentence may not be necessary here but if included change wording to match suggested change to page 1 wording or add see page 1.

Table 4 Add 'in the EU' to the Table caption.

'The same range as in Ackerman et al 2009' Please explain what exactly is quoted in this paper that you have matched for the calibration.

Clarify if the Warren and Ackerman numbers refer to the EU only.

After Table 5, it is absolutely key to explain that PAGE has the good feature of including ranges for the multiplicative weight factors and also is capturing the uncertainty in the relative level of impacts between different regions, by considering these weights as independent variables in the uncertainty analysis. Because the representation of impacts across regions is uncertain, any study which attempts to apportion SCC to different parts of the world, must sample across the uncertainty ranges of these weighting factors. PAGE does this, and it is very important to emphasize that this is the case, as it justifies the validity of the central result presented in the abstract. It is also important therefore, to include more detail about how Anthoff et al (2006) arrive at these ranges for the weighting factors. Does Anthoff et al provide the ranges as well as the mean or mode?

Page 6: how are impacts linked to GDP per capita? Is there an assumption that impacts decline with increasing GDP? If so what kind of relationship is assumed?

Page 6: discontinuities. *When* does the EU lose 5-25% of its GDP?

Page 8 Emissions. Mention that current emission trends are closer to an A1FI pathway, can you comment in the discussion then about whether the results might have higher or lower values of SCC in this case?

Page 8. Adaptation, 'it only works ... (3 deg)' it's not clear here whether you mean 1+2=3 deg or whether you mean 3+2=5 deg . Please clarify.

Page 8. Last para, Parry et al 2009. At what global temp rise does Parry have adaptation as 80% effective in the agricultural sector? Does this include the possible confounding effects of pests and diseases and increases in tropospheric ozone concentrations that are generally not included in ag models? In which case might the Parry estimate be conservative?

Page 8 Adaptation, please explain what you set the adaptation policy variable to in this study, eg 1 and 0 or other values.

Figure 5 should have a colour key indicating that red is BAU and purple is the low emissions scenario.

Page 15 discussion here is very good and clear.

Page 8 Treatment of adaptation in non-economic sectors is good.