SUSTAINABLE
FINANCE
LAB

THE REAL RISKS

How pension funds and supervisors can act on environmental risks in a world of imperfect models and data

In this paper

Environmental models fail to accurately represent the financial risks resulting from climate change and nature degradation.

Pension funds and supervisors should focus on managing environmental uncertainties rather than risks.

They need to find a balance between improving the models and acting precautionary going beyond traditional risk management.

Gerdie Knijp, Aleksandar Simić and Brenda Kramer

January 2025

2

Colophon

Policy Brief

Sustainable Finance Lab publishes different types of publications. This is a Policy Brief. Policy Briefs are concise reports produced by SFL members or employees that contain specific proposals and recommendations for the financial sector or policy makers.

SUMMARY AND RECOMMENDATIONS

3

Pension funds have long-term obligations and are therefore sensitive to uncertainties from the effects of climate change and nature degradation. Pension funds increasingly consider these environmental risks but face challenges in data availability, modelling and estimating the financial impacts on their portfolios. The models are mostly backward-looking and fail to accurately represent potential economic damages of climate change and do not recognise non-linear dynamics, such as environmental tipping points. These models underestimate potential damage and overestimate the time we have to solve the issues.

In order to make decisions in a time of increased uncertainty there is a need to strike a **balance between improving the models and taking action based on precautionary principles**. This policy brief summarises key insights from conversations with Dutch pension funds and supervisors and regulators.

Key insights for pension funds:

1. **Focused portfolio management.** Shift from broad and overdiversified passive portfolios to more focused and consciously selected portfolios, to improve knowledge of the companies in those portfolios. This also enables closer engagement with portfolio companies and better alignment with sustainability objectives.

2. **Enhanced risk management.** Focus on managing inherent uncertainty rather than only risk management. Improve risk models with relevant forward-looking metrics and challenge scenarios and models created by other parties. Become familiar with the underlying narratives and assumptions and perform sensitivity analysis. In decision-making, employ

expert judgment and qualitative scenarios to complement quantitative models.

3.   **Act on negative impacts.** Act on negative environmental impacts directly by engaging companies that can transition and reducing exposure to known harmful companies that cannot or are unwilling to transition. Implement a transition plan to align with net-zero and nature-positive goals and set ambitious targets, for example, on the reduction of carbon emissions and exposure to deforestation.

4.   **Impact integration.** Adopt a "risk, return, and impact" model to systematically prioritize environmental impacts alongside financial performance.

Key insights for supervisors and regulators:

1.   **Expand current supervisory expectations.** Strengthen the consideration of double materiality and add the disclosure and assessment of environmental impact to current supervisory expectations (in IORP II and the supervisory expectations defined by local supervisors). Strengthen the requirements related to scenario analysis in the own risk assessment.

2.   **Improve scenarios and stress testing exercises.** Explore alternative models in scenarios and allow for more severe stress in supervisory and economy-wide stress testing exercises.

3.   **Mandate transition plans.** Mandate the creation of transition plans to align financial institutions with net-zero and nature-positive goals.

4.   **Limit exposure to harmful activities.** Introduce charges or limits on exposure to environmentally harmful activities to reduce systemic risks.

Policymakers should act too. Although not the focus of this policy brief, pension funds and the supervisors are dependent on governments defining stable long-term polices, transition pathways and regulatory guidance. Policymakers are primarily responsible for setting and

committing to long-term pollution pricing. These policies bring regulatory certainty to the real economy and thereby the financial. Pension funds and supervisors can simultaneously advocate for consistent policies on sustainability. Regulatory clarity and predictability are a prerequisite for financial institutions to make informed investment decisions.

5

CONTENT

6

1.
DIAGNOSIS: A WORLD OF IMPERFECT MODELS AND DATA

7

Quantitative scenarios underestimate environmental risks

The financial sector and its supervisors make use of climate models and scenarios to translate environmental changes into economic variables and financial impacts. Financial advisors, for instance, use these models to inform pension funds of financial returns in a world with progressing climate change, while supervisors use them for stress tests (Alogoskoufis et al., 2021; Keen, 2023). However, there are reasons for scepticism in the design and the outputs of these models and scenarios.[1]

Firstly, most climate scenarios omit various relevant climate and nature impacts, such as acute physical risks (floods, droughts, heatwaves, etc.), biodiversity and ecosystem damages, geopolitical and migration impacts, etc (Monasterolo et al., 2023). Secondly, most scenarios rely on backward-looking data relating to temperature and output, ignoring economic uncertainties and non-linearities that future climate change impacts bring (Keen, 2021; Trust et al., 2023). Thirdly, models are often sensitive to certain inputs, like the discount rate, so that outputs vary considerably relative to the modeller's assumptions (Pindyck, 2017). These models also often do not model the financial sector explicitly, ignoring important feedback loops between finance and the transition, and potentially reducing relevance of the outputs of these models for financial risk analysis and investment decision (Monasterolo et al., 2023).

Worryingly, the damages projected by the results of these models do not agree with the findings from climate science (Trust et al., 2023). For instance, the damages projected for 3 degrees warming in 2100 in certain studies range from only 2% to 44% of GDP loss (Aerts et al., 2024). In addition, some financial advisors to pension funds suggested that a 4-degree warming could decrease annual

[1] The criticism of climate models and scenarios has a longer history. For a more exhaustive treatment, see for example Keen (2021, 2023), Pindyck (2017), Stern et al. (2022), Weyant (2017).

returns until 2030 by only 0.06% (Keen, 2023). At the same time, climate scientists warn that any temperature increase above 2 degrees might be catastrophic and incompatible with organized societies as we know them (Carbon Brief, 2014; IPCC, 2021). These findings indicate limited reliability of these models.

Scenarios and models fail to include tipping points and non-linearities

Current climate models cannot accurately, or at all, represent climate tipping points, thresholds beyond which small additional shifts trigger non-linear changes that qualitatively alter the state of an environmental system, powered by self-amplifying feedback loops (Keen, 2021; Trust et al., 2023, 2024). These are 'points of no return' in the Earth systems and these effects are difficult or impossible to predict. To add complexity, some of these tipping points can interact with each other, compounding the negative effect. Examples of the tipping points include the collapse of the Atlantic meridian current, Greenland ice cover and dieback of the Amazon forest. Due to their complexity, it might be simply impossible to predict the ultimate social, economic and financial impacts of the large-scale changes. As a result, the true economic costs of environmental tipping points and tail risks, if they materialize, are simply unknown and, as noted, it is doubtful that they can be estimate with any degree of accuracy.

8

Present studies try to quantify the financial reliance and exposure to some of these nature sectors. For instance, a study by the Dutch central bank (DNB) found that Dutch financial institutions contribute to the loss of over 58,000 km² of pristine nature (more than 1.7 times the land surface of the Netherlands itself) (DNB, 2020). The same study found that at the end of 2019, Dutch financial institutions contributed €96 billion in financing 414 companies with environmental controversies, which is 14% of the €700 billion financing for which data is available (DNB, 2020). Other studies research the financial flows into nature-sensitive areas, and find that $455.5 billion and US $60.2 billion were invested companies into with business models related to Amazon rainforest and Indonesian peatlands degradation, respectively, between 2014 and 2023 (Marsden et al., 2024).

Pension fund risk models have limitations

Additionally, there are issues with the standard Asset and Liability Management (ALM) studies, which are the stochastic models used by pension funds to assess assets and liabilities under different economic scenarios. Traditionally, pension funds use probabilities in risk return analyses for investment decisions. Climate scenarios are narrative based and deterministic by nature. Due to fundamental uncertainty, it is difficult to assign a probability to a climate scenario. Pension funds need to find a way to combine traditional stochastic risk return analysis with climate scenarios (Ortec Finance, 2023).

Another issue is that the typical horizon of the ALM study is 5-15 years. Hence the more devastating impacts of climate change and environmental degradation fall outside of the ALM horizon. This leads to a larger focus on shorter-term risks and ignores the more long-term devasting physical risk impacts of a failed transition.

Moreover, ALM models do not accurately capture the risks of stranded assets. The reason is that in traditional ALM risk is related to the historical volatility of different asset classes (Silver, 2017). However, assets potentially stranded due to climate change were not necessarily high-risk assets in the past.

The outside-in perspective: a too narrow definition of risks

Pension funds increasingly work with these models to evaluate how climate change and nature degradation financially impact their portfolios (outside-in perspective). The supervisors also require pension funds to assess these financial risks. A self-assessment recently conducted by the DNB indicated that 37% of the Dutch pension funds have not started or are at the beginning of the identification of environmental risks (DNB, 2024). Dutch pension funds have not spent much time on climate scenarios in the past years as they were mostly occupied with the reform of the Dutch pension system. A stress test conducted by EIOPA in 2022 for the European Institutions for Occupational Retirement Provisions (IORPs) sector for example shows that only 16% of the IORPs use scenario analysis to manage sustainability risks (EIOPA, 2022). This shows even the assessment of outside-in risks is lagging behind; scenario analysis and more broadly environmental risk analysis has not yet got the attention it should have.

Pension funds are also universal owners. This means they hold large, diversified portfolios representing many segments of the economy, hence being exposed to the overall well-being of the real economy. They therefore have a financial interest in maintaining a stable environment and potentially reducing catastrophic threats. Only looking at the outside-in perspective neglects accounting for how their investments contribute to environmental degradation (inside-out effects) and the build-up of systemic risks.

This potentially limits a holistic understanding of environmental risks. Firstly, impact could be considered a proxy for environmental transition risks (Svartzman et al., 2021). Secondly, financing harmful activities results in the build-up of future physical risks affecting financial stability. These activities contribute endogenously to environmental risks. For example, financing deforestation in the Amazon might not have a significant effect on one balance sheet, but it contributes to climate change and therefore increases risks at the systemic level. This change becomes irreversible when tipping points occur.

9

The double materiality approach recognises both the outside-in perspective (financial materiality, impacts on assets) and the inside-out perspective (environmental materiality, impact of investments on planet and society). It captures the interrelation between the contribution of financing activities of companies on the physical and transition risks financial institutions might ultimately face. It therefore allows for more comprehensive thinking about the role of the financial system in addressing environmental challenges (Boissinot et al., 2022).

From risks to uncertainty

Financial institutions and supervisors still largely rely on the view of quantified climate risks as exogenous and potentially accurate. However, climate change and nature degradation introduce complexities and uncertainties that are hard to model and predict. The translation of economic costs into financial risks is also highly uncertain. It is therefore challenging to link environmental parameters to prudential risk parameters.

10

Instead of talking about risks it might be more accurate to consider these effects as fundamentally uncertain (Chenet et al., 2021, 2022; Kedward et al., 2020). Dealing with environmental uncertainties might require a different set of actions and proposals than doing traditional risk management. The most prudent action to manage risks is to prevent them from happening in the first place. This is now well recognized in the energy transition (OECD, 2023) and it extends more broadly to the environmental degradation.

2.
ACTING SUSTAINABLY UNDER CONDITIONS OF UNCERTAINTY

Knowing what you own

Pension funds recognise the need for an improved understanding of what they own. For any course of action, it is important for pension funds to understand the exposure to harmful investments using science-based evidence, for example on deforestation. The exposure to harmful activities is often concentrated around a small number of firms (Hiebert & Monnin, 2023; Marsden et al., 2024).

Some pension funds in the Netherlands are now moving towards more consciously selected portfolios, reducing the number of companies they invest in. Research shows that it is possible to significantly reduce the number of companies while still having sufficient diversification opportunities (Statman, 2004). Pension funds expect implementing such an approach does not lower their risk-adjusted returns. In doing so they also gain better insights in their portfolios, value chains and can take a more active role in engaging with the underlying companies. It also provides opportunities to create portfolios which are more aligned with the profile of the pension fund including preferences of participants.

Improving risk management practices

There is a need to integrate environmental outcomes into business processes to be able to act on them. Pension funds should strive to improve the models and scenarios. and find a way to include climate scenarios in their stochastic (working with probabilities instead of fixed outcomes) risk models. It is important to engage more actively with climate scientists to bridge the gap between climate science and financial models (Abrams et al., 2024). They should also employ more qualitative analysis in decision making and more forward-looking information based on expert judgement For example by developing more qualitative (long-term) scenarios exploring how interconnected risks other than only volatility could cascade (Trust et al., 2023).

While the scenarios and risk models used in the ALM study require improvement, it is essential to recognize their inherent limitations and to be transparent about the assumptions. It is key to understand the underlying narrative of a scenario (Monasterolo et al., 2023). It is also important to understand the uncertainties in the results, for example by conducting sensitivity analysis on certain assumptions. Pension funds could analyse a wide range of scenarios and world views to test the robustness of the optimal investment strategy.

Fortunately, dealing with fundamental uncertainty is what investors have always done, rather than only thinking through risks that can be computed. Climate change and nature degradation are new challenges that add uncertainty. But it has always been problematic to assume that financial investors know all future states of the world and can assign probabilities to each state, so that they can compute optimal portfolios. The future is unknown, especially around fundamental changes in the system where mere extrapolations do a bad job in predicting.

Implement impact in decision making

One way to deal with fundamental uncertainty is to act on environmental impacts directly rather than to translate them to financial risks. Investments with large negative impacts, like deforestation, can lead to the build-up of risks in the system. But most pension funds, as long-term investors, have a broader interest to reduce negative impact and increase positive impact, from a long-term value creation perspective, following the preferences of their participants, or from reputational risk perspective.

The starting point for acting on impact more broadly is to develop a vision for environmental transitions in key sectors, for example the energy transition, the resource transition and the food transition. Such a vision can help to more systemically invest in transitions rather than having a focus on individual investments. Investments can be mapped to these transitions resulting in different categories: investments that contribute to positive impact, investments into companies that need to and are able to transition, and investments in harmful activities.

The implementation of a transition plan (towards net zero but can also be extended to address nature-related targets), can help in building strategies and defining targets for each of these categories. In the absence of a clear policy, pension funds can either decide to divest from harmful activities or to engage. Research shows it is generally more effective to engage on activities with negative environmental impacts (Kahn et al., 2023). Practice shows engagement is costly and has traditionally often been too vague, a more insistent form of engagement is required. Defining clear metrics (related to the companies' real-world impact), timelines and milestones for asks are preconditions for effective engagement.

Research has not proven that divestment increases costs of capital, but it does have a signalling function if done on a larger scale. Pension funds could decide to divest from activities that cannot or are unwilling to transition and to engage with companies that can and are willing to transition.

Ideally, impact is fully integrated in the traditional risk return framework so it can be used in decision making. Schoenmaker and Schramade provide a theoretical framework for integrated value creation (Schoenmaker & Schramade, 2023). In the meantime, pension funds could set ambitious targets for example to reduce carbon emissions. Carbon reduction targets should be focused on real economy reductions rather than only reducing the carbon footprint of the portfolio by, for example, divesting. This simple divestment strategy does clean up the individual pension fund portfolio but moves the risk of the asset elsewhere and does not reduce the total emissions in the system. Acting on these targets directly potentially reduces catastrophic threats, mitigates systemic risks and partly overcomes the challenges around the quantification of environmental risks.

Pension funds can also assess the external asset managers through which they invest. External asset managers can for example be selected based on their impact track record, their investment beliefs or their portfolio selection methods.

13

Supervisory toolbox

Financial supervisors have a role in maintaining a stable and functioning financial system. The IORP II Directive, which is currently under review, defines minimum regulation for pension funds. It requires pension funds to integrate of environmental, social and governance (ESG) related factors and risks in risk management processes and own risk assessments. Local supervisors can further specify this by defining supervisory expectations or sharing best practices. The DNB, for example, defines supervisory expectations for pension funds and insurance companies for the management of environmental risks (DNB, 2023). The updated IORP II Directive and local supervisory expectations could expand to environmental impacts. The supervisor can for example require disclosure and the assessment of exposures to environmental impacts. They could also define requirements related to long-term risk analysis using scenarios. EIOPA already advises for the integration of a double materiality approach in IORP II taking into account the potential long-term impacts of pension funds investment strategy and decisions (EIOPA, 2023).

Supervisors also have a role in conducting stress tests on the financial sector. In doing so, they can develop or consider alternative models for scenarios, improve scenarios and allow for more severe stress to be considered in these exercises. This results in a more accurate picture of the actual risks to the financial system.

Regulators can mandate financial institutions to make a transition plan, requiring them to set targets to achieve net zero (and other environmental) goals. In such a plan financial institutions can distinguish between companies or sectors that can transition and that cannot.

Supervisors are already engaging on the topic of transition plans but there is a risk the definition of these plans is too narrow, only looking at the transition risks resulting from misalignment with the transition. Given the systemic risks resulting from environmental impacts there is need for financial institutions to set targets and for supervisors to assess the credibility of these targets and the defined actions to achieve the targets. This also improves risk management of supervised institutions and reduces threats to financial stability.

Regulators can also consider implementing new, more systemic, measures addressing environmental risks.[2] For example limiting exposures to certain harmful activities or defining concentration limits for environmental risks. This might be suitable given the empirical findings of the concentration of institutional exposures to various environmentally harmful activities. However, these measures would face challenges with data and models as well. Moreover, prudential policy should not prevent polluting companies from greening their activities (Monnin & Hiebert, 2023). Credible transition plans are essential to address this issue.

14

---

[2] EIOPA for example recommends higher capital charges for fossil fuel assets as part of the Solvency II framework for insurance companies.

3.
CONCLUSIONS

15

Pension funds and supervisors are faced with a difficult situation. On the one hand, they understand the urgency to address the issues of climate change and nature degradation. However, their usual methodology of relying on estimating risks, having accurate models and good data does not help them to act quickly enough in mitigating the risks. A way forward could be to decide not to wait for the perfect data and models, and instead align with a more precautionary approach. In effect, this means acting on environmental impact and avoiding the worst effects of environmental degradation, even if the right transition pathways are not clear on the horizon.

REFERENCES

Abrams, J. F., Benjamin, J., Campanale, M., Keen, S., & Lenton, T. M. (2024). Challenging systemic under-pricing of climate damages within the global financial system. https://carbontracker.org/reports/systemic-under-pricing-of-climate-damages/

Aerts, S., Stracca, L., & Trzcinska, A. (2024, October 22). Economic losses from climate change are probably larger than you think: New NGFS scenarios. CEPR. https://cepr-org.utrechtuniversity.idm.oclc.org/voxeu/columns/economic-losses-climate-change-are-probably-larger-you-think-new-ngfs-scenarios

Alogoskoufis, S., Dunz, N., Emambakhsh, T., Henning, T., Kaijser, M., Kouratzoglou, C., Muñoz, M. A., Parisi, L., & Salleo, C. (2021). ECB economy-wide climate stress test: Methodology and results. (Issue 281). European Central Bank. https://data.europa.eu/doi/10.2866/460490

Boissinot, J., Goulard, S., Le Calvar, E., Salin, M., Svartzman, R., & Weber, P.-F. (2022). Aligning financial and monetary policies with the concept of double materiality: Rationales, proposals and challenges. https://www.lse.ac.uk/granthaminstitute/publication/aligning-financial-and-monetary-policies-with-the-concept-of-double-materiality/

Carbon Brief. (2014, December 8). Two degrees: The history of climate change's speed limit. Carbon Brief. https://www.carbonbrief.org/two-degrees-the-history-of-climate-changes-speed-limit/

Chenet, H., Kedward, K., Ryan-Collins, J., & van Lerven, F. (2022). Developing a precautionary approach to financial policy – from climate to biodiversity (Policy Briefing Paper 02). LSE. https://www.lse.ac.uk/granthaminstitute/wp-

content/uploads/2022/04/INSPIRE-Sustainable-Central-Banking-Toolbox-Policy-Briefing-Paper-2.pdf

Chenet, H., Ryan-Collins, J., & van Lerven, F. (2021). Finance, climate-change and radical uncertainty: Towards a precautionary approach to financial policy. Ecological Economics, 183, 106957. https://doi.org/10.1016/j.ecolecon.2021.106957

DNB. (2020). Indebted to nature: Exploring biodiversity risks for the Dutch financial sector. De Nederlandsche Bank. https://www.dnb.nl/media/4c3fgawd/indebted-to-nature.pdf

DNB. (2023). Guide to managing climate and environmental risks. https://www.dnb.nl/media/devh2uet/76226_dnb_ia_klimaat-en-milieurisico-s-sectoren-2023_eng_web.pdf

DNB. (2024). Pensioenfondsen, breng ESG-risico's in kaart. https://www.dnb.nl/nieuws-voor-de-sector/toezicht-2024/pensioenfondsen-breng-esg-risico-s-in-kaart/

EIOPA. (2022). 2022 IORP Climate Stress Test. https://www.eiopa.europa.eu/system/files/2022-12/report_-_iorp_stress_test_2022.pdf

EIOPA. (2023). Consultation paper on technical advice for the review of the IORP II Directive. https://www.eiopa.europa.eu/system/files/2023-03/EIOPA-BoS-23-071_CP-advice-IORP-II-review.pdf

Hiebert, P., & Monnin, P. (2023). Climate-related systemic risks and macroprudential policy. https://www.lse.ac.uk/granthaminstitute/publication/climate-related-systemic-risks-and-macroprudential-policy/

IPCC. (2021, August 9). Climate change widespread, rapid, and intensifying. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

Kahn, M., Matsusaka, J., & Shu, C. (2023). Divestment and Engagement: The Effect of Green Investors on Corporate Carbon Emissions (w31791; p. w31791). National Bureau of Economic Research. https://doi.org/10.3386/w31791

Kedward, K., Ryan-Collins, J., & Chenet, H. (2020). Managing nature-related financial risks: A precautionary policy approach for central banks and financial supervisors. UCL IIPP. https://www.ucl.ac.uk/bartlett/public-purpose/wp2020-09

Keen, S. (2021). The appallingly bad neoclassical economics of climate change. Globalizations, 18(7), 1149–1177. https://doi.org/10.1080/14747731.2020.1807856

Keen, S. (2023). Loading the DICE against pension funds: Flawed economic thinking on climate has put your pension at risk. Carbon Tracker. https://carbontracker.org/reports/loading-the-dice-against-pensions/

Marsden, L., Ryan-Collins, J., Abrams, J. F., & Lenton, T. M. (2024). Financial System Interactions with Ecosystem Tipping Points: Evidence from the Brazilian Amazon and Indonesian Peatlands [Working paper]. Institute for Innovation and Public Purpose.

Monasterolo, I., Nieto, M. J., & Schets, E. (2023). The good, the bad and the hot house world: Conceptual underpinnings of the NGFS scenarios and suggestions for improvement (Documentos Ocasionales 2302; Documentos Ocasionales, p. 2302). Banco de España. https://doi.org/10.53479/29533

Monnin, P., & Hiebert, P. (2023). Climate-related systemic risks and macroprudential policy. INSPIRE. https://inspiregreenfinance.org/wp-content/uploads/2023/08/INSPIRE-Sustainable-Central-Banking-Toolbox-Paper-14.pdf

OECD. (2023). Understanding and Applying the Precautionary Principle in the Energy Transition. OECD. https://doi.org/10.1787/5b14362c-en

Ortec Finance. (2023). From climate risk analysis to investment decision making. https://www.ortecfinance.com/en/insights/whitepaper-and-report/from-climate-risk-analysis-to-investment-decision-making

Pindyck, R. S. (2017). The Use and Misuse of Models for Climate Policy. Review of Environmental Economics and Policy, 11(1), 100–114. https://doi.org/10.1093/reep/rew012

Schoenmaker, D., & Schramade, W. (2023). Corporate Finance for Long-Term Value. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4468886

Silver, N. (2017). Blindness to risk: Why institutional investors ignore the risk of stranded assets. Journal of Sustainable Finance & Investment, 7(1), 99–113. https://doi.org/10.1080/20430795.2016.1207996

Statman, M. (2004). The Diversification Puzzle. Financial Analysts Journal, 60(4), 44–53. https://doi.org/10.2469/faj.v60.n4.2636

Stern, N., Stiglitz, J., & Taylor, C. (2022). The economics of immense risk, urgent action and radical change: Towards new approaches to the economics of climate change. Journal of Economic Methodology, 29(3), 181–216. https://doi.org/10.1080/1350178X.2022.2040740

Svartzman, R., Espagne, E., Julien, G., Paul, H.-L., Mathilde, S., Allen, T., Berger, J., Calas, J., Godin, A., & Vallier, A. (2021). A 'Silent Spring' for the Financial System? Exploring Biodiversity-Related Financial Risks in France. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4028442

Trust, S., Bettis, O., Saye, L., Bedenham, G., Lenton, T. M., Abrams, J. F., & Kemp, L. (2024). Climate Scorpion – the sting is in the tail: Introducing planetary solvency. https://actuaries.org.uk/media/g1qevrfa/climate-scorpion.pdf

Trust, S., Joshi, S., Lenton, T., & Oliver, J. (2023). The Emperor's New Climate Scenarios: Limitations and assumptions of commonly used climate-change scenarios in financial services. Institute and Faculty of Actuaries. https://actuaries.org.uk/media/qeydewmk/the-emperor-s-new-climate-scenarios.pdf

Weyant, J. (2017). Some Contributions of Integrated Assessment Models of Global Climate Change. Review of Environmental Economics and Policy, 11(1), 115–137. https://doi.org/10.1093/reep/rew018

19