Developing A Short-Term Climate Stress Scenario to 2030 – Combining Climate Narratives with Empirical Credit Model Shocks Benchmarked to the 'Great Recession'[1, 2, 3]

1. Introduction:

Climate change impacts on financial stability are complex, recently garnering substantial discussion as reporting on severe weather hits the front pages of the news daily. The focus more narrowly on the development of climate stress scenarios for the financial system is also a key industry discussion point, with two aspects recently singled out:

1. *Increased focus on developing shorter-run scenarios (relative to NGFS and 2050), and,*
2. *More detailed application of climate 'narratives' to complement model-based climate stress scenario approaches.*[4]

Both, of these short-run focal points, seem to stem partly from the lack of inclusion of explicit risk measures (volatility/shocks) inherent in the current NGFS approach. Substantial uncertainty currently dominates the modelling of financial impacts related to climate change. In addition, standardised scenarios utilising macro-economic based models also lack a certain transparency in terms of their descriptions of climate impacts and their link to specific risk measures suggesting the development of more detailed climate narratives can provide complementary 'climate risk intuition'.

This *Climate Research Note Number Four* applies one of our climate stress scenario development *use cases* to assess climate stress impacts on credit risks over a time horizon to 2030. We have suggested in our climate research that detailed empirical, credit factor models can provide a stronger systematic credit foundation for developing scenarios. Therefore, we combine the Z-Risk Engine approach with a climate narrative to develop a specific climate scenario benchmarked to the Great Recession. We apply a high-level climate narrative provided by the Real World Climate Scenario ('RWCS') industry effort. Consistent with our own published concerns about the lack of explicit inclusion of risk or volatility in climate scenarios, Mark Cliffe who helps lead RWCS has written; 'we need scenarios to embrace the fact that we are living on Planet VUCA: one characterised by volatility, uncertainty, complexity and ambiguity', see Cliffe (2023).

The RWCS climate scenario 'narrative' we focus on is referred to specifically as a credit/climate 'meltdown' scenario, see RWCS (2023).[5] The growing focus on

1 This research note presents preliminary analysis – any errors or omissions remain the responsibility of the authors.

2 Scenarios can be developed over any future horizon, with "short-term" usually covering 2-3 years. We define "short run" in the context of climate scenarios as up to 2030.

3 Revised version, August 11, 2023 to fix a couple of typos

4 Related to the recent industry discussion focused on short run scenarios, see NGFS (2023) which outlines a request to the industry for 'Expressions of Interest' in developing approaches for short-run climate scenarios to 2030.

5 In addition to the 'Meltdown' scenario narrative we apply here, the other three RWCS scenario narratives are characterized as, 'Carbon Bubble', 'Roaring 20s' and 'Green Phoenix'. We focus only on the "downside" risk meltdown scenario although we could develop climate scenarios from any climate narrative.

info@z-riskengine.com

developing 'economic narratives' (a form of 'economic phenomenology') extends beyond climate change, and can be found increasingly in the risk literature, for example in ex-post assessment of 'suggested black swan' drivers of the Great Recession, see, Jena (2023). In the climate adaptation literature, Huet et. al. (2016), suggest a climate structural framework that 'combines narratives and model-based approaches'.[6] O'Neill et. al. (2021) present, a 'climate change scenario framework' by 'developing climate and societal futures in parallel, and then combining them in integrated research'.[7] Kay and King (2020) in their book 'Radical Uncertainty' also recommend the application of narrative-based methods when uncertainty 'dominates'.

Given the complex nature of climate change, the lack of observed empirical links between climate and financial risks (See, our Climate Stress Research Note Num Two) and the general exclusion of risk (volatility) in current scenarios, it's not surprising the development of complementary climate narratives is a current discussion point.

A. How We Develop a Short-Run Climate Stress Scenario:

This climate research note develops a climate risk scenario where we combine climate narratives with a short-run scenario horizon to 2030. We:

- Apply the Z-Risk Engine multi credit-factor model to develop a quarterly, climate scenario to 2030 to assess prospective expected credit losses for an illustrative roughly £300b NA/UK wholesale credit portfolio,[8]
- Set the broad climate narrative 'drivers' by applying the RWCS 'meltdown' climate scenario,
- Develop a deterministic industry/region credit-factor scenario by applying credit/climate 'shocks' (in 2026/27) combined with an additional climate transition shock in mid-2027 predicated on the global agreement of a climate mitigation policy in the form of explicit global carbon taxes, and,
- Calibrate the overall application of credit/climate 'meltdown' shocks to the Great Recession of 2007/8.[9]

To develop climate stress scenarios subject to observed systematic industry/region credit risk volatility we have proposed three use cases to-date:

- Assess NGFS GMT-derived **volatility multipliers** applied in credit-factor simulations, Aguais and Forest (2023 a),
- Apply discrete **credit-factor shocks** Aguais and Forest (2023 c), where we applied a single illustrative shock across all industry sectors in 2035 credit-factor simulations combined with a set of carbon intensity betas, and,

6 Huet et. al. (2016) page 1.

7 See O'Niell et. al. (2020) page 1074.

8 The ZRE region factor segmentation can be applied to several regions globally, including multiple individual countries, therefore our application to only two regions, NA and the UK is illustrative.

9 Some recent climate stress test commentary has expressed concerns that climate scenarios subject to uncertainty rely too much on 'what if' ('mostly made up') scenarios. As we have discussed at length in our climate research papers, we agree with this general concern which is why assessing future climate related credit risks should be founded on a robust, empirical systematic credit-factor foundation. While Baer et. al. (2023) suggest 'All scenarios are wrong, but some are useful', we scale the short-run narrative-driven scenario we present here, directly to the aggregate credit risk innovations observed during the Great Recession of 07/08. This scaling approach to observed credit risk history therefore provides a solid benchmark foundation for the prospective portfolio credit loss analysis we present.

- Derive, **through-the-cycle PD shifts consistent with top-down NGFS/bottom-up** company approaches, see Aguais and Forest (2023 d), like that described by the ECB, see ECB (2021).

Here we apply a more detailed variation of the second climate scenario *use case* but applied on a deterministic basis. While we use the term 'shocks', to be clear these are applied deterministically using credit factor models without simulation.[10] We apply multi-period, differential industry 'shocks' based on the observed innovations in our Z credit cycle industry sectors during the Great Recession. We also drive the industry shocks with the broad narrative outline of the RWCS Meltdown Scenario and finally, we apply an additional carbon tax shock (transition risk) with carbon intensity betas after applying the meltdown shocks.[11]

The future industry-specific shocks we apply are derived from observed historical innovations in the Z models and are well founded in observed historical credit risk volatility. In this sense application of these shocks prospectively can be thought of as similar to 'add-factors' applied in macro-econometric model forecasting, see Webb (1999) for an overview for applying macro add-factors. Add-factors, however, as generally applied are usually more subjective. In our case the shocks we apply in the scenario are derived from observed Z credit risk innovations and are therefore statistical not subjective.

The RWCS Meltdown climate narrative suggests potential large short-term shocks that represent a combination of pure credit risk and interdependent climate influences. As explained below, increasingly severe weather as physical climate risk is a contributor to the size of the projected Meltdown recession, we apply in 2026. Therefore, we describe this as a combination of credit and climate. This part of the scenario is what is scaled in the aggregate to the Great Recession, but we apply a different mix of industry sector shocks in this Meltdown scenario, relative to those observed in 07/08. Occurring after the Meltdown in the scenario horizon, a carbon tax shock is applied in mid-2027 as a pure climate shock and subject to the illustrative carbon intensity betas we have applied in earlier papers.[12]

The balance of this climate research note is organized as follows:

In the following **Section Two** we summarize the RWCS Meltdown climate narrative and outline the industry and region credit-factor and climate shocks we apply in the scenario,

In **Section Three** we summarize the detailed impact of the climate scenario on various credit risk measures.

10 For clarity, in Aguais and Forest (2023 c) we applied a single-quarter deterministic shock within a credit-factor simulation.

11 For the purposes of this discussion, we refer to historically observed in-sample deviations from the fitted industry Z second-order credit cycle models as innovations, which is consistent with the modelling literature and we refer to what we apply over a future scenario horizon as 'shocks'.

12 The carbon intensity betas are described in Aguais and Forest (2023 c). To be clear these are illustrative because in an implementation of our climate stress test scenario approach these betas would be derived from detailed carbon emissions data. In implementation we would also develop a more detailed brown/green segmentation reflecting for example more energy sector detail.

2. Designing a Short-Run Climate Stress Scenario to 2030:

The development and application of the short-run climate stress scenario described here requires three components to be applied in our ZRE Credit Factor approach:

1. The broad climate narrative provided by the RWCS Meltdown Scenario,
2. A somewhat more detailed narrative supporting the choice of specific industry sector shocks,[13]
3. A broad, benchmark calibration for scaling the aggregate industry shocks based on past observed innovations during credit cycle downturns. For this we apply the 2007/08 Great Recession.

Below we outline each of these three scenario components.

A. RWCS Meltdown Scenario Overview:

The RWCS effort goes back to mid-2022 and is a cross-industry effort organized to bring together an array of industry perspectives to 'flesh-out' more detailed climate scenario narratives. This effort stems partly from frustration, consistent with our own research, with the unusually 'smooth' ('trend') approach usually applied in IAM models and in the NGFS scenarios generally as discussed in Cliffe (2023). The RWCS has published the broad outline of four climate scenarios in a two-by-two matrix, see, RWCS (2023) and is working across the industry stakeholders involved to flesh out further climate scenario details.[14]

Broad Outline of the RWCS Meltdown Scenario:

- **Politics: '**Nationalism and division, return of Trump(ism), geopolitical conflict'
- **Growth**: 'L shaped (also because of climate physical shocks), pandemic recurs, (energy) trade war'
- **Investment weak:** Nationalist governments support home fossil fuel industries and (in consuming nations) renewables to achieve 'energy security''
- **Energy and asset prices:** 'energy trade war keeps fossil fuel prices volatile. Asset stranding hurts financial system'

The scenario also suggests, 'policy failures compound weak growth, [with] low policy intervention'.[15]

This broad narrative informs the short-run climate scenario we develop, but to be clear, this 'meltdown' climate scenario is very high level and in fact could support even within a climate 'meltdown' scenario as described by RWCS, a vast range of future scenario outcomes derived from these high-level descriptors. Therefore, we take these only as a broad starting point and develop a slightly more detailed narrative to operationalize the industry sector mix for applying the shocks.

13 To focus primarily on industry sector impacts, the shocks are applied only to the 21 industry sectors not the two region factors covering NA and the UK which we keep at their historical TTC averages.

14 For the application of the RWCS Meltdown scenario in this note, we use just the broad meltdown scenario descriptions provided by RWCS as a starting point.

15 See RWCS (2023).

info@z-riskengine.com

B. Adding Further Narrative Detail to RWCS to Specify the Scenario:

As outlined above, to develop a specific, illustrative climate scenario deterministically by applying specific shocks to each ZRE industry sector credit factor, we require a more detailed narrative that helps define more specifically the link between the high-level RWCS Meltdown scenario and the application of these prospective shocks. The Meltdown shocks we input into each ZRE industry factor model in the future are applied quarterly in 2026 and early 2027. Below we provide further explanation of the narrative we derive from the RWCS Meltdown to specify the required shocks. This more descriptive narrative is also one of many that could be described.

Below we add additional detail to the high-level Meltdown narrative to facilitate development of the industry sector-specific shocks:

- The economy in 2023 to 2025 exhibits reasonable economic growth with generally declining interest rates and slowing inflation.
- Severe weather continues to get worse creating physical impacts but more importantly this leads to substantial consumer uncertainty and confidence declines substantially by mid-2025.
- The suggested 'low policy intervention' is seen in no agreement on a global coherent carbon policy until 2027 when we apply a climate shock based on this and combined with our carbon intensity betas.[16]
- Countries are beginning to put up further restrictions on migration and an additional trade war leads to declines in international trade, therefore impacting sectors which have higher export shares.
- The suggested second pandemic doesn't lead to a Covid 'lockdown' but combined with increasingly severe weather and substantial and growing geopolitical uncertainty, consumer confidence exhibits substantial weakness.
- Traded export sectors face weakness due to economies becoming more 'closed'.

To summarize, the somewhat more detailed narrative comments suggest the result is a consumer led recession broadly with traded export weakness, volatile energy markets and related impacts on energy sensitive industry sectors. Climate impacts from increasing severe weather are embedded with the credit risk shocks we apply, and severe weather also drives substantial weakness in consumer's general outlook. As we also detail below, we are scaling the primary 5-quarter recession in 2026/27 to the Great Recession. But the industry mix of shocks while scaled in the aggregate to 2007/08, is different then the Great Recession based upon the overall climate narrative described above.

C. Applying Specific ZRE Industry Sector Climate 'Shocks':

Here we develop the third component required to implement the specific short-run climate risk scenario, covering the application of industry sector specific shocks. We outline the historical shocks observed generally in the ZRE approach and show the specific shocks observed over 2007/08 for two example industry sectors. We then describe the derived shocks we apply in the scenario going forward that are scaled to the Great Recession. The shocks we apply in 2026 can be thought of as driven by a combination of credit and climate (physical), and the 2027 shock we apply based upon agreement of a global carbon tax can thought of as pure climate transition risk.

16 By global carbon policy we mean most countries agree to a unified carbon tax but specifically this agreement includes the USA and China.

As explained in our ZRE papers, the ZRE approach estimates individual second order 'Mean Reversion-Momentum' ('MM') models for each observed industry 'Z' credit-factor derived from Moody's CreditEdge EDFs for 21 standard industry sectors.[17] These sector credit-factor models capture the systematic component observed historically in the Zs. The Z model innovations we apply are derived from the sector MM models and **Figure 1** and **Figure 2** plot two examples of the observed MM Credit Cycle innovations for the Banking and Hotels and Leisure sectors in units of unitary standard deviations. We measure Z innovations in units of unitary standard deviations with each Z sector sigma of zero representing neutral credit conditions where, PIT PDs = TTC PDs.

Positive Z values represent economic expansion when credit conditions are improving and PIT PDs are declining below long-run TTC PDs. When Z in sigma terms is negative, credit losses are rising above their long-run average as PIT PDs rise above TTC PDs. Therefore, we see large, negative credit risk innovations (rapidly rising PIT PDs) during recessions.

The magnitude of the Great Recession can be seen clearly which led to substantial credit losses. The Covid Pandemic shocks can also be seen clearly which greatly impacted GDP due to the 'lockdown' and high equity market volatility impacting Zs but we know from this time that the impact on credit losses was quite benign as compared to 07/08.

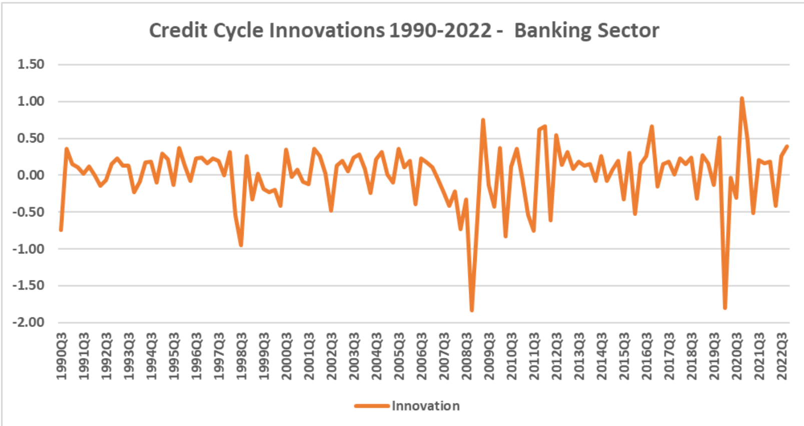

Figure 1: Sector Innovations Historical Example - Banking (Standard Deviation)[18] *Source: Moody's CreditEdge and Z-Risk Engine.*

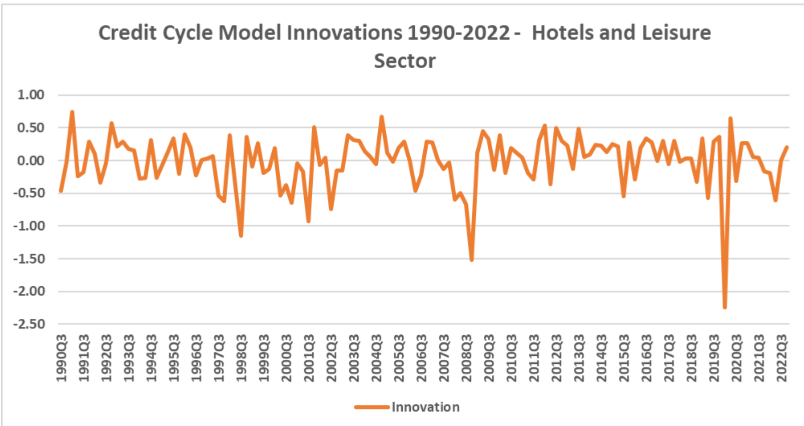

Figure 2: Sector Innovations Historical Example – Hotels and Leisure (Standard Deviation) *Source: Moody's CreditEdge and Z-Risk Engine.*

17 See Forest and Aguais (2019) for more details.

18 By 'standard deviation' we mean the standard deviation of the historical, one-year changes in the related Z index.

Next, we show the average aggregate Z innovations observed for the Great Recession for 2007:Q4 to 2008:Q4 in **Figure 3**. We see that the largest average aggregate innovation of about -1.4 sigma occurred in the final quarter of 2008. To apply the Meltdown scenario as described we benchmark the future shocks we apply to the Great Recession as seen in **Figure 4**. We also show the carbon tax shock (climate) we apply in **Figure 4** for 2027:Q3 which is about equal to the average innovation (credit) observed across the Great Recession.[19]

As the Meltdown scenario outlines, the scenario narrative envisions future economic shocks that stem from combinations of direct credit impacts and indirect climate impacts primarily through increasingly severe global weather (physical risk). The carbon tax shock is therefore a pure climate transition risk shock.

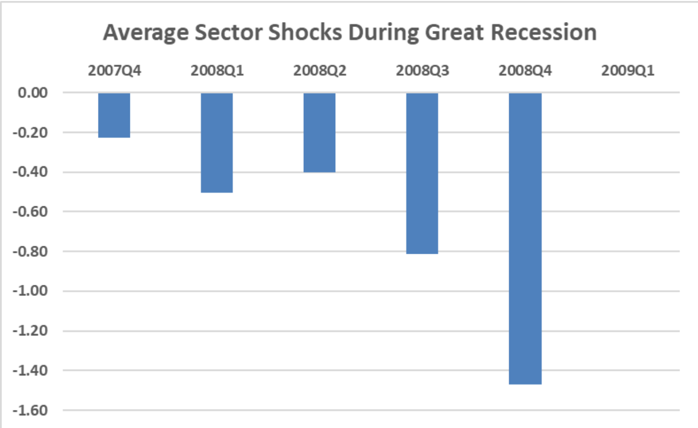

Figure 3: Observed Average Sector Shocks During Great Recession (Standard Deviation)
Source: Moody's CreditEdge and Z-Risk Engine.

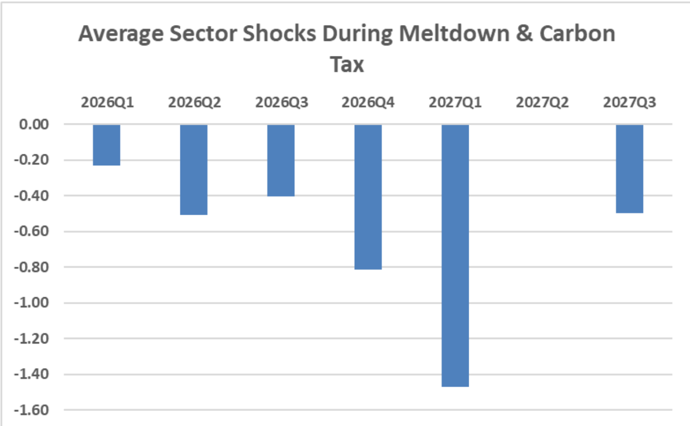

Figure 4: Average Industry Sector Shocks Applied in 2026/27 (Standard Deviation)
Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

To see the aggregate, individual industry sector impacts of the Great Recession vs the Meltdown scenario, below in **Table 1** we compare the total cumulative industry sector innovations from 07/08 with the cumulative sector Meltdown shocks we apply in 2026/27.

19 For illustration we assume the Climate Shock is equal to the average Credit Shock. Ultimately further research is required to support more specifically the size of hypothetical Climate Shocks vs Credit Shocks.

Industry Sector	Great Recession 2007:Q4-2008:Q4	Meltdown 2026:Q1-2027:Q1
AEROSPACE AND DEFENSE	-3.42	-1.26
AGRICULTURE	-3.68	-2.76
BANKING	-3.80	-4.14
BASIC INDUSTRIES	-4.11	-3.51
BUSINESS AND CONSUMER SERVICES	-3.67	-2.76
CHEMICALS AND PLASTIC PRODUCTS	-3.14	-2.76
CONSTRUCTION	-3.88	-4.77
CONSUMER PRODUCTS	-3.29	-3.64
FINANCE, INSURANCE AND REAL ESTATE	-3.63	-2.76
HOTELS AND LEISURE	-3.83	-4.89
MACHINERY AND EQUIPMENT	-3.17	-3.01
MEDIA	-3.72	-3.01
MEDICAL	-3.21	-2.01
METALS	-3.60	-3.01
MINING	-3.41	-3.01
MOTOR VEHICLES AND PARTS	-2.31	-6.02
OIL AND GAS	-3.31	-5.65
RETAIL AND WHOLESALE TRADE	-2.37	-3.51
TECHNOLOGY	-3.46	-2.01
TRANSPORTATION	-2.91	-4.27
UTILITIES	-3.46	-4.14

Table 1: Cumulative Total Industry Sector Innovations (07/08) and Cumulative Shocks (27/28) *Source: Moody's CreditEdge, RWCS and Z-Risk Engine.*

3. Summarizing The Meltdown Scenario Credit Risk Impacts:

Here we summarize the impacts of applying the climate stress shocks outlined in **Section 2**. We apply the Z prospective credit and climate shocks to a NA/UK credit portfolio as outlined in **Appendix I.** This portfolio is larger than our earlier papers to represent an expanded corporate and commercial portfolio more representative of a large bank. Total limits are about £329 billion across about 10k credit facilities with the largest credit limit of £100 million and the smallest limit of £2 million. We apply the fixed portfolio outlined in the Appendix on a static, basis over the time horizon to 2030.

Below we show:

1. Projected credit losses and aggregate PDs derived from application of the two separate scenarios, Meltdown, and the carbon tax transition shock.[20]
2. Aggregate credit losses and PDs for the combined Meltdown and Carbon Tax Shock, and,
3. The individual industry sector scenario credit losses across Meltdown, the Carbon Tax Shock and the Combined Scenarios.

20 The methodology we apply for credit losses and the credit model specifications we utilize are outlined in detail in Aguais and Forest (2023 a). For brevity we only show aggregate scenario PDs and exclude LGDs and EADs. However the shocks are applied to all three Credit Model measures.

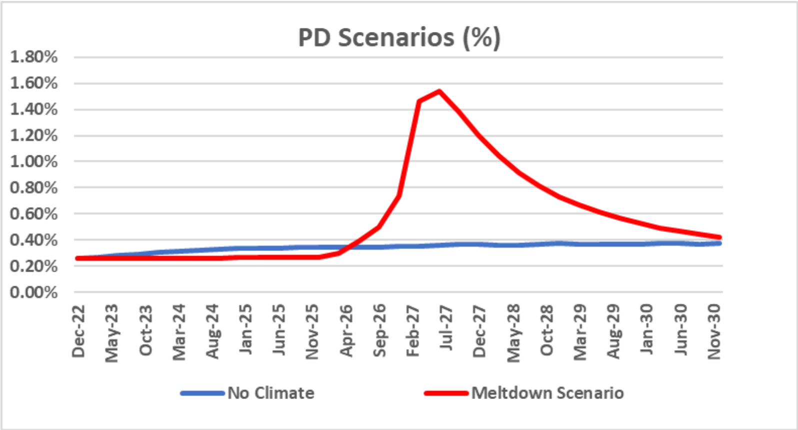

Figure 5: Average Scenario PDs: Meltdown vs 'No Climate' Assumption (%)

Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

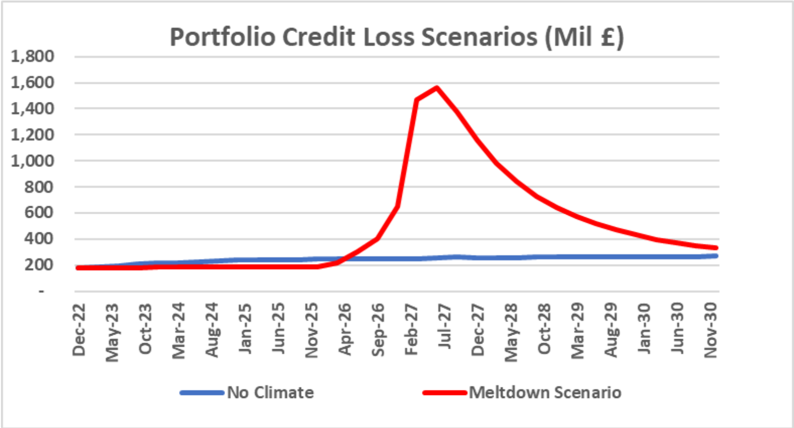

Figure 6: Portfolio Credit Losses: Meltdown vs 'No Climate' Assumption (Mil £)

Source: Moody's CreditEdge and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

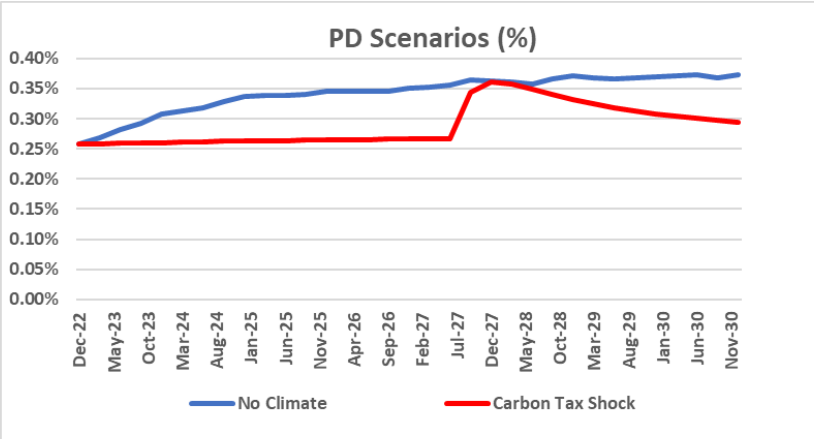

Figure 7: Average Scenario PDs: Carbon Tax Shock vs 'No Climate' Assumption (%)

Source: Moody's CreditEdge and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

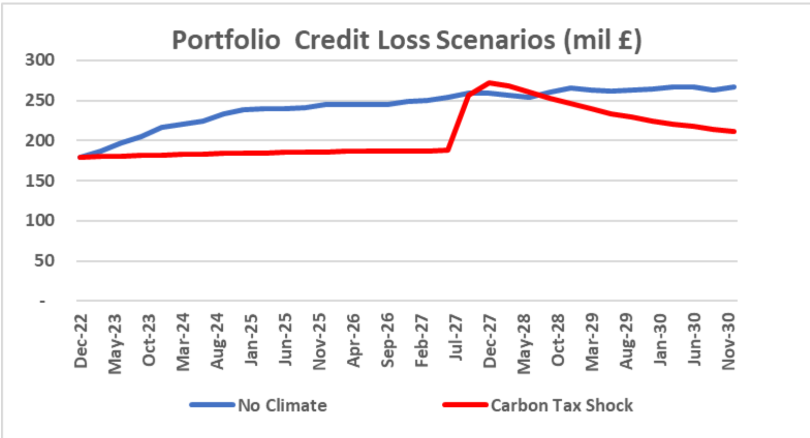

Figure 8: Portfolio Credit Losses: Carbon Tax Shock vs 'No Climate' Assumption (Mil £)

Source: Moody's CreditEdge and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

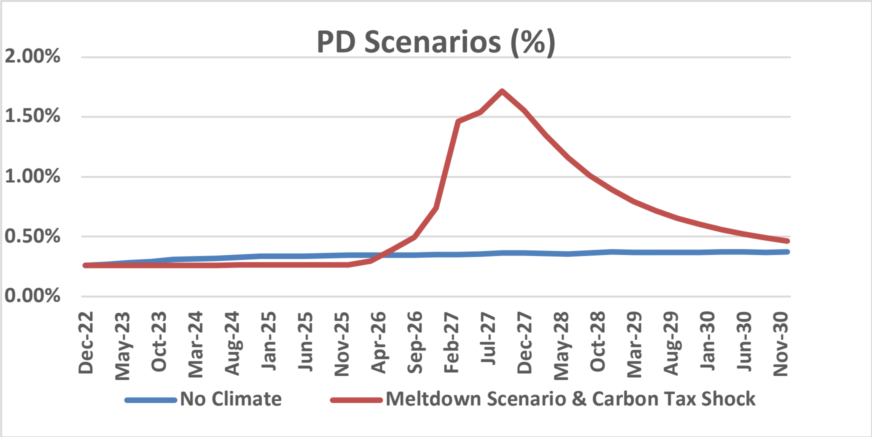

Figure 9: Average Scenario PDs: Combined Meltdown & Carbon Tax Shock vs 'No Climate' Assumption (%)

Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

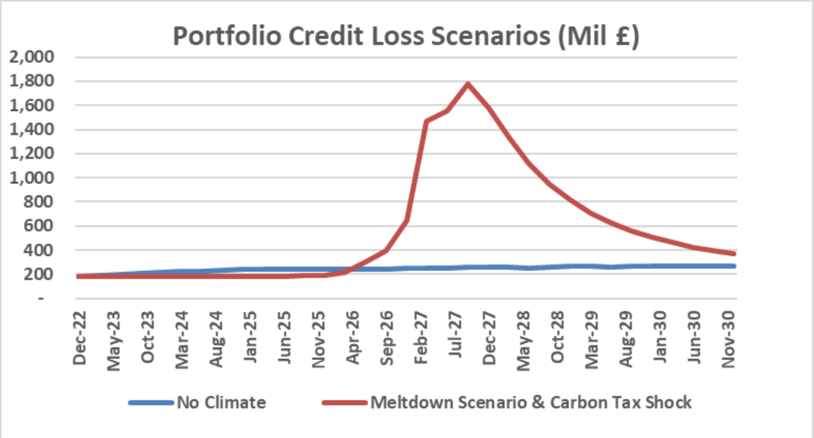

Figure 10: Portfolio Credit Losses: Combined Meltdown & Carbon Tax Shock vs 'No Climate' Assumption (Mil £)

Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

The No Climate scenario (blue line) is an expectation determined by simulation, without shocks

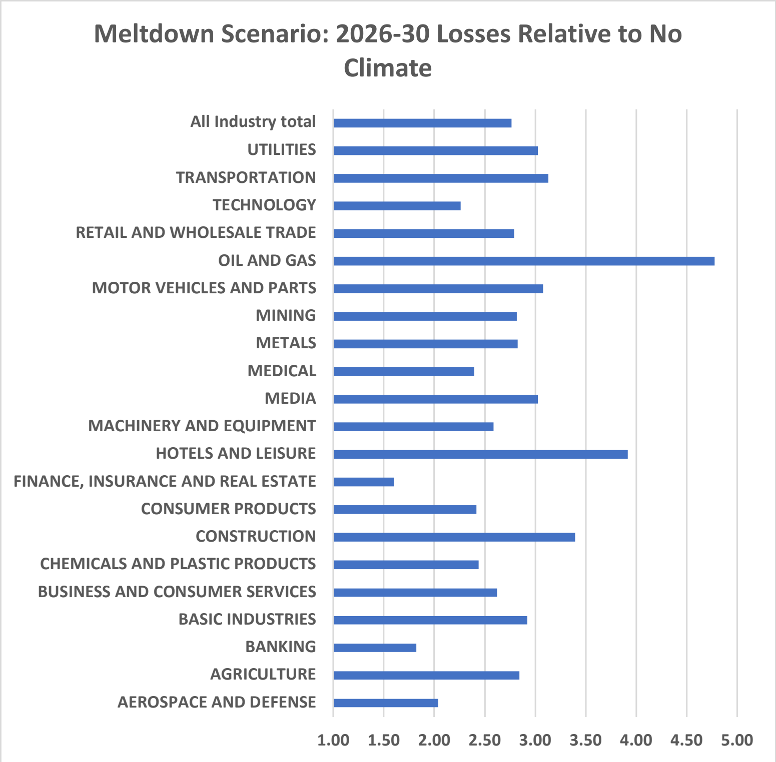

Figure 11: Portfolio Credit Losses (2026-30) by Industry Sector: Meltdown Scenario vs 'No Climate' Assumption (multiple above 'No Climate' assumption)
Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

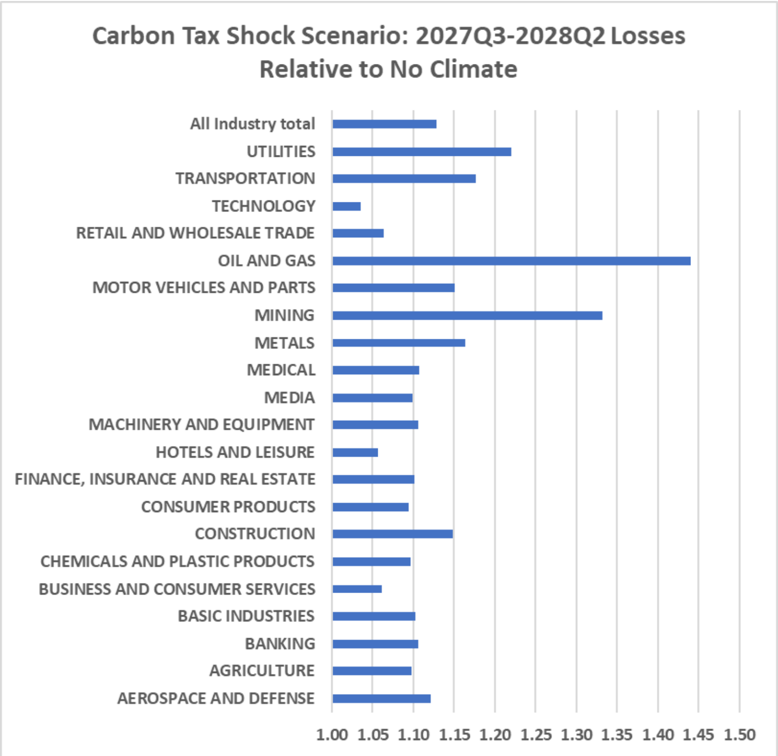

Figure 12: Portfolio Credit Losses (2027:Q3-2028:Q2) by Industry Sector: Carbon Tax Shock Scenario vs 'No Climate' Assumption (multiple above 'No Climate' assumption)
Source: Moody's CreditEdge, and Z-Risk Engine.

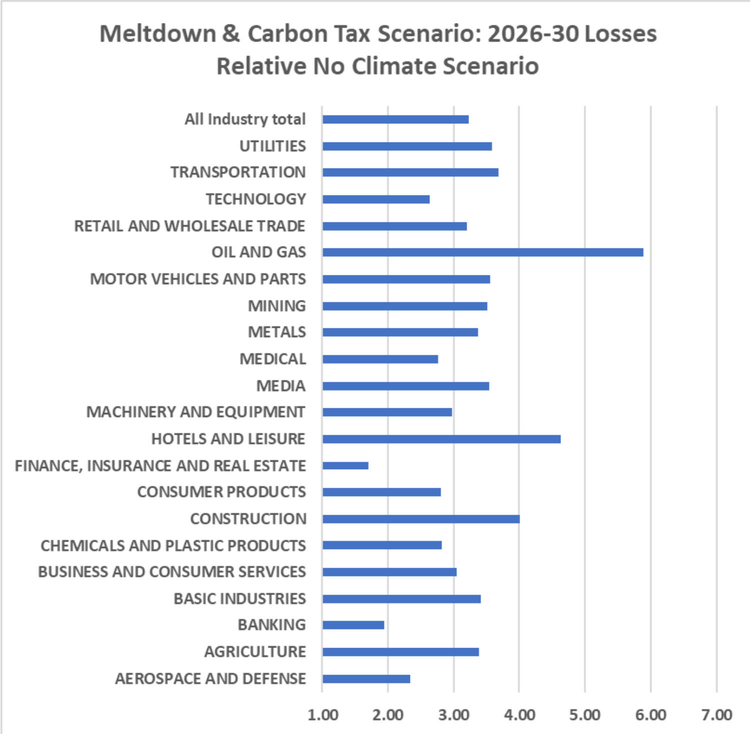

Figure 13: Portfolio Credit Losses by Industry Sector: Combined Meltdown & Carbon Tax Shock vs 'No Climate' Assumption (multiple above 'No Climate' assumption)
Source: Moody's CreditEdge, RWCS and Z-Risk Engine.

The prospective scenario credit and climate risk impacts shown above describe a quite severe combined scenario, with credit losses increasing to roughly 3-3.5X the no climate scenario. This impact is larger than the observed impacts of about 2.5X for observed credit losses in 2007/08 for two reasons. First, we add the additional impact of the standalone carbon tax shock on top of the Meltdown scenario. Second, while we scale the Meltdown aggregate shocks to 07/08, we start these scenarios with neutral Z (zero) values for every Z to focus attention on the direct scenario impacts.

In projecting credit losses and prospective PIT PDs using ZRE, for example to support IFRS9, the starting point Z values for industries and region projections begin at the last observed historical values. These last observed historical Z values can take on any value as opposed to the neutral Z values we start our projections with here. Therefore, a second reason why aggregate combined scenario losses are higher here than those observed for 07/08 is because the average aggregate Z value in 2007:Q3 was about 0.9. Starting with larger positive Z values produces smaller aggregate credit losses relative to long-run expected losses in comparison to starting scenarios at a neutral (zero) Z value.

Overall, the MM model approach in ZRE also means that large shocks also produce larger relative loss contributions from the momentum specification compared to the mean reversion model specification. We see this in the credit loss scenario impacts that take about 4 years to revert to roughly average, expected credit losses.

Most of the losses come from the Meltdown scenario which recreates the Great Recession which is the second worst recession observed in the last 100 years. The carbon tax climate shock has a much smaller, cumulative, impact compared to the meltdown shock so the detrimental effects on credit losses are smaller. These impacts are larger however in energy sectors involving brown technologies and higher carbon intensity betas as compared to industry sectors with lower carbon betas.

4. Summary:

This *Climate Research Note Number Four* presents a climate stress scenario assessing potential credit losses up through 2030 for a large NA/UK credit portfolio of about £300b in limits and about 10k corporate and commercial exposures. The scenario demonstrates a Z-Risk Engine credit-factor scenario *use case* involving the application of deterministic industry sector shocks. To broadly set the context for deriving the sector shocks we use a broad climate narrative developed by the RWCS climate scenario industry group.

These scenarios combine two of the current industry discussion points related to climate scenario development, focused on shorter run horizons to 2030 compared to the usual 2050, time horizon and, also the application of climate narratives. Narratives are a key aspect of 'climate risk story telling' to complement model-based scenario development motivated by both the lack of observed climate impacts on economic risk measures and growing concerns over current climate scenario approaches that lack both transparency and risk volatility impacts.

The ZRE use case presented in this note could be applied to develop any future climate stress scenario which combines narratives and empirical credit factors.

While climate risk assessments are generally framed as 'what if' scenarios, this is also the way we characterize the scenario presented in this note. However, to provide a stronger empirical foundation for the magnitude of the aggregate shocks, we apply the shocks observed during the great recession as a benchmark. *The application of observed shocks from an historical benchmark coupled with a solid empirically based credit factor foundation we see as key to extending climate stress scenarios from their current approach to one that explicitly assesses systematic credit risk (volatility).*

In addition to the detailed climate scenario presented here, we are also working on our first forthcoming climate stress paper collaborating with Oxford CGFI which will cover a detailed framework for developing climate stress test scenarios.

Appendix I: Overview of Credit Portfolio Applied in the Meltdown and Carbon Tax Scenarios:

Market Segment Composition (limits)		Avg Limit (mil)
Large Corporate	82%	£61.8
SME	18%	£10.3

Portfolio Size (Bil £)	
Limit (millions)	329,136
Facility count	10,002

Regional Composition (limits)	
NORTH AMERICA	56%
UK	44%

Industry Composition (limits)	
AEROSPACE AND DEFENSE	2.83%
AGRICULTURE	2.89%
BANKING	6.02%
BASIC INDUSTRIES	5.31%
BUSINESS AND CONSUMER SERVICES	11.28%
CHEMICALS AND PLASTIC PRODUCTS	1.84%
CONSTRUCTION	5.99%
CONSUMER PRODUCTS	3.88%
FINANCE, INSURANCE AND REAL ESTATE	5.39%
HOTELS AND LEISURE	5.06%
MACHINERY AND EQUIPMENT	4.71%
MEDIA	4.86%
MEDICAL	4.61%
METALS	1.55%
MINING	5.01%
MOTOR VEHICLES AND PARTS	4.17%
OIL AND GAS	5.32%
RETAIL AND WHOLESALE TRADE	5.78%
TECHNOLOGY	4.58%
TRANSPORTATION	4.49%
UTILITIES	4.43%

Facility-Type Composition (limits)	
Term	33%
Revolving	40%
Backstop	25%
Contingent	2%

TTC Grade Composition (limits)	
AAA	0.86%
AA	1.24%
A+	3.09%
A	4.79%
A-	6.37%
BBB+	8.93%
BBB	11.47%
BBB-	13.08%
BB+	11.65%
BB	10.02%
BB-	6.80%
B+	7.30%
B	5.47%
B-	5.20%
CCC+	2.63%
CCC	1.10%

TTC Grade/PD Composition (limits)		
AAA	1%	0.01%
AA	1%	0.02%
A+	4%	0.04%
A	6%	0.05%
A-	6%	0.06%
BBB+	8%	0.12%
BBB	8%	0.17%
BBB-	12%	0.27%
BB+	10%	0.51%
BB	10%	0.72%
BB-	9%	1.49%
B+	8%	2.42%
B	7%	4.04%
B-	7%	6.61%
CCC+	3%	11.03%
CCC	1%	22.63%

info@z-riskengine.com

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Authors

Scott D. Aguais, *Managing Director and Founder*, has over 30 years' experience developing and delivering advanced credit analytics solutions for large banking institutions. He led the successful Basel II Waivers at Barclays Capital and RBS, including leading the industry in implementing the first advanced Dual Ratings approach using both Point-in-Time (PIT) and Through-the-Cycle (TTC) risk measures.

He then established the Z-Risk Engine ('ZRE') solution which uses the PIT/TTC methodology to support IFRS9/CECL and Stress Testing. A recent Case Study at DBS bank in Singapore outlines their implementation and business benefits of using ZRE.

Dr Aguais holds a PhD in Economics and is an Associate Research Fellow at the University of Oxford CGFI climate institute, collaborating on further climate risk research.

Lawrence R. Forest Jr., *Global Head of Research*, leads all of ZRE's credit risk analytics research, model development and design. Dr. Forest has over 30 years', experience, designing and developing advanced credit analytics solutions for large banking institutions, including leading the design of the first advanced PIT/TTC Dual Ratings for Barclays Capital, RBS and ZRE.

He led the econometric design and development of advanced Basel 2 PD, LGD and EAD credit models and most recently the application of ZRE to assessing climate driven credit risks.

Dr Forest holds a PhD in Economics.

Developed by Aguais And Associates Ltd, Z-Risk Engine® (ZRE) provides a highly accurate, centralised, and integrated solution supporting global bank's compliance for IFRS9, CECL and Stress Testing regulations. ZRE is also being adapted to support Climate Stress Testing.

ZRE is a proven and efficient route to regulatory compliance for CROs and CFOs that also delivers up to a 30% reduction in IFRS9 modelling operational costs. As an advanced suite of Python or SAS® based software that works with a bank's own IRB wholesale internal credit models, ZRE unlocks complex industry and regional credit cycles to accurately convert TTC PD, LGD and EAD models into PIT measures. Whilst lowering implementation risk, the solution is also highly configurable and customisable to support large bank's detailed portfolio mix of commercial, corporate and bank clients.

info@z-riskengine.com

www.z-riskengine.com

info@z-riskengine.com

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