Contingent Resilience-Linked (CORL) bonds: combining public and private capital for resilience

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This paper proposes contingent resilience-linked (CORL) bonds, that combine sustainability-linked features with credit enhancement, as a capital efficient way to incentivise issuers to reach resilience targets and encourage much-needed private capital to finance such efforts.

The development community, such as development finance institutions (DFIs), multi-lateral development banks (MDBs) and government agencies, is struggling to mobilise private finance to deliver the United Nations' Sustainable Development Goals (SDGs). At the same time, private capital is increasingly keen to adopt environmental, social and governance (ESG) criteria and deliver impactful investment. This indicates that the right incentives and/or structures are not currently present.

The CORL concept provides a potential solution to some of the issues at hand. The structure is based on a DFI or MDB providing credit enhancement contingent on an issuer reaching its resilience or sustainability targets. By using an option-pricing approach for Sustainability-Linked Bonds (SLB), we show that it is possible to – in the case of contingent credit enhancement-structure step-down SLBs with fixed coupons priced at the same level as equivalent vanilla bonds.

We show that CORL bonds can be structured to offer sizable and incentivising step-downs only needing a relatively modest credit enhancement, and with a balanced incentive structure for all stakeholders:

- The **investor** gets an investment that is at least as good as a traditional bond, with added non-pecuniary benefits and potential upside from credit improvements.
- The **issuer** gets incentivising financing with potentially lower cost-of-capital for investments in resilience and sustainability.
- The **concessionary risk provider** (DFI/MDB) has a relatively low, well-defined contingent exposure that may act as a hedge on other types of exposures to the issuer.

With an estimated USD1.8trn needed for climate resilience investments by 2030, and an associated USD7.1trn in economic benefits, it is both urgent and economically rational to catalyse synergies between public and private capital.[1] **As a flexible credit enhancement to entice private capital, the proposed CORL structure could play a significant role in that.**

[1] "Designing a climate resilience classification framework. To facilitate investment in climate resilience through capital markets", UNDRR, 2023.

Not investment advice. This version 31 Oct 2023. Important disclaimers at end of the document. This work has been conducted in parallel with the United Nations Disaster Risk Reduction Investment Advisory Board. *(*) Anthropocene Fixed Income Institute (www.anthropocenefii.org), Contact: uge@anthropocenefii.org.*

Introduction

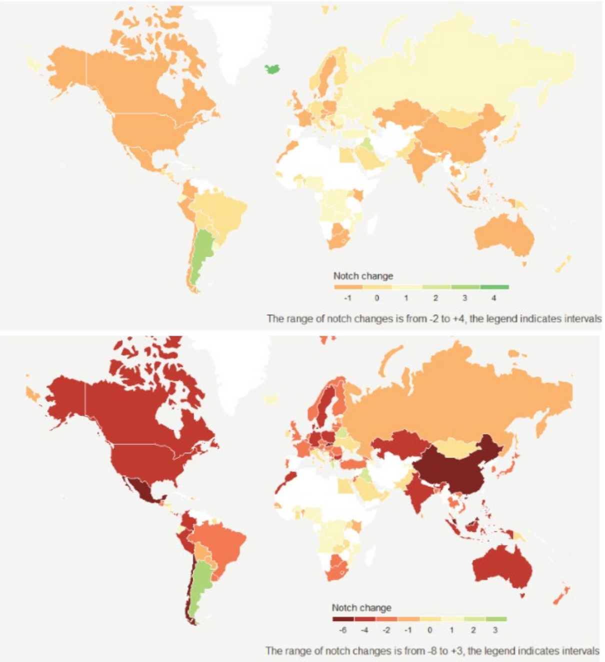
> - The development community is struggling to mobilise private finance for the Sustainable Development Goals (SDGs), especially in sectors and geographies where funding is most needed.
> - And yet, private investors seem increasingly keen to adopt environmental, social and governance criteria and are gradually aligning investments with the SDGs.
> - But, for lack of consistent incentives, development finance institutions (DFIs) including multilateral development finance institutions (MDFIs) are failing to stimulate SDG-aligned private investment.
>
> […]

“Making private finance work for the SDGs”, OECD, July 2022.

Effective ways to combine public and private capital to be deployed to deliver SDGs is a key topic for global finance in general and fixed income in particular. One of the thorny issues has been that traditionally, economic analyses of, for example, climate change, have estimated relatively modest impacts on GDP and other macroeconomic variables, consequently leading to minimal projections of deteriorating credit ratings on bond issuers.

Times and analyses are both changing. In a recent paper, “Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness”[2], the authors directly model impact on credit ratings, resulting in more differentiated and front-loaded ratings changes (see Figure 1). .[3] Another study is available in “Nature Loss and Sovereign Credit Ratings”[4], generating similar rating deltas but based on nature rather than climate change factors.

Figure 1. Global climate-induced sovereign rating changes (2100, Representative Concentration Pathways 2.6/ 8.5)). Source: Klusak et al. (2023).



Still, such empirical analyses may look at implications that are too long-term for investors and, perhaps more importantly, not offer them a connection between their investments and avoidance of downside scenarios. If economic risks, or risk reductions, are only hypothetically tied to investment outcomes, the potential synergies between pubic and private capital are less compelling to the individual investor.

This is where the concept of labelled bonds, such as green- or sustainability-linked bonds (SLBs) come into play, as they seek to combine the investment dimension with some form of positive

[2] Klusak, P., Agarwala, M., Burke, M., Kraemer, M. and Mohaddes, K., Cambridge WP in Economics 2127.

[3] Other recent analyses around rating risks and climate risk effects include “Rating stability at risk from looming climate downgrades”, IEEFA, 21 Aug 2023; “Barclays Warns of Bond Risk Few Creditors Are Pricing Right”, Bloomberg, 4 Sep 2023.

[4] Agarwala, M., Burke, M., Klusak, P., Kraemer, M. and Volz, U., Finance for Biodiversity Initiative, July 2022.

impact. In particular, the SLB structure seems suitable for lower-rated, smaller issuers,[5] where the underlying capital expenditure needed for the positive impact may be hard to attach to already existing assets. [6] Both green bonds and SLBs have the benefit of being possible to trade in open, liquid markets, which is a crucial component to access broader pools of fixed income capital.

Recognising that SLBs have been almost entirely private capital market transactions, without the involvement DFIs, the question arises how to combine such incentivising structures with public capital to make them appealing to general fixed income investors.[7,8]

To this end, this paper deploys an SLB option pricing approach[9], to develop what is called a CORL bond structure. Superficially, the CORL bond is a 'standard' SLB with a step-down, but where a third party – e.g., a DFI – provides credit enhancement contingent on the achievement of the SPT. In practice, the DFI commits capital to achieve a higher recovery rate on the CORL bond in the case of SPT achievement and default of the issuer.

The step-down SLB can price with a fixed coupon struck at the same interest rate as an equivalent vanilla bond if the step-down implies a credit improvement. This is important for creating an incentivising structure for the borrower. Furthermore, we show how this structure could in fact be attractive to all stakeholders, including DFIs.

The first section of the paper introduces the approach of pricing bonds according to risky discount curves, illustrating how an investor might value a certain cash flow from a higher versus a lower rated source. We then continue by tying that valuation approach to a more fundamental approach, looking at valuing cash flows based on underlying default probabilities implied by the ratings.

In the third section, we briefly introduce sustainability-linked bonds (SLBs), and show how the pricing of SLBs can be highly dependent on assumptions of correlation between sustainability-performance target (SPT) achievement and underlying credit worthiness/rating. We then use that model to infer how public capital can be used to generate implicit rating uplifts in case of SPT performance. In a worked example, we show how this CORL bond tructure is able to generate substantial step-downs with a relatively modest credit enhancement commitment from public capital.

The final sections then discuss the resulting incentive structure from the perspectives of the three main stakeholders: the issuer, the investor and the DFI, including various calibration options and caveats on the CORL framework.

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5 See "SLBs: complementary, my dear Investor", Anthropocene Fixed Income Institute (AFII), 13 Apr 2023.

6 In terms of development finance, the difference between program and asset specific financing, and the need to shift to the former, is discussed in the recent "How to finance a faster shift to a better world", Financial Times, 17 Oct 2023.

7 To our knowledge, the only DFI supported SLB so far has been a bond by Rwanda, see "World Bank Approves First Sustainability-Linked Bond for Rwanda to Boost Private Capital Mobilization", World Bank, 29 Sep 2023, with a reported small size, USD24.8mn. There have been a number of other sovereign SLBs, e.g. Chile ("Offi-Chile the largest sovereign SLB issuer", AFII, 29 Jun 2023) and Uruguay ("Uruguay SLB: market update", AFII, 5 Jun 2023).

8 One could also consider SLBs with non-pecuniary rather than coupon differential effects as a sort of concessionary capital proposition, see "Sustainability-Linked Bonds: alternative steps", AFII, 23 May 2023 for examples of alternative step structures.

9 The option pricing approach used in this paper was originally discussed in "Notes on Risk-Neutral Pricing of SLBs and Step-down Structures", Erlandsson, Mielnik, Richardson and Rimaud (2022).

Pricing bonds using risky discount curves

The concept of discount curves is ubiquitous in finance, but perhaps not always that much discussed in terms of actual investment decisions in the sustainable finance domain. The basic principle is that future cash flows are valued according to some discount curve: in the risk-free world, it is – or should be – obvious that a cash flow of an annual 4% for 10 years is more valuable if the risk-free rate is 1% than if it is 5%.

Discount rates can also be used beyond risk-free rates, to account for expected default risks and other risk premiums. This is what we call risky-discount curves, illustrated in Table 1. The most common way to define default risk in terms of discounting curves is to use credit ratings: a BBB rated bond should be discounted with a BBB discount curve and so on. As we can see in the table, the discount factor for the BBB-rated bond for a 10-year payment is 1.784 versus 2.067 for the BB-rated risk. In other words, a $4 coupon payment in year ten is worth $2.24 in net-present value terms if the underlying risk is BBB, and $1.94 if it is BB-rated.

Table 1. Spot rates and (risky) discount curves, August 2023. Source: Bloomberg, AFII.

	Spot rates			Discount factors		
Year	AAA	BBB	BB	AAA	BBB	BB
1	5.41%	6.08%	6.87%	1.054	1.061	1.069
2	4.75%	5.91%	6.85%	1.097	1.122	1.142
3	4.35%	5.80%	6.85%	1.136	1.184	1.220
4	4.23%	5.72%	6.89%	1.180	1.249	1.305
5	4.29%	5.69%	6.97%	1.233	1.319	1.400
6	4.46%	5.72%	7.09%	1.299	1.396	1.508
7	4.64%	5.77%	7.20%	1.374	1.481	1.627
8	4.79%	5.82%	7.31%	1.454	1.573	1.759
9	5.03%	5.89%	7.42%	1.555	1.673	1.904
10	5.50%	5.96%	7.53%	1.708	**1.784**	**2.067**

This suggests that investors can price in anticipated credit rating deterioration or improvements in bond prices by applying risky discount curves. If an investor believes a BB rated bond will improve in terms of credit worthiness, then applying a BBB discount curve will give them a valuation above the current, implying that the investor should be a buyer today.

Risky-discount curves are of course time-varying, both as underlying risk-free rates change, but more importantly as the risk perception between rating categories change. The data in Figure 2 plots average yields across different rating categories for bonds since 1996 to give a first cut of this variability over time.

It is important to note that spreads between rating categories do not follow a linear pattern. For example, the difference between the AAA and AA rating change in terms of spreads is much lower than that between BBB and BB. This goes back to the definition and calibration of credit ratings versus default probabilities, where ratings are based on exponential increases rather than being linear. Table 2 shows this numerically: for example, the incremental change in spreads sits at 32.5bps (basis points) when going from AA to A, whereas it is almost 160bps when going from BBB to BB. The right-hand panel of the table furthermore shows the large increases in default probabilities as one moves between letter grades. A BBB rating implies a 5-year default rate of 2.6% whereas a BB rating has historically meant an 8.3% 5-year default rate, more than 3x higher than for the BBB rating.

Figure 2. Average yields across rating segments based on Bank of America data, FRED-database. 1995-2023. Source: Federal Reserve, BofA-ML.

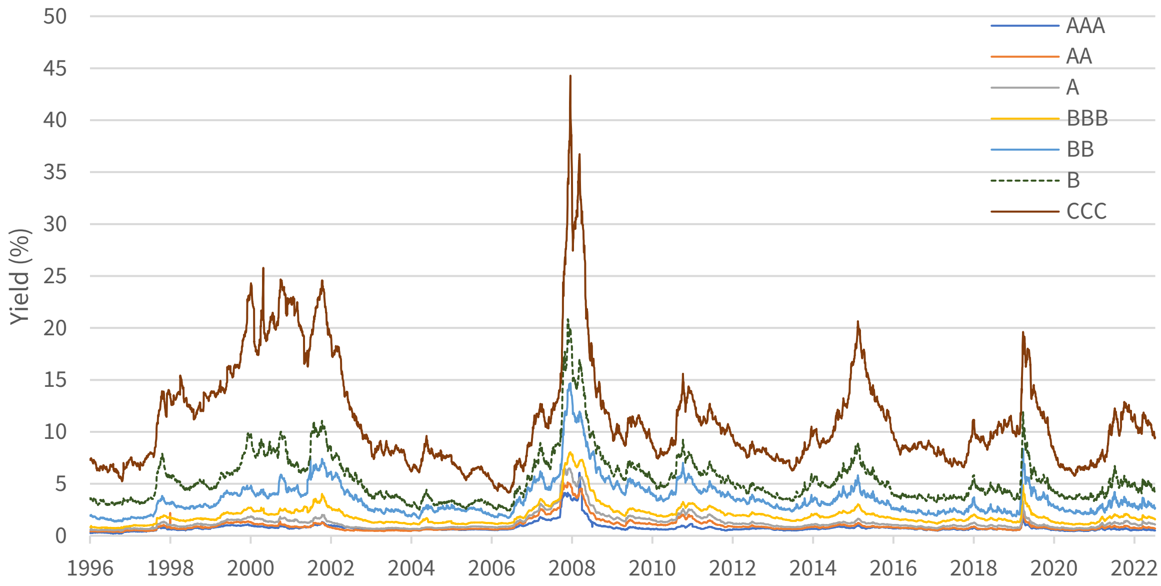


Table 2. Rating categories and average yields and spreads, 1995-2023, not adjusted for maturity; cumulative default rates for rating grades (subsequent ratings post initial rating). Source: FRED, S&P Global Ratings, AFII.

					Cumulative default rates (S&P)/ by year				
Rating notch	Rating points	Average yield	Spread over AA (bps)	Delta (bps)	1	3	5	7	Total
AAA	100	0.78	-18.5		-	-	-	-	-
AA	90	0.97	0.0	18.5	-	0.1%	0.1%	0.2%	0.5%
A	75	1.29	32.5	32.5	0.2%	0.6%	0.8%	0.9%	2.2%
BBB	60	1.97	100.1	67.6	1.6%	2.1%	2.6%	3.2%	5.2%
BB	45	3.57	259.9	159.8	4.0%	6.8%	8.3%	9.3%	11.9%
B	30	5.40	442.9		24.6%	32.5%	35.1%	35.6%	34.7%
CCC	15	11.22	1025.2		66.4%	53.0%	47.7%	44.9%	38.7%
			Average	69.60					

Let us now move to an explicit example: we assume a 10-year bond with a fixed annual coupon of 7.25%. This is illustrated in Table 3, where when we discount the bond with a BB curve, we get a bond price of 98.892. However, if we use a BBB curve, the price goes up by almost 9 points, to 109.89. Effectively, this means that the value to the investor of having a BBB profile on this bond, compared to BB, is approximately 10 points (percentage points of the nominal price). This price differential can be viewed as the benefit (to investors) and gross cost (to providers) of providing "credit enhancement", where we simply define credit enhancement as any structural and/or economic support to lift the bond from BB to BBB.[10] An advantage of this approach in the context of using DFI capital more efficiently is that it provides a direct, market-derived, net-present-value of a credit enhancement commitment. This number will be substantially lower than booking a nominal amount as exposure.

[10] We will return to a more detailed analysis of credit enhancements below.

Table 3. Value of a 7.25% coupon bond (simplified) based on BBB and BB, and a split BB/BBB discount curve respectively. Split as BB 0-5y, then BBB 5-10y. USD. as of 25 Aug 2023. Source: AFII, Bloomberg

		BBB bond				BB bond				BB 1-5y, BBB 5-10y			
Year	Coupon	Spot rate	Disc. Factor	Disc. Coupon	Disc. Nominal	Spot rate	Disc. factor	Disc. coupon	Disc. nominal	Spot rate	Disc. Factor	Disc. Coupon	Disc. Nominal
1	7.25	6.075	1.061	6.83		6.87	1.069	6.784		6.87	1.069	6.78	
2	7.25	5.909	1.122	6.46		6.85	1.142	6.350		6.85	1.142	6.35	
3	7.25	5.795	1.184	6.12		6.85	1.220	5.943		6.85	1.220	5.94	
4	7.25	5.716	1.249	5.80		6.89	1.305	5.555		6.89	1.305	5.55	
5	7.25	5.691	1.319	5.50		6.97	1.400	5.177		6.97	1.400	5.18	
6	7.25	5.721	1.396	5.19		7.09	1.508	4.807		7.00	1.501	4.83	
7	7.25	5.767	1.481	4.90		7.20	1.627	4.455		7.04	1.610	4.50	
8	7.25	5.823	1.573	4.61		7.31	1.759	4.123		7.10	1.731	4.19	
9	7.25	5.885	1.673	4.33		7.42	1.904	3.808		7.16	1.864	3.89	
10	7.25	5.957	1.784	4.06	56.07	7.53	2.067	3.508	48.38	7.23	2.011	3.61	49.74
SUM				53.82	56.07			50.51	48.38			50.83	49.74
Bond price					**109.89**				**98.89**				**100.56**

A further refinement to this is to look at a situation where we anticipate this BB bond to achieve its rating uplift to BBB some time into the life of the bond. Assume that we believe the bond will follow a BBB risk curve after five years, what should the bond price be in that case? This is tabulated in the rightmost panel of Table 3, where we can see that the price ends up as 100.56, which is relatively close to the BB-only bond. As we will see later, this is related to default risk being front-loaded: most of the incremental risk in the BB bond happens in the first five years (before the bond has assumed a lower BBB default trajectory) and hence the default probability reduction in the backend is relatively low.

Default risk pricing

More specifically, it can be argued (and also counterargued) that the risky discount curve approach is based on a risk-free underlying rate, and then some spread to compensate for default risk (see Table 2) and other factors such as liquidity. If we write out the bond pricing relationship between these factors more explicitly: the bond price P^{BB} (which has the yield r^{BB} as per above) is the risk-free discounted cash-flow of coupons and return of nominal, probability weighted, and the risk-free discounted value of recovery in case of default:

$$P^{BB} = \sum_{i=0}^{T} \phi_i^{rf} \cdot S_i^{BB} \cdot C_i + \sum_{i=0}^{T} \phi_i^{rf} \cdot \Delta\left(1 - S_i^{BB}\right) \cdot R + \phi_T^{rf} \cdot S_T^{BB} \cdot N$$

Where ϕ_i^{rf} is the risk-free discount factor for time *i*, and S_i^{BB} is the survival probability for a BB bond until time *i*, such that $1 - S_i^{BB}$ is the cumulative default probability at time *i*.[11] There is an equivalent BBB-rated bond with price P^{BBB} built analogously to the BB bond. We exemplify pricing the same BBB and BB bond structures as before, but using default probabilities, in Table 4.

[11] $\Delta(1 - S_i^{BB})$ is the marginal default rate ("hazard rate") between time *i* and *i-1*.

Table 4. Pricing BBB and BB bonds using risk-free discount rates and expected losses given by historical default rates and a 40% recovery assumption. Source: AFII.

Year	BBB				BB			
	Cum. default	Disc. coupon	Expected recovery	Nominal pay-back	Cum. default	Disc. coupon	Expected recovery	Nominal pay-back
1	1.0%	6.809	0.379		5.5%	6.500	2.087	
2	1.8%	6.491	0.273		9.4%	5.989	1.403	
3	2.5%	6.222	0.264		13.2%	5.539	1.355	
4	3.1%	5.952	0.203		14.7%	5.239	0.508	
5	3.7%	5.660	0.195		16.2%	4.925	0.486	
6	4.1%	5.354	0.108		16.9%	4.637	0.215	
7	4.4%	5.044	0.102		17.6%	4.348	0.204	
8	5.3%	4.725	0.238		18.6%	4.058	0.284	
9	6.1%	4.376	0.223		19.7%	3.745	0.266	
10	7.0%	3.947	0.203	54.446	20.7%	3.366	0.242	46.426
BPC		54.580	2.189	54.446		48.346	7.052	46.426
Bond price				**111.215**				**101.824**

There are three distinct valuation differences highlighted in the table:

- **Coupon payouts:** the BBB bond coupon stream is more valuable (contributes 54.58 to the bond price) than for the BB (bond price contribution 48.346) as it is more likely that the above-risk-free rate coupons will be paid out to the investor.
- **Expected recovery and nominal pay-back:** somewhat counterintuitively, the expected values recovered are higher in the case of the BB (7.052 vs 2.189 BPC), but this is a function of the recoveries being paid out more often in the BB case – recoveries are only paid out in case of default. This is matched by a lower expected **nominal pay-back** which is substantially higher in the case of the BBB (54.446) versus the BB (46.426) as it is simply more likely the nominal will be fully repaid in the BBB case.

Looking into this split, the **bond valuation's main two components are (i) the likely coupon stream to be received** (54.580 vs 48.346, BBB vs BB) **and (ii) the valuation of the repayments of notional and recoveries** ([54.446+2.189]=56.635 vs [46.426+7.052]=53.478, BBB vs BB). Looking at the full valuation differential between the BBB and BB of 111.215-101.824 = 9.391, we see that 54.580-48.436=6.234 dollars of that is being driven by the coupon stream, and 56.635-53.478=3.157 is driven by claims to the nominal. This distinction will be used below in the context of credit enhancements, where credit enhancement could be designed to cover risks of the investor for factor (ii) repayment, but not necessarily factor (i). [12]

Sustainability-linked bonds with SPT correlation to credit ratings

Sustainability-linked bonds are a relatively new concept with the first issuances in 2019. The SLB (or similarly, Sustainability-Linked Loan (SLLs)) concept is simple: create a contractual linkage between performance of the borrower toward some sustainability performance targets (SPTs) and interest rates on the borrowing.

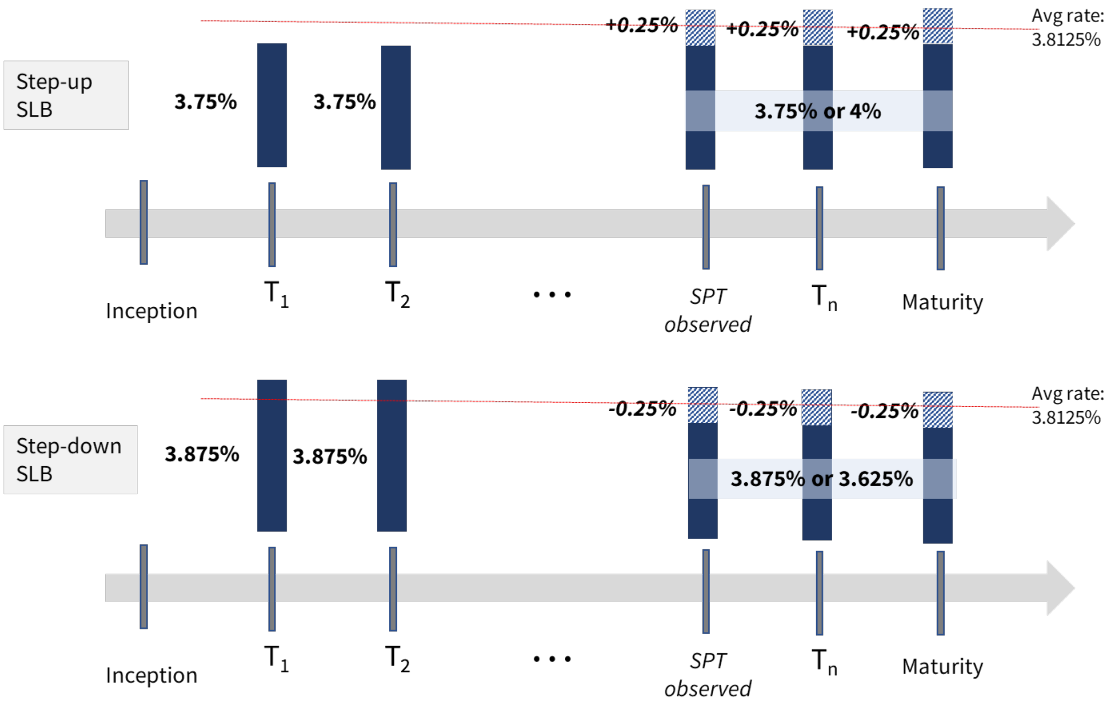
A conceptual graph of this is illustrated in Figure 3, where the upper panel illustrates an SLB with a **step-up** structure. Here the "fixed rate" of the SLB is 3.75% but has the potential to increase to 4%

[12] An eloquent discussion around the separation of coupon streams and principal payments is made in "The credit spread curve I: Fundamental concepts, fitting, par-adjusted spread, and expected return", Martin, R. (2022), https://doi.org/10.48550/arXiv.2201.01330.

if the bond issuer does not reach the sustainability performance target at the observation date. This is often referred to as a "penalty" on the issuer, however, it should rather be seen as a hedge for the investor in the structure. The bottom panel illustrates the less-common **step-down** structure (SLBDs), where the interest rate has the potential to go down by 0.25% if the SPTs are achieved by the observation date.

Figure 3 also superimposes the average expected rate for the step-up and step-down, assuming a 50% probability of the step happening. This level, 3.8125%, will naturally be below the fixed coupon[13] in the case of the step-down, and above the fixed coupon level of the step-up structure. This point is often missed in the discussion of SLBs**: initial coupons should be set away from the equivalent vanilla bond coupon, to compensate for future lower/higher coupon levels.**

Figure 3. Coupon levels in a sustainability-linked bond structure. The average/expected interest of both the step-up and step-down structure is 3.8125% assuming a 50/50 probability for the step up to happen. A vanilla bond for the same structure should be expected to price with a 3.8125% coupon. Source: AFII.



The SLB format has a few differences to the more commonly known green bond format. In the context of this paper, three main conceptual differences stand out:

- **SLBs are general corporate purpose (GCP) versus use-of-proceeds (UOP).** This means that the SLB investor is targeting a holistic performance of the issuer, rather than specific assets. Theoretically, a UoP format would allow an issuer to build coal plants next to UoP financed renewable energy assets, whereas an SLB might be tailored to look at the total emissions of the issuer, which would make such behaviour harder.
- **Data and investor incentives to follow up on sustainability performance**. Investors are extracting financial value of the SLB on the basis of performance targets being met (or not), hence they should have a willingness to deploy resources to properly monitor sustainability performance.

[13] By "fixed coupon", we refer to the initial coupon level of the SLB structure.

- **Electoral cycle considerations** for (quasi)-sovereigns. Performance targets can be set such that they also act as a check on future policies, not only that of the current political force in power, for example by setting the coupon adjustment next well into the electoral cycle. The need for this has been illustrated by recent backtracking by the UK and Swedish sovereign green bond issuers.[14]

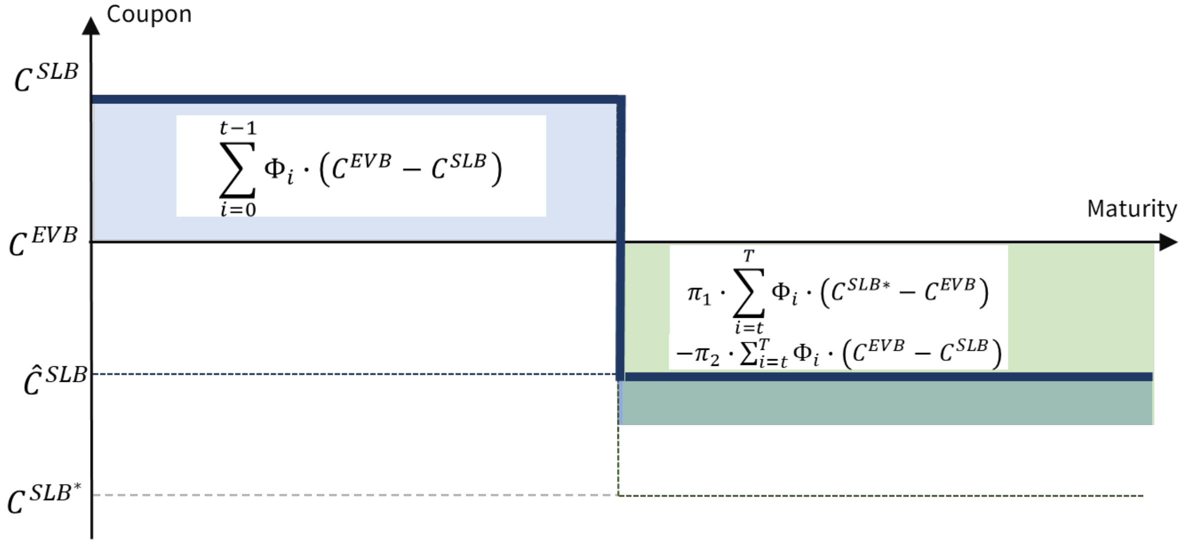
One should also recognise the critique of the SLB market, for example low financial materiality, unambitious SPTs/KPIs and callability ahead of sustainability target dates. It is beyond the scope of this note to elaborate on these topics, for further discussion see e.g. "SLBs: complementary, my dear Investor" , AFII, 13 Apr 2023; "In defence of SLBs", GlobalCapital, 4 Apr 2023; "Sustainability-Linked Bonds and how to use them credibly", Eco-Business, 29 Aug 2023; "SLBs: no cal(l)amity", AFII, 20 Sep 2023.

Pricing of step-down SLBs with credit quality and SPT correlation

The notion of step-ups containing a stigmatising "penalty" on non-performance has moved more and more attention to step-down structures, where the achievement of target is prized instead. However, SLBs with step-downs have one significant drawback in their basic format as alluded to in Figure 3 above and Figure 4 belwo: the fixed coupon must, everything else equal, fix above the equivalent vanilla bond (EVB) in order to be attractive to investors. And this is very unattractive to the issuer side.

In a risk-neutral context, if we consider an EVB with 5% coupon and compare it with an SLBD that steps down by 0.5%, then that SLBD should have a fixed coupon of more than 5% in order to compensate investors for the potentially lower coupon in the future. This dynamic is illustrated in Figure 4, and described in further detail in "Notes on Risk-Neutral Pricing of SLBs and Step-down Structures", Erlandsson, Mielnik, Richardson and Rimaud (2022).

Figure 4. Coupon structure and pricing equations in an SLBD. Source: Anthropocene Fixed Income Institute.



[14] For a further discussion on suitability for SLBs in a sovereign context, see "The potential of sovereign sustainability-linked bonds in the drive for net-zero", Bruegel Policy Brief, 23 Mar 2023.

An mathematical expression for the relationship between the fixed coupon in the SLBD and the EVB can be derived using a simple no-arbitrate relationship:[15]

$$\sum_{i=0}^{t-1} \Phi_i \cdot (C^{EVB} - C^{SLB}) = \gamma_1 \cdot \sum_{i=t}^{T} \Phi_i \cdot (C^{SLB*} - C^{EVB}) - \gamma_2 \cdot \sum_{i=t}^{T} \Phi_i \cdot (C^{EVB} - C^{SLB}) \quad [1]$$

where Φ_i is the risky discount factor for time *i* (which runs from $0 \ldots t \ldots T$ where t is the step date and T is the maturity date), C is the coupon for the *EVB*, the start date SLB and the stepped up *SLB**. The probability to step is denoted γ_1 with the non-step probability $\gamma_2 = 1 - \gamma_1$.

However, it may be difficult for an issuer/CFO to argue that one should pay a higher coupon in the short term, in order to get a lower one in the future as in the SLBD no-arbitrage pricing model. But now consider merging this with our discussion on switching risk curves. We know that an investor sees more value in a bond traded at a "better" risk curve, where we have alternated between a risk discounting perspective, as well as a perspective based on derived (from ratings) default risks. Can we use that higher valuation to frontload a lower SLBD coupon? It turns out the answer to this is yes.

Consider Table 5 where we set the SLBD with a fixed 7.25% coupon and allow it to drop by 0.1% if a sustainability target is met. This would be correlated with an improvement in creditworthiness, thus allowing us to assume a BBB discount curve after year 5. This SLBD would price at 100.27, meaning that it would be more attractive than the BB bond without the credit improvement (but also without a step-down). The more lenient discount curve more than compensates for the lower coupons for the investor.

Table 5. Pricing an SLBD with 7.25% fixed coupon, a 0.1%/0.23% step-down after year 5, and split (BB/BBB) discount curves. Source: AFII.

	BB bond				BB 1-5y, BBB 5-10y, SD -0.1% SD				SD -0.57%
Year	Spot rate	Disc. factor	Disc. coupon	Disc. nominal	Spot rate	Disc. Factor	Disc. Coupon	Disc. Nominal	Disc. Coupon
1	6.87	1.069	6.784		6.87	1.069	6.78		6.78
2	6.85	1.142	6.350		6.85	1.142	6.35		6.35
3	6.85	1.220	5.943		6.85	1.220	5.94		5.94
4	6.89	1.305	5.555		6.89	1.305	5.55		5.55
5	6.97	1.400	5.177		6.97	1.400	5.18		5.18
6	7.09	1.508	4.807		7.00	1.501	4.76		4.45
7	7.20	1.627	4.455		7.04	1.610	4.44		4.15
8	7.31	1.759	4.123		7.10	1.731	4.13		3.86
9	7.42	1.904	3.808		7.16	1.864	3.84		3.58
10	7.53	2.067	3.508	48.38	7.23	2.011	3.56	49.74	3.32
BPC			50.51	48.38			50.54	49.74	49.17
Bond price				**98.89**				**100.27**	**99.90**

Indeed, if we price the SLBD such that is equal in value to the original EVB, we can set the step-down to -0.57%, as indicated in the rightmost column of Table 5. This means that – under the condition that the bond risk switched to BBB after the step-down date – the investor would be agnostic about that structure or the equivalent vanilla bond.

[15] An explanation of this pricing relationship and the graphs is available in "Greenback SLBs: an impact standardisation proposal", AFII, 10 May 2023.

Here it is important to note that, as our baseline pricing measure is the price of non-structured bonds, the probability of the SLB step happening does not matter to the pricing of the bond.

The key here is in the improvement of creditworthiness and thus a switch in discount curves. As indicated in the pricing equations, in a real-world setting, this must be set according to the probability of the improvement happening, thus dampening the above results somewhat. Credit enhancement is a way to hardcode that this change would actually happen.

CORL: Credit enhancement contingent on SPT performance

In order to see how credit enhancement can play a role in this setting of ratings-based risky discounting, we start looking at historical loss-given-default (LGD) rates and default rates (PD) within rating categories. We start by assuming the following simple relationship:

$$P^{BB} - E(L^{BB}) = P^{AAA} \leftrightarrow P^{BB} = P^{AAA} + E(L^{BB})$$

I.e. the price (present value of cash flows) of the BB-rated bond, P^{BB}, is equal to the price of the risk-free bond, P, plus the (present value of) expected loss of the BB-rated bond, $E(L^{BB})$. We assume a zero risk-premium here. We furthermore define the expected loss as:

$$E(L^{BB}) = PD^{BB} \cdot LGD^{BB} = \pi^{BB} \cdot (1 - R)$$

Where $PD^{BB}$is the probability of default for the BB bond and LGD^{BB} is the loss-given-default. Loss-given-default is alternatively defined as $(1 - R)$, where R is the recovery rate for the bond. We will assume, unless otherwise stated that $R$is 40%, and that it is equal across rating categories.

If we assume that same notation for a BBB bond, we can write the price of the BB bond as a function of the price of the BBB bond, and the incremental expected loss between BB and BBB:

$$P^{BB} = P^{BBB} + [E(L^{BB}) - E(L^{BBB})] \leftrightarrow r^{BBB}{=}r^{BB} - [E(L^{BBB}) - E(L^{BB})]$$

In other words, the price of the BB-rated bond is simply the price of the BBB-rated bond plus the expected (increased) loss on the BB-rated bond.

Now, suppose there is an R^* such that

$$E(L^{BBB}) = PD^{BBB} \cdot LGD^{BBB} = \pi^{BBB} \cdot R = \pi^{BB} \cdot R^* \qquad [2]$$

This $R^*$is the recovery rate which would be required in order to match the expected loss of a BBB-rated bond, but assuming a BB default probability.

This means that if we improve the recovery rate on the BB-rated bond, to R^*, we can create a BBB rated asset – the investor should be indifferent to a higher probability of default and a lower loss rate, or a lower default rate and a higher recovery. This is one of the main strands of credit enhancements: the guarantor does not lower the probability of default but covers losses in case it happens.[16]

[16] Note that not all credit ratings agencies use loss-given-default in their rating assessments. This means that one rating agency would likely consider an asset with a 100% recovery rate as nearly risk-free and have as high a rating as the credit enhancement provider, whereas another would rate it significantly lower, just looking at the probability of default. A illustrative example of this is: "Norway's Eksportfinans Cut to Junk by Moody's Amid Wind Down", Bloomberg, 22 Nov 2011.

Table 6. Pricing the BB bond with changing recovery assumptions to analyse credit enhancements. Source: AFII.

Year	BBB base case	BB base case	BB with 58% recovery	BB with 93% recovery	BB with 100% recovery
1	0.38	2.087	3.026	4.866	5.218
2	0.27	1.403	2.035	3.272	3.509
3	0.26	1.355	1.965	3.160	3.389
4	0.20	0.508	0.737	1.185	1.271
5	0.19	0.486	0.705	1.134	1.216
6	0.11	0.215	0.312	0.502	0.539
7	0.10	0.204	0.295	0.475	0.509
8	0.24	0.284	0.412	0.663	0.711
9	0.22	0.266	0.385	0.620	0.664
10	0.20	0.242	0.351	0.564	0.605
Sum R	2.19	7.05	10.23	16.44	17.63
Disc. nominal	54.446	46.426	46.426	46.426	46.426
Coupon	54.580	48.346	48.346	48.346	48.346
Bond price	**111.215**	**101.824**	**104.997**	**111.212**	**112.402**

Now consider a worked example of this: a third party commits to cover some of the losses of the investor in case of default of a BB-rated bond. This means that the investor will get the improved recovery rate R^* vis-à-vis the non-enhanced case in case of default. Default probabilities π^{BB} themselves are not affected, but it is only the "expected recovery" leg that is affected in terms of our calculations. We tabulate this in two versions in Table 6. First, we look at setting the value of the recovery such that the two legs of the BB and BBB are equal. In other words, what is the recovery rate such that the investor is then indifferent between the BBB and BB bond in terms of return of nominal amounts, but excluding coupon payments? This happens at a $R^* = 58\%$ recovery rate (i.e. an 18% credit enhancements), with a bond price of 104.997.

Second, we look at what recovery rate the investor would be indifferent between the BBB and BB bond, including both the value of the coupon streams as well as the notional as discussed above. In other words, what is the recovery rate for the BB bond for which the price of the BB bond is equal to that of the BBB bond? This number is approximately 93.25% recovery rate. This does not seem intuitive; with an almost 100% assured recovery rate, the BB investor is no better off than the BBB investor. Core to this result is that the BB investor would be cut off from the (high-coupon) stream and is then assumed to invest the recovered nominal in a risk-free rate.

An important decision here is thus to decide if the credit enhancement should cover nominal repayments (i) only or (ii) also cover for (lower) likelihoods of getting the full coupon stream. Here we opine that the first option should apply: an investor should only look for credit enhancement to target a certain expected loss $E(L^{BBB})$, and reinvestments of any recoveries should be upon the investor to decide.[17]

We will now assume that credit enhancement is provided by concessionary capital amounting to $R^* - R$, and then analyse various alternatives to do this. In the first version, the enhanced recovery

[17] A special case arises when credit enhancements provide 100% recovery. Then the investor will, in case of default, be able to reinvest the full notional again, in some other asset yielding what the original coupon of the bond was, which would appear a good outcome for the investor compared to holding a straight BBB bond. As illustrated in Table 6, the 100% recovery BB bond only prices 1.2 points above the BBB bond with 40% recovery, which seems relatively small. This illustrates the assumption in the pricing model that the recovery is not reinvested.

rate is offered across the whole life of the bonds (non-contingent; NC); and in the second instance, the enhanced recovery is only offered if the SPT has been achieved (contingent, C). Going back to the earlier discussion, the latter case corresponds to when an investor views the SLB as BBB rated in case of SPT performance, and BB otherwise. This then allows us to price in the possible step-down that could be 'offered' in the SLB structure to the issuer, given various credit enhancements, while still holding the SLB fixed coupon at the same level as the EVB.

To illustrate this, consider the bond pricing approach in Table 4 and Table 6 above where we had a BB rated bond with a 40% recovery pricing at 101.824. Using the same structure but applying a step-down of 1% (and holding the SLB fixed coupon at the equivalent vanilla bond level, 7.25%), the resultant bond price is 99.044, which just shows that the step-down structure would not be attractive to the investor. This is case (B) in the table.

We then seek the R^* that would equalize the expected loss of the BBB and BB bond, non-contingent and then contingent on the bond having stepped down. This can be done by a simple numerical search, and as the results in the rightmost section of Table 7 show, we find the first number to be 56% at a -1% step-down.[18]

At that assumed "enhanced" recovery rate, the SLB step-down structure is pricing just slightly above (is more attractive) than the straight BB bond, at 101.865 versus 101.824. In the second case, we assume a -0.25% step-down, and a contingent enhanced recovery of 63%, again seeing that this prices at 101.825 and slightly above the EVB.

Put simply, with a relatively modest amount of contingent credit enhancement, an SLB step-down bond with a fairly high (and incentivising) step-down would price equal to a straight non-step bond. Indeed, if we look at the proposed structure and assume a 50% probability for the step to happen, then the option value is $1.39 in bond price terms, which is clearly above a Greenback SLB threshold.[19]

Table 7. Pricing the BB bond (A), with a step-down structure (B), and a step-down structure but with higher recovery rate throughout the life of the bond (C), and with a step-down and contingent recovery rate (D). Source: AFII.

	(A) Vanilla BB bond		(B) -1.0% stepdown		(C) -1.0% SD and 56% non-cont. recovery		(D) -0.25% SD and 63% contingent recovery	
Year	Disc. Coupon	Expected recovery	Disc. Coupon	Expected recovery	Disc. Coupon	Expected recovery	Disc. Coupon	Expected recovery
1	6.500	2.087	6.500	2.087	6.500	2.922	6.500	2.087
2	5.989	1.403	5.989	1.403	5.989	1.965	5.989	1.403
3	5.539	1.355	5.539	1.355	5.539	1.898	5.539	1.355
4	5.239	0.508	5.239	0.508	5.239	0.712	5.239	0.508
5	4.925	0.486	4.925	0.486	4.925	0.681	4.925	0.486
6	4.637	0.215	3.997	0.215	3.997	0.302	4.477	0.339
7	4.348	0.204	3.748	0.204	3.748	0.285	4.198	0.321
8	4.058	0.284	3.498	0.284	3.498	0.398	3.918	0.448
9	3.745	0.266	3.228	0.266	3.228	0.372	3.616	0.419
10	3.366	0.242	2.902	0.242	2.902	0.339	3.250	0.381
BPC	48.346	7.052	45.566	7.052	45.566	9.873	47.651	7.749
Bond price		**101.824**		**99.044**		**101.865**		**101.825**

[18] Obviously, the step-down and necessary recovery rate are jointly determined. The 1% step-down is assumed in order to find the corresponding enhanced recovery required.

[19] A "Greenback SLB" is where the risky discounted value of the coupon step stream is more than $1 in bond price terms, and assuming a 50% probability of step. See "Greenback SLBs: an impact standardisation proposal", AFII, 10 May 2023.

Another use of these results is to answer the question: what would be the cost to provide credit enhancement such that the SLB step-down structure would be considered BBB? Numerically, as shown in case (C) in Table 7, the cost of providing 56%-40% = 16% credit protection (which lifts the bond from BB to BBB in terms of expected loss in the stepdown scenario) in case of default is 101.865 – 99.904 = 2.821, or in other words, less than 3% of bond notional in net present value terms. From the perspective of a DFI, that would be the required value to book upon the issuance of the bond. Of course, in case it does crystallise, the payout would be 16% of bond notional, but that is being heavily discounted both through time-discounting as well as actual default probabilities.

Finally, in case (D) in Table 7, we look at how much credit enhancement is necessary for a certain step-down level if credit enhancement is contingent on the SPT being achieved. In other words, the enhanced recovery rate only gets paid out in case of the sustainability/resilience target having been achieved. In the (D) example, we assume a 25bps step-down, and in that case require a 63% (23% credit enhancement) recovery rate in order to price the structure flat to the EVB. Making the credit enhancement contingent on STP achievement reduces the potential step-down, but also the expected cost to the credit protection provider.

Table 8. Calibrating CORL structures: (E) represents a non-contingent structure aligning with a Greenback definition ($1 of option value); (F) is a hybrid structure with both non- and contingent credit enhancements at 5% and 23% respectively. Source: AFII.

	(E) "Greenback" CORL SD - 0.72% SD 52% non-contigent recovery		(F) CORL semi-contingent SD -0.50%, 45% NC R, 63% contingent R	
Year	Disc. Coupon	Expected recovery	Disc. Coupon	Expected recovery
1	6.500	2.713	6.500	2.348
2	5.989	1.824	5.989	1.579
3	5.539	1.762	5.539	1.525
4	5.239	0.661	5.239	0.572
5	4.925	0.632	4.925	0.547
6	4.176	0.280	4.317	0.339
7	3.916	0.265	4.048	0.321
8	3.655	0.370	3.778	0.448
9	3.373	0.345	3.486	0.419
10	3.032	0.315	3.134	0.381
BPC	46.344	9.168	46.956	8.479
Bond price		**101.938**		**101.860**

In Table 8, we calibrate the contingent and non-contingent structures a bit further. Case (E) looks at how big a step-down and what sort of enhanced recovery would be required to make the structure "Greenback", i.e. the optionality of the structure being at least $1/1% of the bond price, assuming a 50% probability of the step happening. Case (F) combines both a non-contingent credit enhancement (5% to 45% recovery), and a contingent one (23% enhancement, to 63% recovery). Both these cases illustrate how the structure can be flexibly adapted to target a particular step-down size, option values and other parameters.

So far, we have only considered what implicit rating effects have in terms of loss given default, treating default probabilities themselves as exogenous. In practice, we have assumed that the issuer follows a BB default rate probability pathway irrespective of the implementation of resilience measures, as well as potentially cheaper financing through the bond structure. What happens if we start assuming that default probabilities decrease as measures as implemented?

Table 9. Repricing the bond structures under the assumption of an improved default trajectory, equivalent to moving from BB flat to BB+. Source: AFII.

			(G) Hybrid BB(1-5)/BBB(6-10) SD -0.37% cont. 63% recovery			(H) BB+ EVB			(K) BB+ upgrade, SD -1.25% cont. R 60%	
Year	BB+ default rate	BB/BBB hybrid def. r.	Nominal	Disc. Coupon	Expected recovery	Nominal	Disc. Coupon	Expected recovery	Disc. Coupon	Expected recovery
1	4.0%	5.5%		6.500	2.087		6.603	1.518	6.603	1.518
2	6.8%	9.4%		5.989	1.403		6.157	1.027	6.157	1.027
3	9.6%	13.2%		5.539	1.355		5.766	0.992	5.766	0.992
4	10.8%	14.7%		5.239	0.508		5.477	0.407	5.477	0.407
5	12.0%	16.2%		4.925	0.486		5.170	0.389	5.170	0.389
6	12.6%	16.6%		4.418	0.170		4.876	0.180	4.035	0.269
7	13.2%	16.9%		4.161	0.160		4.580	0.170	3.790	0.255
8	14.2%	17.8%		3.892	0.376		4.280	0.269	3.542	0.404
9	15.2%	18.6%		3.599	0.351		3.955	0.251	3.273	0.377
10	16.1%	19.5%	47.128	3.242	0.320	49.099	3.560	0.229	2.946	0.343
BPC			47.128	47.506	7.217	49.099	50.424	5.431	46.760	5.980
Bond price					**101.851**			**104.954**		**101.840**

Our first example of this is shown in case (G) in Table 9 where we assume that the CORL bond follows a BB default trajectory the first five years, but that the then-marginal default probabilities follow the pattern of a BBB rating after the achievement of the SPT.[20] Assuming a 63% contingent recovery rate, like in case (D), we can induce that the corresponding step-down could be 37bps compared to 25bps in case (D) where we assumed a simple BB default trajectory. **The improved default trajectory changes the possible step-down size significantly.**

Next, we re-run the above framework but assuming that the BB flat bond improves such that it starts following a BB+ trajectory. In order to derive default probabilities for the BB+, we linearly interpolate the BB versus BBB rating default probabilities (see leftmost column of Table 9 below). First, case (H) in Table 9 prices an equivalent vanilla bond at the BB+ level to 104.594, to be compared with 111.215 for the BBB letter bond in Table 4, and 109.89 using risky discount curves in Table 3. This can be interpreted as potential profit (approximately 104.59-101.82=2.8 points) for an investor who has bought into structures (C)-(F) above, if either of those structures leads to a fundamental improvement of credit quality to BB+.

But if there is an inherent credit improvement, one can argue that the spoil of that should be split between the issuer, the DFI and the investor, rather than end up only with the investors. Now assume that an external credit rating agency would consider re-rating the CORL structure from BB to BB+ if there is a higher recovery, and a potentially lower interest rate payment. Clearly, there would have to be a discussion between the DFI (as credit enhancement provider) and the rating agency, to see how much enhancement is needed in order for a rating notch uplift on the structure. Here, we assume that a 20% contingent recovery enhancement (to an expected recovery rate of 60%) combined with a step-down of -1.25%, in combination with a compelling SPT, would suffice to achieve the one notch uplift.

This resulting pricing is shown in case (K) in Table 9. Not entirely coincidentally, such a structure would be valued at 101.84, just slightly above the BB vanilla bond. **The possible large step-down (125bps) in this case is a function of the large impact default probability trajectories (and**

[20] This default trajectory is shown as "BB/BBB hybrid default" in the table.

improvements thereof) have on the valuation of the bond. Having a view that the structure equates a one notch of uplift does generate a lot of value, and the potential for more ambitious step pricing.

The structures (G) and (K) is what we could call a true Contingent Resilience Linked (CORL) bond. Credit enhancement is only contingent on SPT performance; however, it is strong enough to improve the credit rating and/or underlying default expectation assumption, which is core to the concept of investments' resilience.[21]

CORL bond: stakeholder analysis

In order to make the CORL structure work optimally, four stakeholder groups need to come to an understanding: the issuer, investors, the DFI and a rating agency.

The issuer has the most obvious interest in this structure, as essentially the step-down is a free, or at least a very cheap, option to pay a lower interest rate. It does provide strong incentives, while allowing for more freedom on how to achieve targets than traditional asset-focused financing. Also, the structure provides a way for current policymakers to lock in ESG/resilience policy to extend beyond the current electoral cycle.. This may itself be a strong incentive for making expenditure in the first place: if a policymaker is unsure that a capex spending program will be completed in the next electoral cycle, they may very well decide not to implement it in the current cycle. With the SLB/CORL structure, there is greater influence over long-term alignment of policy for current policymakers.

Linking in private and DFI capital may also bring other types of technical support that might not be in place otherwise. Suppose the links are to flood defences and there is a need for spatial examinations to monitor flooding resilience improvements. Then it could be expected that DFIs and investors offer assistance in terms of such monitoring, as it would quite closely relate to the valuation of their own exposures. Indeed, as we have argued, one of several benefits of the SLB structure is how it improves incentives for data provisioning.[22] This data should be used to the benefit of the issuer, to improve resilience, and not only be seen as a follow-up measure for the bond structure.

Lastly, for the issuer, the CORL structure may indeed be a way to access pools of capital that would not otherwise be accessible. The examples above are on the cusp of investment grade versus high-yield ratings, which traditionally is a rather well-defined border between different pools of capital. Many large asset owners will be unable to invest in pure high-yield, but the CORL hybrid structure at least moves closer to accessing such money, not least considering fairly substantial commitments from investors to invest in climate- and nature-loss mitigating investments.

Turning to the **investors' participation**, the exact specification of the structure will provide varying degrees of incentives. In the formats where the DFI is providing credit enhancement, and the pricing assumes no improvements in terms of future default risks, the structure should be most attractive; any correlation between the SPT and creditworthiness will count towards a rising bond price, and P&L benefits for the investor.

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[21] It has not been discussed here, but an analogous point could be made around potential credit rating deterioration

[22] For a practical example of this, see "The Forensic Carbon Accountant: JBS SLB", AFII, 21 Sep 2023.

Furthermore, we have not accounted for non-pecuniary benefits tied to the CORL investment for the investor. These can range from entirely non-monetizable effects, such as being able to provide better impact reporting and real-world outcomes for universal owners, to more business related factors, as the potential to include well-defined CORL bonds into dedicated sustainability funds, e.g. the EU's SDFR Article 8 and 9 categories.[23]

It should be recognised that the valuations above rest on a number of assumptions, requiring a bit of work on behalf of investors in terms of their valuation models. The investor will need to take risk in terms of considering realised versus historical default rates, as well as realised versus assumed recovery rates. In terms of the final CORL specification (H), the investor will need to convince themselves that the rating uplift is reasonable for that type of resilience improvement. Neither of these analyses would be very far from traditional credit analysis, however.

What are the incentives **for the concessionary capital/DFIs?** "Investors get something better value, issuers get a free option, all financed by credit enhancement by concessionary capital" could be a critique of the CORL structure. We would disagree; the implicit assumption here is that the concessionary (in the CORL) stakeholder has other exposures to the issuer, where the potential cost/loss in those exposures will decrease if the SPT-related measures are put in place. From a global perspective, MDBs and DFI often act as implicit insurance companies, paying out in aid and assistance after 'accidents' strike. Consider the following example/analogy:

An insurance company is providing flooding insurance to a municipality where the magnitude of insurance premiums to be paid on basis of flooding risk is hard to define, or hard to actually monetise from the municipality.[24] If the municipality implements measures to reduce flooding risks, then the insurance company can expect a lower future loss rate, which is an economic gain for the insurance company. This expected gain from flood defence policy implementations can then be used as a counterbalance to providing concessionary capital in the CORL structure. The insurance company would step in to provide the contingent credit enhancement in a CORL with targets based on flooding resilience metrics, thus providing longer-term incentives to implement such measures for the issuer as well as crowding in private capital interest into the policy.[25]

Of course, the "concessionary" capital part should also link to non-pecuniary factors, where DFIs often have performance metrics linked to sustainable development goals or similar targets. The negative case could be problematic for a DFI: if – in our example – an event occurs where losses would have been mitigated by resilience measures, but the DFI had not been proactive in bringing those about, owner/stakeholder pressures might build.

Lastly, there is an increasing debate around utilising DFI/MDB capital more efficiently. The CORL structure allows for a rather specific and well-defined calculation around what sort of exposures would need to be booked up front for a DFI providing the credit enhancement. Going back to our

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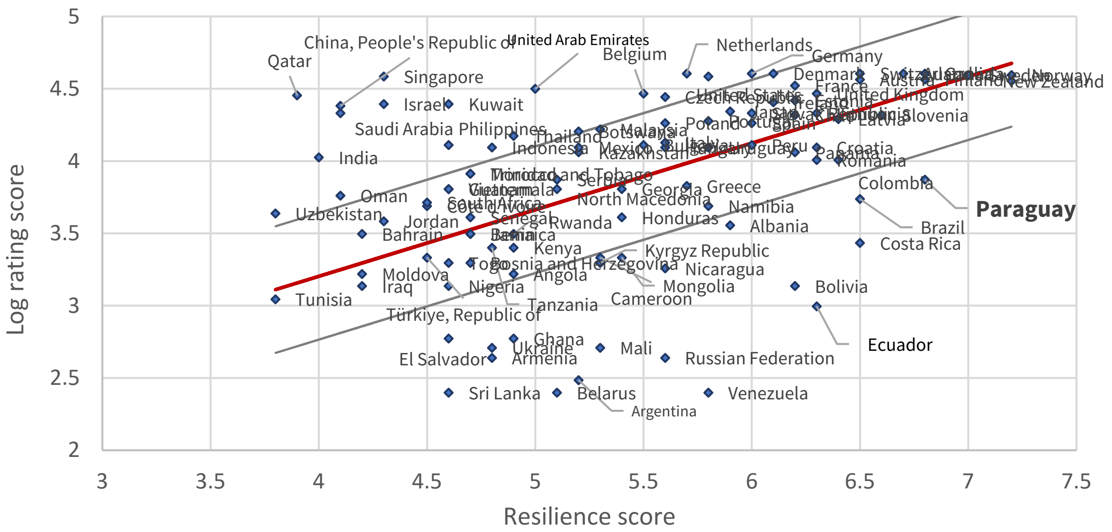
[23] There is an ongoing debate on whether SLB structures are eligible for inclusion under such regulations. Our understanding is that the source of such confusion may lie in the potential impact of the instrument: if the potential impact is more robust – as suggested in these CORL structures - our discussions with related regulatory parties indicate that inclusion should be possible.
[24] Regulatory reasons may, for example, make it difficult to differentiate premium payments from various sub-government entities.
[25] Data provisioning and SPT construction seem to be a feasible exercise in the area of flooding exposures, see "Global evidence of rapid urban growth in flood zones since 1985", Rentchler et. Al, Nature 622, 87.92 (2023). The paper does highlight the conflict between better flood protection and urban planning, which we argue above are better suited to target through GCP rather than UOP bonds.

example of a BB/BBB CORL structure above, a $500mn transaction would require a DFI to book a current 3% notional = $15mn exposure today.[26] We believe the ratio between financing raised and current exposure $500mn/$15mn at 33x should be appealing in terms of improving capital efficiency.

Finally**, rating agencies** play a role implicitly in the final (H) structure: they could formally suggest that the credit improvement of the structure versus a baseline is such that pricing could become ever more impactful. It is beyond the scope of this paper to evaluate the technical modalities of ratings analysis, we just note that rating agencies have been paying increasing attention toward nature related risks.[27] It does, however, still seem that environmental resilience has some way to go, as indicated in Figure 6. As an example, related to the above quantitative discussion, Paraguay (rated BB+/BB/Ba1) scores high on environmental resilience and could be expected to have a credit ratings upside if that resilience played a bigger role in terms of the rating.[28] We also believe that rating agencies have the best data and expertise to gauging default risks over the longer term, and their role in terms of knowledge input in a CORL structure development would be a clear advantage.

Figure 5. Environmental resilience score vs (natural log) rating score. Regression lined based on a Total Least Squares/ orthogonal regression, 0.75 standard deviation two-sided confidence intervals in grey. Source: Fund For Peace [State Reilience Index](), Bloomberg, AFII, UNDRR.



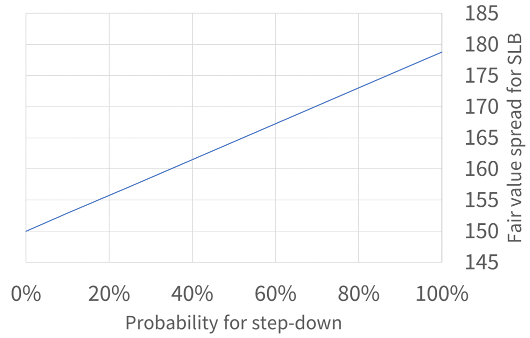
[26] In this example, the payout exposure in case of a default when the SPT has been achieved would be $85mn, which has a net present value (and discounted for the probability of it happening) of $15mn.
[27] See for example "[Nature risk is material. And measureable]()", S&P Global Ratings website, accessed 27 Oct 2023; "[Moody's Has a $1.9 Trillion Warning Over Biodiversity]()", Bloomberg, 28 Sep 2022; "[Climate Physical Risks to Sovereigns Growing]()", Fitch Ratings, 23 Nov 2021.
[28] As an example bond from the issuer, consider PARAGUY $5.85 08/33 (USP75744AM75), trading at yield of 6.98% (27 Oct 2023).

Calibrations and caveats

The above CORL discussion is conceptual and will of course need to reflect several calibrations and caveats to be implemented:

- **Default rates and recoveries**: In this discussion, we have assumed a rather coarse, historical data-set on expected defaults and associated losses. With more granular data on rating and underlying default probabilities, a more detailed analysis should be possible.
- **Point-in-time SPTs**: A natural question arises in terms of "what happens once the issuer has achieved the SPT and then has little additional incentives to continue the investment from a cost-of-capital basis?" First, one could consider pricing the CORL bond in terms of a series of SPT tests rather than a single point-in-time. This is quite feasible, although we would have some concern that additional complexity may reduce investor appetite – there are some red lines in many mandates between what could be perceived as a "structured" product and something which is similar to a vanilla bond. We also believe that the SPTs may act as a good way for the issuer (and to some extent the DFI) to extend possible maturities on future issuances of bonds. As the underlying projects and targets may not be reasonable to meet within a short timeframe, the discussion with investors could probably be anchored further out on the maturity curve than would be possible with a vanilla bond.[29]
- **Rates and curve sensitivity**: Our pricing examples have taken the current shapes of the risk-free and risky curves as a basis for the pricing analyses. These curves, and specifically their shape will have first and second order effects on the valuations of the CORL structure. In particular, we note that curves are currently very flat or even inverted in some parts, meaning that discount factors in the front-end are relatively high compared to the backend.
- **Probability for SPT achievement and ambition level of the SPTs**: Our earlier work indicates that the core valuation factor in a traditional SLB structure is the probability for the step to happen, as replicated in Figure 7. In the above discussion, we have not elaborated on the probability for the step-down to happen, as we have calibrated pricing such that the *investor* is indifferent from financial standpoint on whether the step happens or not. However, once we start assuming a correlation between achievement of the SPT and the credit worthiness (or inversely, default probabilities), then the probability to step becomes more relevant. In practice, investors should ask for an ambition level and target levels of the SPTs that are most likely to lead to a creditworthiness improvement of the issuer.

Figure 6. Calculating fair-value fixed coupon in an SLB step-down structure based on the probability of the step-down to happen. The equivalent vanilla bond (0% probability to step down) would price with a fixed coupon at 150bps; an SLB with a 50% probability of the step to happen would price at approximately 164bp fixed coupon, in absence of any credit enhancement. Source: AFII.



[29] "You are a higher-risk borrower and we think it makes sense to lend money to you for three years, and then we can have a renewed discussion [roll the debt]" would be a hypothetical argument from private investors in a vanilla bond. In a CORL structure, the valid counterargument would be, "we need to borrow at a slightly longer term in order to have the target SPTs, and start accruing the benefits from that, and this will also benefit you as an investor".

From the perspective of the DFI, there are counterbalancing forces: the lower the probability for the step to happen, the lower its expected liability in terms of having to pay out the credit enhancement (with the contingent provision of a higher recovery rate for investor). This would mean that the DFI would seek as ambitious (demanding) SPTs as possible, which also would be in line with the perspective of the DFI looking to minimise future 'insurance' payouts.

On the issuer front, the inclination will be to maximise the probability of the step-down occurring, in other words to seek as unambitious targets as possible, with the exception of the agency dimension. If a current policymaker is trying to lock in policies across the electoral cycle, they may pursue more ambitious targets.

This suggests that investors may be best placed as arbiters of where the ambition level should be. As suggested, they will seek a calibration of the SPT to get the maximum improvement in terms of underlying creditworthiness, and as providers of the bulk of the risk-capital, this is also a natural position for the investors to hold.

Conclusion and final remarks

This paper suggests that CORL bonds are a tractable model for blending private and public capital in a sustainability-linked bond framework. We suggest using a step-down structure, as this flips 'negative' incentives (as in step-up structures) into positive incentives for the issuer. This is something that appears to be particularly important to public issuers. By using the credit enhancement element, we can arrive at a step-down structure that overcomes the main obstacle to "investability", namely that step-downs normally would have to price with fixed coupons above that of an equivalent vanilla bond.

In the example we analyse, we find that a relatively modest credit enhancement (contingent on SPT performance) can allow for a coupon step size of a magnitude significantly larger than what is the market standard – in many of the examples, we generate step-down in excess of -0.5% and even -1%. Thus, another implicit benefit of using CORL structures could be to improve financial materiality in the SLB sector in general, by showing structures with stronger incentives.

One factor that could be positively impacted by CORL structures is the acceptance of sustainability-linked structures for regulatory classifications, such as the EU's Article 8 and 9 SFDR frameworks. Traditionally, investors have been wary of including SLBs as eligible for such classification, but with a more impactful structure, we may see that change. Moreover, a structure that has implicit support – in this case from a DFI or MDB – would likely have a fairly straightforward explanatory journey about its impact.

We recognise that there are other obstacles that need to be solved in parallel with the bond structure when looking especially at developing market financing. Bond liquidity and the issues with domestic or hard currency funding, and associated FX hedging, are important, but hopefully more liquidity in the form of private capital interest can have positive spillover effects on those issues. The CORL structure is rather parsimonious, which should be good for liquidity, and one could even envisage dedicated pools of liquidity and market-making capacities for these types of investments.

The above discussion has not explicitly discussed implementation in terms of a step-up structure. Step-up structures have an advantage because they provide lower coupons in the early life of the bond, which could be crucial in situations such as coal retirement mechanisms. The CORL structure could be deployed for this purpose as well; we will return to this in future work.

Anthropocene Fixed Income Institute SLB resources

An option pricing approach for sustainability-linked bonds

Notes on risk-neutral pricing of SLBs and step-down structures

SLBs: no cal(l)amity

Sustainability-Linked Bonds: alternative steps

A review of SLBs approaching KPI observation dates

Understanding dynamics between sustainable and traditional debt

SLBs: complementary, my dear Investor

SLB triggers: What if Nobian or PPC miss their targets?

Enel – Market update on 2022 KPI observation

One small step for Orlen, one giant leap for the SLB market

Enel SLBs: update on 2023 observation date

Nordea SLLB: driving for a sustainability-linked future

Le SLB d'Auchan, il change la vie?

Airport Sustainability-Linked Bonds: clear for takeoff

Chemical sector: synthesizing impact with SLBs

Deutsche Post SLB: does it deliver?

Carrefour: 1 SLB, 2 KPIs, 3 Scopes of emissions included

BHP: Think big with an SLB

Nissan: Shift expectations with an SLB?

Air France-KLM: Come fly with SLBs

Chile's Peso SLB issuance

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