The skin-in-the-game bond:

a novel sustainable capital instrument

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Outline of the presentation

Introduction

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The **skin-in-the-game** bond is a **sustainable capital** instrument.

> **Sustainable investing** refers to the process of taking due account of environmental (E), but also social (S) and corporate governance (G) considerations in investment decision-making[1].

> A person having **skin-in-the-game** is directly involved in and affected by an action and its negative consequences, especially financially.

[1] See European Commission (2018).

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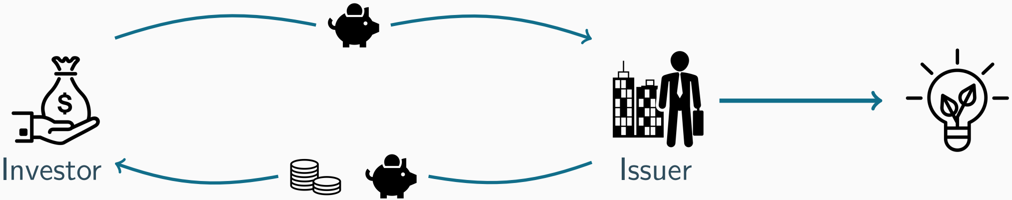
> A person having **skin-in-the-game** is directly involved in and affected by an action and its negative consequences, especially financially.

$\longrightarrow$ Lack of skin-in-the-game may cause moral hazard.
e.g. 2008 financial crisis, 2010 Deepwater Horizon oil spill ...

[1] See European Commission (2018).

Sustainable investing: green, social and sustainability bonds

Green, social and sustainability bonds are issued with the purpose of financing resp. a green project, social project or combination of both[2].



[2] See Park (2019).

Sustainable investing: green, social and sustainability bonds

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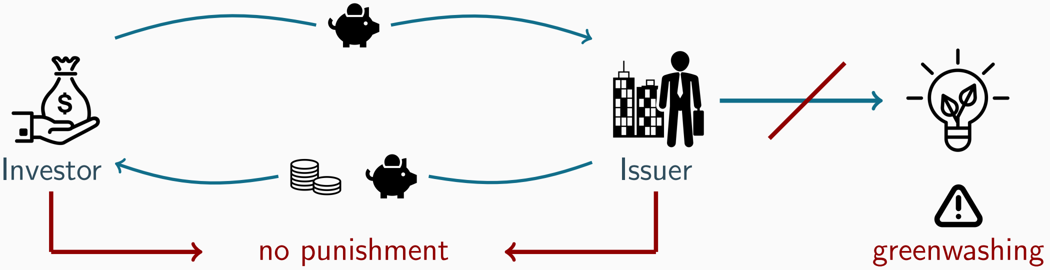
Despite the existence of voluntary frameworks:



→ Both issuer and investor do not have skin-in-the-game.

[2] See Park (2019).

Sustainable investing: sustainability-linked bonds

> Sustainability-linked bonds have varying financial characteristics, depending on whether the issuer achieves predefined sustainability objectives[3].

The objectives are

(i) measured through predefined **Key Performance Indicators** (KPIs),

e.g. Direct Greenhouse Gas Emissions Amount (Scope 1)

(ii) assessed against predefined **Sustainability Performance Targets** (SPTs).

e.g. 125gCO2e/kWheq by 2030

[3] See ICMA (2020).

Sustainable investing: sustainability-linked bonds

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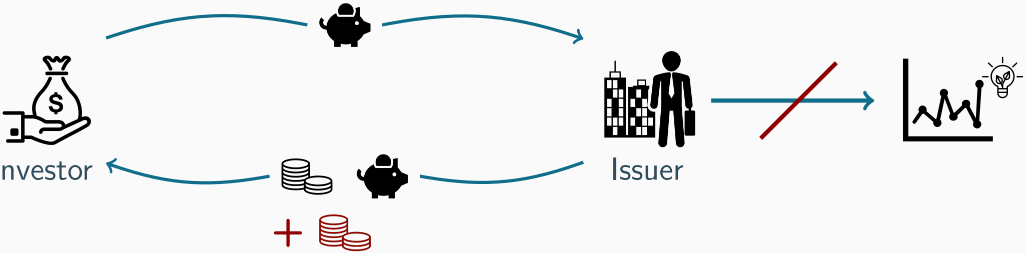


⟶ The **issuer** has skin-in-the-game.

⟶ The **investor** has no skin-in-the-game.

[3] See ICMA (2020).

Sustainable investing: skin-in-the-game bond

Which parties do have skin-in-the-game in sustainable investing?

	Issuer	**Investor**
Green, Social or Sustainability bond	✗	✗
Sustainability-linked bond	✓	✗
Skin-in-the-game bond	✓	✓

> The skin-in-the-game bond is built on the principle that **both parties**, issuer and investor, **should have skin-in-the-game** and suffer financially if sustainability promises are not delivered.

Features of the Skin-in-the-game Bond

The design of the skin-in-the-game bond

	Contingent Convertible[4]
Issuer	financial institution
Benchmark	related to the capital level
Trigger event	benchmark below a fixed threshold
Trigger consequence	(part of) the face value is withheld
Withheld part	to the issuer

[4] See De Spiegeleer, Schoutens and Van Hulle (2014).

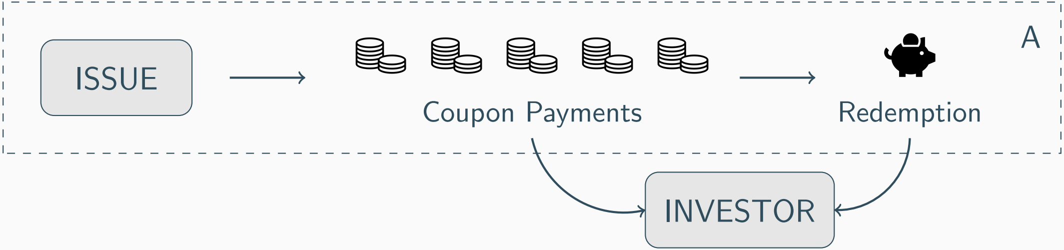
The design of the skin-in-the-game bond

	Contingent Convertible[4]	Skin-in-the-game Bond
Issuer	financial institution	company in any sector
Benchmark	related to the capital level	related to the broad concept of sustainability (E,S,G)
Trigger event	benchmark below a fixed threshold	benchmark below a fixed threshold
Trigger consequence	(part of) the face value is withheld	(part of) the face value is withheld
Withheld part	to the issuer	to an external fund

[4] See De Spiegeleer, Schoutens and Van Hulle (2014).

The skin-in-the-game bond's life cycle

Scenario A: **no trigger** event.



The skin-in-the-game bond's life cycle

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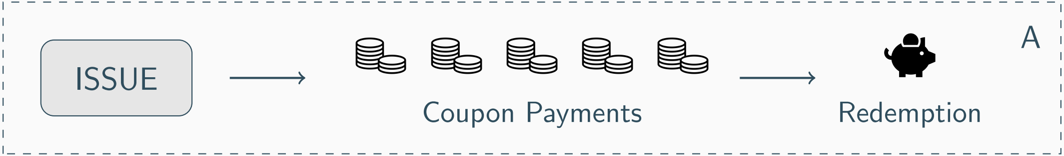
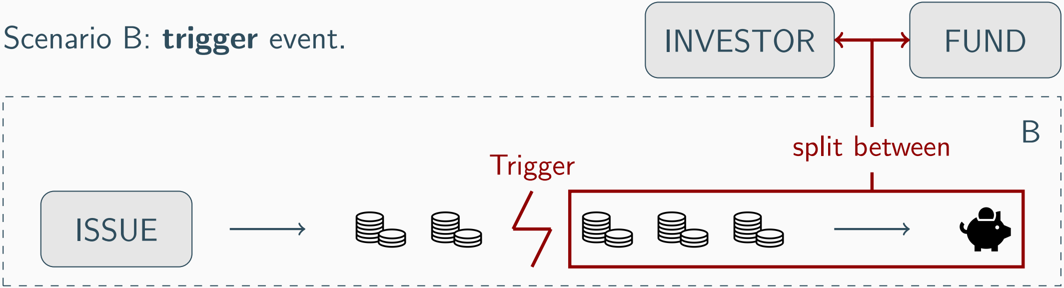
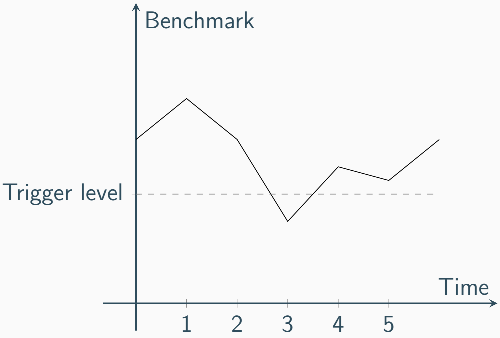
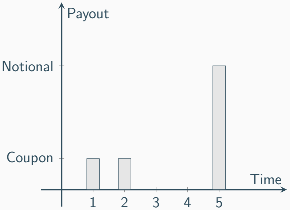


Scenario B: **trigger** event.

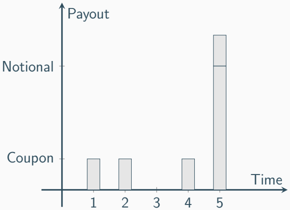


Examples of trigger penalties

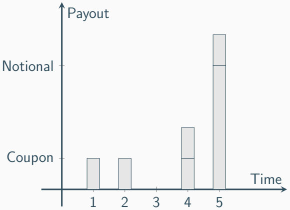




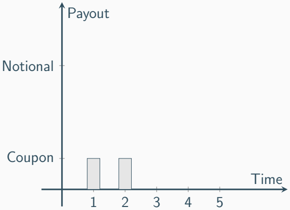
permanent coupon loss



temporary coupon loss



coupon withholding



full write-down

Advantages

1. The **investor** has skin-in-the-game.
   - speculate on meeting the E, S and/or G related goals
   - cash-in an above risk-free coupon
2. The **issuer** has skin-in-the-game.
   - clear market driven incentive to optimize the level of the benchmark
   - excessive risk-taking and mismanagement are immediately punished
     - reputational damage
     - cost of capital increases
3. External **fund** makes sure that issuer is not exempt from payment and it may be used to cover costs related to a trigger event.

   e.g. oil spill, nuclear event ...

Valuation of the Skin-in-the-game Bond

The valuation of a skin-in-the-game bond

Standard corporate bond

- subject to the issuer's bankruptcy risk
- offers a **yield** $c = r + c_s$, with r the risk-free rate and c_s the credit spread

Skin-in-the-game bond

- trigger characteristic increases the probability for the investor to suffer a loss on the invested amount
- to compensate, a higher **yield** $c = r + c_s + t_s$ is offered, with t_s the trigger spread

The valuation of a skin-in-the-game bond

The **price** $\boldsymbol{P}$ of the bond is determined as

$$P = \sum_{t=1}^{T} \frac{\mathbb{E}_{\mathcal{Q}}[C_t]}{(1 + r + c_s)^t} := N,$$

with T the maturity, C_t the cash-flow at time t, $\mathcal{Q}$ the pricing measure, and N the notional.

$\mathbb{E}_{\mathcal{Q}}[C_t]$ depends on the **trigger probability** $\boldsymbol{PT_t}$ and the trigger spread t_s.
For $t \neq T$, we have:

$$\mathbb{E}_{\mathcal{Q}}[C_t] = PT_t \cdot 0 + (1 - PT_t) \cdot c \cdot N = (1 - PT_t) \cdot (r + c_s + t_s) \cdot N.$$

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$\longrightarrow$ If we estimate PT_t, we can **calculate** $\boldsymbol{t_s}$, assuming r, c_s known.

Example 1 - ESG

The ESG skin-in-the-game bond

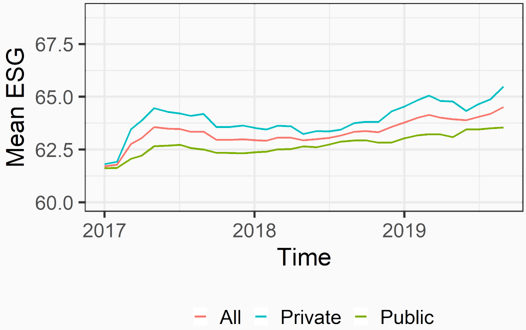
> The ESG skin-in-the-game bond uses the **ESG rating of a company**, provided by a particular rating agency[5], **as the benchmark** underlying the trigger mechanism of the bond.

- Historical ESG data from **Sustainalytics** is used to estimate the trigger probability.
  - monthly scores (0-100) between January 2017 and September 2019
  - higher score means better ESG practice
  - private and public companies per sector

[5] Due to the differences across the ratings published by various ESG rating providers, the ESG skin-in-the-game bond should merely be seen as an illustrative example, see, e.g., Dorfleitner, Halbritter and Nguyen (2015).

The ESG skin-in-the-game bond

> The ESG skin-in-the-game bond is an example of a skin-in-the-game bond with a **continuous benchmark**. This means that the benchmark is the quantification of a relevant parameter, which can, in principle, be monitored continuously.



ESG skin-in-the-game bond characteristics

The trigger spread depends on the bond's characteristics. We look at a specific example.

Characteristics	**Bond-specific values**
issuer	public firm in communication services sector
risk-free rate r	0.010
credit spread c_s	0.025
duration	5 years
notional N	100
coupon frequency	annual
initial rating	A
trigger level	BB
trigger penalty	permanent coupon loss

The trigger probability (1)

We exploit the literature on credit ratings[6] to estimate trigger probabilities.

Step 1 Transform the raw ratings (between 0 and 100) into **ESG rating categories**.

Rating category	C	CCC	B	BB	BBB	A	AAA
Raw score	0-48	48-54	54-61	61-69	69-74	74-79	79-100

Step 2 Under the time-homogeneous, first-order Markov assumption, estimate a **transition probability matrix**, per company type and sector.

[6] See, e.g., Kalbfleisch and Lawless (1985) and Jackson (2011).

The trigger probability (2)

One-year transition matrix for a public firm in the communication services sector.

	C	**CCC**	**B**	**BB**	**BBB**	**A**	**AAA**
C	0.53213	0.18029	0.22725	0.05577	0.00409	0.00042	0.00005
CCC	0.12705	0.47922	0.30573	0.08110	0.00618	0.00065	0.00007
B	0.06587	0.10967	0.51331	0.27567	0.03119	0.00379	0.00050
BB	0.00884	0.02761	0.12200	0.67539	0.14099	0.02163	0.00355
BBB	0.00089	0.00364	0.01845	0.19021	0.62482	0.13169	0.03031
A	0.00009	0.00048	0.00263	0.03941	0.25367	0.58823	0.11549
AAA	0.00002	0.00012	0.00064	0.01078	0.08476	0.19875	0.70492

Step 3 Calculate the **trigger probability** based on transition probability matrix.

e.g. $PT_1 = 0.03941 + 0.00263 + 0.00048 + 0.00009 = 0.04261.$

The trigger probability (3)

Step 4 Transform $\mathcal{P}$ to $\mathcal{Q}$.

- transition probabilities based on historical data are under measure $\mathcal{P}$
- pricing requires probabilities under pricing measure $\mathcal{Q}$
- use transformation from Cariboni et al. (2011)

	Year **1**	Year **2**	Year **3**	Year **4**	Year **5**
$PT^{\mathcal{P}}$	0.04261	0.12309	0.20974	0.29175	0.36613
$PT^{\mathcal{Q}}$	0.10174	0.21241	0.30324	0.37521	0.43258

The trigger probability (4)

Step 5 Calculate the **trigger spread**.

$$
\begin{aligned}
P &= \sum_{t=1}^{T} \frac{\mathbb{E}_{\mathcal{Q}}[C_t]}{(1+r+c_s)^t} \\
&= \frac{0.89826cN}{1.035} + \frac{0.78759cN}{1.035^2} + \frac{0.69676cN}{1.0356^3} + \frac{0.62479cN}{1.035^4} + \frac{0.56742cN + N}{1.035^4} \\
&= N = 100.
\end{aligned}
$$

We find $c = 0.048567$, with $r = 0.010$, and $c_s = 0.025$, this results in

$$\boldsymbol{t_s = 0.013567.}$$

Discussion on the trigger spread (1)

Trigger spread (bps) for a 5-year ESG skin-in-the-game bond with annual coupon payment, permanent coupon loss, and trigger level (column). The issuer has initial rating (row).

	C	**CCC**	**B**	**BB**	**BBB**	**A**
CCC	173					
B	107	223				
BB	40	90	228			
BBB	15	35	84	300		
A	6	16	39	$\boxed{136}$	424	
AAA	4	8	21	75	222	459

Discussion on the trigger spread (2)

- The trigger penalty has a **large impact** on the trigger spread.
  - smallest spreads for a temporary coupon loss and coupon withholding penalty
  - largest spreads for a full write-down penalty
- Calculations are done for an average company within a specific sector. In reality, **market mechanism** will charge different yields for different companies.
  - lower yield if it is likely that promises are fulfilled
  - higher yield if it is likely that promises turn out differently than promoted

Example 2 - Nuclear

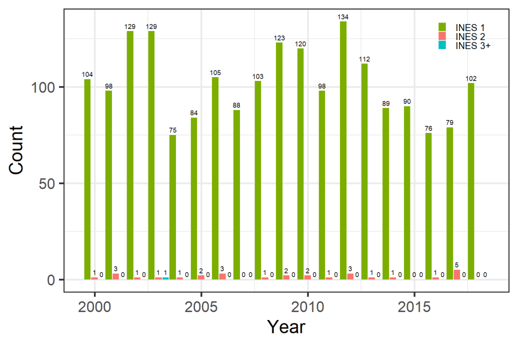
The nuclear skin-in-the-game bond

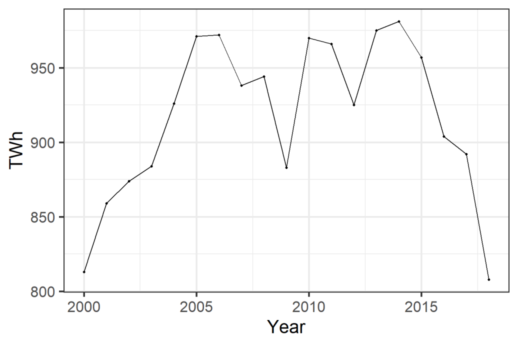
> The nuclear skin-in-the-game bond uses the number of **INES events** of a certain level, **as the benchmark** underlying the trigger mechanism of the bond.

- INES = International Nuclear Event Scale.
  - expresses the severity of nuclear/radiological events within a power plant
  - level 1 to 7 (e.g., Chernobyl, Fukushima)
- Historical data from 2000 to 2018 on INES rated events in European nuclear power plants is used to estimate the trigger probability.

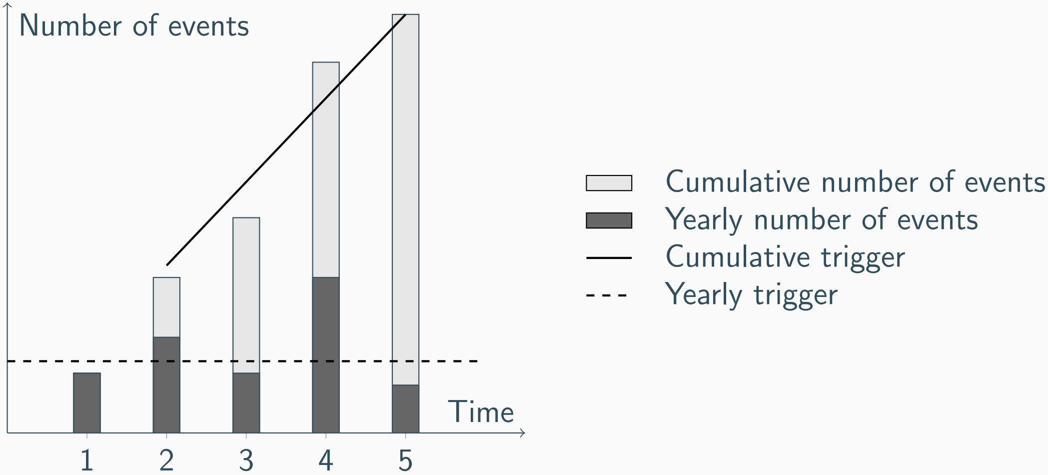
The nuclear skin-in-the-game bond

> The nuclear skin-in-the-game bond is an example of a skin-in-the-game bond with a **counting benchmark**. This means that the benchmark is based on the occurrence of a number of events of interest in relation to the total exposure.





Counting benchmark



Nuclear skin-in-the-game bond characteristics

Characteristics	Bond-specific values
issuer	European NPP with a yearly production of 10 TWh
risk-free rate r	0.010
credit spread c_s	0.025
duration	5 years
notional N	100
coupon frequency	annual
yearly trigger level	3 INES 1 events
yearly trigger penalty	temporary coupon loss
cumulative trigger level	4 INES 1 events
cumulative trigger penalty	full write-down

A valuation framework (1)

The valuation framework for the nuclear skin-in-the-game bond is based on the assumption that a **Poisson process** $\{N^{(1)}(t) \mid t \in (0, \infty)\}$ counts the number of INES level 1 events that occur at a **fixed intensity** $\boldsymbol{\lambda^{(1)}}$ per unit of time and unit of TWh electric energy[7].

- $M_t^{(1)} = N^{(1)}(t) - N^{(1)}(t-1)$.
  - the number of INES 1 events that occur in year t
- $M_t^{(1)} \sim \text{Poisson}(\lambda^{(1)}\omega_t)$, for $t \in \{2000, 2001, \dots\}$.
  - ω_t the total net capacity in TWh electric energy produced in year t

[7] See Hofert and Wüthrich (2012).

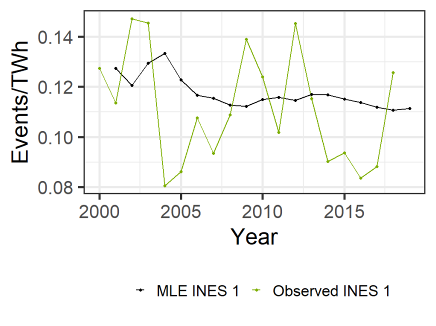
A valuation framework (2)

> We estimate $\lambda^{(1)}$ using the maximum likelihood estimator, i.e., the **sample mean** of the yearly number of INES 1 events, per unit of TWh electric energy produced, yet available at the beginning of year t.

As an example,

$$\widehat{\lambda}^{(1)}_{2019} = \frac{1}{2019-2000} \sum_{t=2000}^{2019-1} \frac{M_t^{(1)}}{\omega_t},$$

$$= 0.11.$$



The yearly trigger probability

The bond's **yearly trigger** level is set at **3 INES 1 events**, with a temporary coupon loss penalty upon a trigger event. The probability at year $t = 1, \ldots, 5$ that a coupon is withheld due to the yearly trigger then equals

$$P[M_t^{(1)} \geq 3] = \sum_{k=3}^{\infty} \frac{\exp(-\widehat{\lambda}^{(1)}\omega)(\widehat{\lambda}^{(1)}\omega)^k}{k!} = \sum_{k=3}^{\infty} \frac{\exp(-1.1)(1.1)^k}{k!} = 0.09958.$$

This also equals the real trigger probability at **time 1**, $\mathrm{PT}_1^{\mathcal{P}}$.

The cumulative trigger probability

The bond triggers when the **cumulative number** of events exceeds **$4 \cdot t$ INES 1 events**, for $t = 2, \ldots, 5$. As an example, at time $t = 2$ we have that

$$
\begin{aligned}
\mathrm{P}[N^{(1)}(t) - N^{(1)}(0) \geq 4t] &= \mathrm{P}[M_1^{(1)} + M_2^{(1)} \geq 8] \\
&= \sum_{k=8}^{\infty} \frac{\exp(-\widehat{\lambda}^{(1)}\omega t)(\widehat{\lambda}^{(1)}\omega t)^k}{k!}, \\
&= \sum_{k=8}^{\infty} \frac{\exp(-2.2)(2.2)^k}{k!} = 0.00198.
\end{aligned}
$$

The total trigger probability

We have a final trigger probability at **year 2** equal to

$$\begin{aligned}
\mathrm{PT}_2^{\mathcal{P}} &= \mathrm{P}[M_1^{(1)} \geq 3 \text{ or } M_1^{(1)} + M_2^{(1)} \geq 8], \\
&= \mathrm{P}[M_1^{(1)} \geq 3] + \mathrm{P}[M_1^{(1)} + M_2^{(1)} \geq 8] - \mathrm{P}[M_1^{(1)} + M_2^{(1)} \geq 8, M_2^{(1)} \geq 3], \\
&= 0.09958 + 0.00198 - 0.00172 = 0.09984.
\end{aligned}$$

A similar reasoning results in

		Year **1**	Year **2**	Year **3**	Year **4**	Year **5**		t_s
						cN	N	
Bond 1	$\mathrm{PT}^{\mathcal{P}}$	0.09958	0.09984	0.10119	0.10135	0.10138	0.00202	106
	$\mathrm{PT}^{\mathcal{Q}}$	0.18379	0.18412	0.18582	0.18602	0.18605	0.01150	

Discussion on the trigger spread

- The trigger penalty has a **large impact** on the trigger spread. If the severity of the bonds' benchmark increases, it is also appropriate to increase the severity of the penalty.

- Calculations are done for an average European nuclear power plant. In reality, the **market mechanism** will charge different yields for different plants.
  - higher yields will be charged to less safe power plants
  - plant specific history of INES events is needed

Conclusion

Conclusion

We argue for the **skin-in-the-game bond** as a sustainable capital instrument with an embedded financial penalty related to E, S and/or G promises.

1. clear incentives to the **issuer** to reduce excessive risk-taking, reach sustainability goals and bring transparency
2. mechanism for **investors** to gain above risk-free returns in compensation for clearly upfront specified risks

$\longrightarrow$ skin-in-the-game is enforced and moral hazard risk is reduced

Thank you!

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https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3827001

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Additional information

Goodness-of-fit test for multi-state Markov model

A formal goodness-of-fit test for the fitted multi-state Markov model on ESG data is currently missing. A possible candidate could be a **Pearson-type** goodness-of-fit test for multi-state models fitted to panel-observed data, as developed by Aguirre-Hernandez R. and Farewell V. (2002).

"Pearson-type statistic to examine the goodness-of-fit of stationary and time continuous Markov regression models of order one. The statistic is designed for models in which the transition rates depend on several explanatory variables. The test statistic is also suitable for panel data in which the spacing between the responses and the total number of observations vary from one individual to another."

We could also add confidence limits on the estimated parameters.

ESG Skin-in-the-game Bond - Numbers (1)

	C	CCC	B	BB	BBB	A	AAA
C	0.53213	0.18029	0.22725	0.05577	0.00409	0.00042	0.00005
CCC	0.12705	0.47922	0.30573	0.08110	0.00618	0.00065	0.00007
B	0.06587	0.10967	0.51331	0.27567	0.03119	0.00379	0.00050
BB	0.00884	0.02761	0.12200	0.67539	0.14099	0.02163	0.00355
BBB	0.00089	0.00364	0.01845	0.19021	0.62482	0.13169	0.03031
A	0.00009	0.00048	0.00263	0.03941	0.25367	0.58823	0.11549
AAA	0.00002	0.00012	0.00064	0.01078	0.08476	0.19875	0.70492

$$
\begin{aligned}
\mathrm{PT}_2 = \mathrm{PT}_1 \quad & + \Pr(\text{no trigger at time } 1 \wedge \text{trigger at time } 2) \\
= \mathrm{PT}_1 \quad & + \Pr(A \to BBB) \times \Pr(BBB \to BB^-) \\
& + \Pr(A \to A) \times \Pr(A \to BB^-) \\
& + \Pr(A \to AAA) \times \Pr(AAA \to BB^-)
\end{aligned}
$$

ESG Skin-in-the-game Bond - Numbers (2)

	C	**CCC**	**B**	**BB**	**BBB**	**A**	**AAA**
C	0.53213	0.18029	0.22725	0.05577	0.00409	0.00042	0.00005
CCC	0.12705	0.47922	0.30573	0.08110	0.00618	0.00065	0.00007
B	0.06587	0.10967	0.51331	0.27567	0.03119	0.00379	0.00050
BB	0.00884	0.02761	0.12200	0.67539	0.14099	0.02163	0.00355
BBB	0.00089	0.00364	0.01845	0.19021	0.62482	0.13169	0.03031
A	0.00009	0.00048	0.00263	0.03941	0.25367	0.58823	0.11549
AAA	0.00002	0.00012	0.00064	0.01078	0.08476	0.19875	0.70492

1. Simulate N paths from the above transition matrix, using a multinomial distribution.
2. Create matrix *Payouts*. At every payment date: (0) if triggered, (1) if not and payouts are made.
3. Trigger Probability under $\mathcal{P}$ = (N - np.sum(*Payouts*, axis=0))/N.

Nuclear Skin-in-the-game Bond

A possible extension could be to model λ using an exponential decay, e.g.,

$$\lambda_t = \gamma \exp(-(t - 1999)\beta).$$

Nuclear Skin-in-the-game Bond - Numbers

$$
\begin{aligned}
\Pr(M_1 + M_2 \geq 8, M_2 \geq 3) = \quad & \sum_{i=3}^{7} \Pr(M_1 + M_2 \geq 8 \mid M_2 = i) \Pr(M_2 = i) \\
& + \sum_{j=8}^{\infty} \Pr(M_1 + M_2 \geq 8 \mid M_2 = j) \Pr(M_2 = j), \\
= \quad & \sum_{i=3}^{7} \Pr(M_1 \geq 8 - i) \Pr(M_2 = i) \\
& + \sum_{j=8}^{\infty} 1 \cdot \Pr(M_2 = j).
\end{aligned}
$$

At later time points, we use a similar reasoning, in addition to the independent increment property.