Greening the Successor: A Quantitative Model of Sovereign Debt Instruments under Political Turnover

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This is a preliminary draft. The latest version is available here.

Abstract

Green transitions require sustained investment over decades, while the governments that finance them alternate in power. I study whether sovereign debt design can serve as a commitment device against successor governments with weaker environmental preferences. I develop a sovereign default model with perpetuity bonds, two-type political turnover, and endogenous green capital, and use it to compare three financing regimes, namely conventional bonds, green bonds, and sustainability-linked bonds (SLBs). Conventional bonds carry no environmental feature, green bonds attach a use-of-proceeds label, and SLBs make debt service contingent on a measurable environmental performance indicator. Under an SLB, the government pays a higher coupon if it misses its emissions target, an incentive channel for green investment that conventional and green bonds lack. Under the terms of Chile's sovereign SLB, the SLB barely changes green investment, emissions or default risk, because the step-up is small and the emissions target lies out of reach. With a larger step-up or a more attainable emissions target, the SLB raises green investment and lowers emissions, and it works mainly by constraining brown governments. A more attainable target achieves this with a smaller step-up and without raising default risk. Annual tests strengthen the SLB further. A target on green capital weakens it, because brown governments are further from meeting it and because its step-up, unlike that of an emissions target, does not fall more often in good times.

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1 Introduction

A country's green transition requires the sustained accumulation of green capital over decades, building up stocks of renewable capacity, clean infrastructure, and abatement technology. The governments that finance this investment, however, alternate in power, and they do not all share the same commitment to environmental goals. For example, in Brazil, Amazon deforestation surged under President Bolsonaro, who dismantled environmental protections and rolled back climate commitments. His successor Lula reversed course upon taking office in 2023, recommitting to zero deforestation. In the United States, the Biden administration's Inflation Reduction Act of 2022 committed hundreds of billions of dollars to clean energy investment. The incoming Trump administration withdrew from the Paris Agreement and moved to freeze IRA funding within weeks of taking office in January 2025. A new government can repeal its predecessor's climate laws overnight. However, debt is different. Outstanding bonds must be serviced, or default follows. Strategic debt issuance can bind successor governments in ways policy cannot (Persson and Svensson 1989; Alesina and Tabellini 1990). This paper asks whether the same logic extends to environmental policy. Can a green government design its sovereign debt to constrain the environmental choices of a future brown successor?

To answer this, I focus on the two main contractual forms of green sovereign debt that have emerged in recent years. Green bonds (hereafter GB) earmark issuance proceeds for environmentally oriented spending. Under existing standards, GB labels are voluntary and not contractually enforced. Sustainability-linked bonds (hereafter SLB) instead tie the bond's debt service to a measurable sustainability outcome through a contractual key performance indicator (KPI). Chile issued the first sovereign SLB, a 20-year bond, on 2 March 2022, under the outgoing Piñera administration, which had declined to join the Escazú Agreement on environmental rights. Nine days later the Boric administration took office, and a week after that it signed the bill for Chile to join the agreement. Since March 2026 the Kast administration, which campaigned on cutting environmental regulation, has governed in the run-up to the bond's target years, 2030 and 2032. The bond was therefore issued by one government, while its targets have become the responsibility of successor governments with different environmental commitments. The contract specifies a 12.5 basis-point coupon step-up if Chile misses either its 2030 emissions target or its 2032 renewable-energy target, and a 25 basis-point step-up if it misses both. Because the step-up is written into the bond contract, it remains in force regardless of which government holds office or why the bond was issued, transmitting an environmental commitment into the fiscal cost of whichever successor's policy choices follow. This is the channel through which contractual debt design can survive a political transition that ordinary climate legislation cannot.

I formalize this question in a sovereign default model that builds on Eaton and Gersovitz (1981) and Arellano (2008) with perpetuity bonds following Hatchondo and Martinez (2009). The framework adds political turnover between green and brown governments, endogenous green investment with type-dependent emissions disutility, and three debt regimes, in which the government issues conventional perpetuities alone or together with a green or a sustainability-linked tranche. I then calibrate the model and study its quantitative implications.

This paper makes three contributions. First, I develop a unified sovereign-default framework in which the government chooses both its repayment strategy and its level of green investment, comparing conventional bonds, green bonds, and sustainability-linked bonds within a common environment. Second, I characterize the contractual incentive channel unique to SLBs, through which environmental performance shifts future borrowing costs via the KPI step-up. Third, I study how this contract design interacts with political turnover, assessing whether SLBs can function as cross-government commitment devices when environmental preferences shift across governments.

2 Related literature

This paper contributes to four strands of literature, namely sovereign default models, the financing of green public investment, the emerging work on sustainability-linked sovereign debt instruments, and the political-economy view of sovereign debt as a commitment device.

The first strand is the sovereign default literature, which provides the core analytical foundation for the framework developed in this paper. The analysis builds on the canonical limited-commitment environment of Eaton and Gersovitz (1981), in which governments choose intertemporal debt positions while retaining the option to default. Aguiar and Gopinath (2006) extend this framework by introducing a stochastic trend in income alongside transitory shocks, and Arellano (2008) formalize its quantitative implementation with a stochastic endowment process, output costs of default, and temporary exclusion from credit markets. Subsequent work enriches this baseline along several dimensions. Yue (2010) introduce debt renegotiation to generate realistic recovery dynamics. Hatchondo and Martinez (2009) introduce long-duration debt with geometric coupon decay to better match observed sovereign debt levels and spread dynamics. Chatterjee and Eyigungor (2012) combine long-term debt with iid transitory income shocks to better match observed sovereign spread levels and volatility. Mendoza and Yue (2012) place sovereign default in a general-equilibrium setting to examine its interaction with production and business-cycle dynamics. Pouzo and Presno (2016) introduce investor ambiguity to generate uncertainty premia. Na et al. (2018) further augment the EG framework with nomi-

nal rigidities, producing the Twin-D episodes. Despite these developments, this literature has rarely incorporated environmental investment and has not studied the contractual features of green and sustainability-linked instruments. This paper does both.

The second strand concerns the financing and macroeconomic implications of green public investment. Integrated assessment models such as Nordhaus (1992), Nordhaus (2008), and Nordhaus (2018) establish the foundational link between economic activity, emissions, and climate dynamics, highlighting the intertemporal trade-offs associated with mitigation. Building on this perspective, recent work examines how governments finance environmental and climate-related investment under fiscal and political constraints. Besley and Persson (2023) emphasize that green transitions require credible long-term policy commitments, which governments often lack. Acemoglu et al. (2012) show how environmental policy can redirect innovation toward clean technologies, and Chamon et al. (2022) analyze innovative climate-financing instruments such as debt-for-climate swaps, showing that their effectiveness depends critically on whether they generate additional climate spending rather than refinancing existing debt. This literature highlights the importance of both commitment and financing design but does not connect these issues to sovereign default risk, which is central to my analysis.

The third strand is the emerging literature on sustainability-linked bonds, with only limited sovereign issuance to date. Existing studies therefore focus primarily on corporate SLBs. Berrada et al. (2022) provide an analytical framework for understanding SLB design, emphasizing how sustainability targets and penalties shape incentive alignment and issuer credibility. Empirical evidence, though still scarce, points to potential shortcomings. Kölbel and Lambillon (2022) document that SLBs often issue at yields lower than otherwise comparable conventional bonds, with the funding cost reduction often exceeding the maximum contractual step-up penalty, suggesting that issuers may enjoy a financial "free lunch" even when targets are not met. These findings underscore both the promise and the limitations of SLBs as commitment devices and motivate a sovereign framework for evaluating their incentive and fiscal implications, which this paper develops.

The fourth strand studies the strategic use of sovereign debt as a commitment device against successor governments. Persson and Svensson (1989) and Alesina and Tabellini (1990) show that governments anticipating loss of power may deliberately issue debt to constrain a successor with different policy preferences, with debt quantity functioning as the commitment device. Hatchondo, Martinez, and Sapriza (2009) introduce heterogeneous borrower types with stochastic transitions into a quantitative sovereign default model, a framework adapted here to capture political turnover. These contributions establish the general principle that debt can bind successor governments through fiscal

channels. This paper extends the principle to the environmental dimension and asks whether contractual design within sovereign debt can serve the commitment role, complementing the quantity-based mechanism in the existing literature.

3 Environment

The theoretical analysis builds on the sovereign default model of Eaton and Gersovitz (1981), with the quantitative extension as in Arellano (2008), including a stochastic endowment process with AR(1) dynamics, output losses upon default, and temporary financial exclusion with stochastic reentry. To capture how long-duration debt constrains successor governments by remaining outstanding across political transitions, the model replaces the one-period bond of Eaton and Gersovitz (1981) with the perpetuity bond structure of Hatchondo and Martinez (2009), in which each bond pays a stream of coupons that decays geometrically over time.

I extend the baseline framework in three dimensions. First, the model introduces an environment block with two components, emissions and green capital investment. Emissions are positively related to output and negatively related to the green capital stock. The government experiences disutility from emissions. It endogenously chooses green investment each period to accumulate the green capital stock that reduces emissions.

Second, the model introduces government turnover. There are two types of government, green and brown, with different environmental mandates. A green government values reduced emissions more than a brown one does. Each government holds office for a fixed term. When a term ends, the incumbent is replaced, and the successor's type, green or brown, is drawn independently of the incumbent's.

Third, the menu of sovereign liabilities is enlarged to include green sovereign debt instruments. These contracts either earmark proceeds for green investment as green bonds or tie borrowing costs to environmental outcomes as sustainability-linked bonds, thereby altering the government's incentives to invest in green capital and to repay its debt. The central question is whether such instruments, in particular sustainability-linked bonds, can preserve green investment incentives even after a political transition brings a brown government to power.

3.1 Economy

The economy is a small open economy with a benevolent representative government that makes all decisions concerning consumption, external borrowing, green investment, and whether to repay or default. Time is discrete and infinite.

3.2 Endowment process

In each period, the representative country is endowed with y_t units of consumption goods, which I refer to as output interchangeably. The endowment y_t has the AR(1) law of motion

$$\ln y_t = \rho \ln y_{t-1} + \sigma_\epsilon \, \epsilon_t \tag{3.1}$$

where $\rho \in [0, 1)$ is the serial correlation, $\sigma_\epsilon > 0$ is the standard deviation of innovations, and $\epsilon_t \sim \mathcal{N}(0, 1)$ is i.i.d.

3.3 Green capital and green investment

In practice, green investment builds durable capacity, including solar farms, wind turbines, and grid upgrades, that depreciates slowly and reduces emissions over multiple periods. Sovereigns issue green bonds and sustainability-linked bonds to finance these long-lived green capital projects. The model captures this by introducing a green capital stock K_t as a state variable that accumulates according to a standard law of motion. The green capital stock evolves as

$$K_{t+1} = (1 - \nu) \, K_t + x_t \tag{3.2}$$

where $\nu \in [0, 1]$ is the depreciation rate and $x_t \geq 0$ is physical green investment. The government chooses x_t each period, and it adds to the green capital stock from the following period on.

Skilled labor shortages, equipment delivery lags for panels and transformers, and competition for prime installation sites all drive up the marginal cost of green investment as the pace of expansion increases in renewable energy deployment. Following Coulomb et al. (2019), who model investment in renewable power capacity at a convex cost, the model captures these rising marginal costs with the resource cost

$$x_t + \frac{\eta}{2} \, x_t^2, \tag{3.3}$$

where $\eta > 0$ governs the curvature of this cost. The government pays this cost out of its budget.

3.4 Emissions

Emissions are modeled as a function of output and the green capital stock.

$$e_t = \mu_y \, y_t \, e^{-\mu_K K_t / y_t} \tag{3.4}$$

Here $\mu_y > 0$ is a scale parameter and $\mu_K > 0$ governs how quickly emissions intensity falls in the green-capital-to-output ratio. The two terms map onto the Environmental Kuznets Curve (EKC) decomposition in Grossman and Krueger (1995). The term $\mu_y y_t$ is the scale effect, whereby higher income raises emissions proportionally. The term $e^{-\mu_K K_t/y_t}$ is the technique effect, whereby government-accumulated green capital reduces emissions intensity.[1]

This functional form has some useful properties. First, emissions stay strictly positive for any level of the green capital stock. Second, the semi-elasticity of emissions with respect to green capital is $\partial \ln e_t / \partial K_t = -\mu_K / y_t$, which does not depend on K_t. Each additional unit of green capital therefore cuts emissions by the same percentage, regardless of how much green capital is already in place, so the absolute amount it cuts shrinks as the emissions level drops. This gives diminishing returns to abatement. Third, $e_t/(\mu_y y_t) = e^{-\mu_K K_t/y_t}$ is the ratio of actual emissions to the emissions that output alone would generate, absent any green capital. This ratio is the same for any two economies with the same K_t/y_t, whatever their absolute size. Other things equal, consider two economies with different but fixed levels of output y_t. If green capital in each economy rises by the same share of its own output, emissions in each economy fall by the same proportion.

3.5 Government turnover

The government's environmental mandate changes over time as elections bring different types of government to power. At any date t the incumbent is of type $z_t \in \{H, L\}$. A green government of type H places weight γ_H on the disutility from emissions, while a brown government of type L places weight γ_L, with $\gamma_H > \gamma_L \geq 0$. The type is publicly observed and enters the state space alongside the endowment, the debt level, and the green capital stock.

Governments serve terms of fixed length N, as in the presidential democracies whose constitutions fix the term length. Let $n_t \in \{0, 1, \ldots, N-1\}$ denote the number of periods remaining in the current term, with

$$n_{t+1} = \begin{cases} n_t - 1, & \text{if } n_t \geq 1, \\ N - 1, & \text{if } n_t = 0. \end{cases} \tag{3.5}$$

The counter evolves deterministically and is unaffected by any decision. The incumbent type is constant within a term, so $z_{t+1} = z_t$ whenever $n_t \geq 1$. At the end of the period in which $n_t = 0$, the handover takes place and a successor type is drawn independently

[1]The third component of the EKC decomposition, the composition effect, captures how structural shifts toward cleaner sectors reduce emissions as income rises, generating a negative relationship between e_t and y_t. This channel is absent by construction in the single-sector endowment framework.

of the incumbent's,

$$\Pr\{z_{t+1} = H\} = p, \tag{3.6}$$

with $p \in (0, 1)$ exogenous in the baseline.

Hatchondo, Martinez, and Sapriza (2009) model government turnover as a two-state Markov chain in which the incumbent's type is redrawn with the same probability every period. Holding office for even one more period is therefore never guaranteed. Turnover modeled in this paper instead fixes a term length of N. The incumbent knows for certain that it will remain in office for the next n_t periods. Incumbent behavior can therefore depend on how close it is to leaving office.

3.6 Preferences

The government's period utility depends on consumption and emissions. A government of type $i \in \{H, L\}$ evaluates paths according to

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t) - \gamma_i \, e_t\right] \tag{3.7}$$

where $\beta \in (0, 1)$ is the subjective discount factor, c_t denotes consumption in period t, and e_t denotes emissions in period t. The period utility function u takes the constant relative risk aversion (CRRA) form

$$u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \tag{3.8}$$

where $\sigma > 0$ is the coefficient of relative risk aversion.

The term $-\gamma_i e_t$ captures the government's intrinsic valuation of environmental quality, so higher emissions reduce welfare. The parameter $\gamma_i \geq 0$ governs the strength of a government type's environmental mandate, with the two types described in the preceding subsection. The disutility is linear in emission flows for simplicity. The emissions are specified as flows here rather than the accumulated atmospheric carbon stock, because any single country's cumulative stock of emissions is a negligible fraction of the global atmospheric stock, so tying the government's objective to stock damages would eliminate its incentive to abate. Countries' actual emission commitments, including Paris Agreement Nationally Determined Contributions (NDCs) and those embedded in sovereign sustainability-linked bond contracts, are stated as annual flow targets. A flow specification may appear to lack intertemporal force, but abatement incentives are preserved through green capital persistence, since green capital invested today continues to reduce emissions in all future periods as long as it remains undepreciated.

A green government strictly dislikes the emissions a brown successor would generate, even

in periods when the brown government is the one in power and making choices. This is what gives an incumbent a motive to constrain its successor. Following the treatment of partisan preferences in Persson and Svensson (1989) and Alesina and Tabellini (1990), each type's value function applies its own weight to the entire future path regardless of which type is actually in power at each date, and the incumbent chooses the policy that maximizes the value function of its own type.

3.7 Bond structure

I follow Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012) in modeling government debt as a long-term perpetuity bond. Hatchondo and Martinez (2009) model the bond as a geometrically declining stream of coupons, with coupons shrinking at rate λ each period after issuance, while Chatterjee and Eyigungor (2012) cast the same bond as one that matures independently each period with probability $1 - \lambda$. Chatterjee and Eyigungor (2012) show that the two descriptions are equivalent. I adopt the geometric coupon decay description here. Specifically, a bond issued in period t pays 1 unit of the consumption good in period $t+1$ and $\lambda^{\tau-1}$ units in period $t+\tau$, for $\tau \geq 2$. The parameter $\lambda \in [0, 1)$ governs the rate of coupon decay, with $\lambda = 0$ recovering the one-period bond.

The government's debt position in period t is the total coupon due from all outstanding bonds, denoted d_t. After repaying d_t, each outstanding bond's coupon decays by λ, so the aggregate coupon liability carried into the following period is λd_t regardless of when individual bonds were issued, making d_t alone a sufficient statistic for future debt service. The current government then chooses a total next-period debt level d_{t+1}, issuing $d_{t+1} - \lambda d_t$ units of new bonds at the equilibrium price q_t, so that bond proceeds are $q_t \cdot (d_{t+1} - \lambda d_t)$. When $d_{t+1} > \lambda d_t$ the government borrows on net. When $d_{t+1} < \lambda d_t$, it retires debt.

This perpetuity structure is common to all three debt instruments studied in this paper, the conventional bond (CB), the green bond (GB), and the sustainability-linked bond (SLB), described in turn below. The model is solved separately under three regimes. The baseline, the CB regime, has only conventional debt. The government can additionally issue a GB tranche in the CB-GB regime, and an SLB tranche in the CB-SLB regime. This tranche structure reflects real-world sovereign debt portfolios, in which conventional debt makes up the large majority of outstanding obligations and green or sustainability-linked instruments are a small, incremental addition.[2] Comparing outcomes across the three regimes shows the effect of each instrument's contractual design.

[2]Sovereign green bonds make up about 0.2 percent of government debt securities outstanding in the OECD area (Ando et al. 2022). Sovereign sustainability-linked bond issuance is smaller still, accounting for roughly 2 percent of cumulative sovereign labeled bond issuance to date (World Bank 2025).

3.7.1 Conventional bond (CB)

Conventional bonds are not earmarked for any specific use, carry no greenium, and add no other environmental contingency to the generic perpetuity structure introduced above. CBs serve as the baseline against which green bonds and sustainability-linked bonds are compared. Conventional debt also continues to finance the non-tranche portion of the government's borrowing in the CB-GB and CB-SLB regimes. Formally, in the CB regime, the government issues $d_{t+1} - \lambda d_t$ units of new debt at the price $q^{\mathrm{CB}}(d_{t+1}, K_{t+1}, y_t, z_t, n_t)$, raising proceeds $q_t^{\mathrm{CB}} \cdot (d_{t+1} - \lambda d_t)$. In the CB-GB and CB-SLB regimes, the same price additionally depends on the size of the coexisting tranche, and in the CB-SLB regime also on the KPI clock and step-up status introduced below.

3.7.2 Green bond (GB)

Green bonds differ from conventional perpetuities in three respects. First, they carry a use-of-proceeds label that nominally allocates issuance proceeds to green spending. The earmarking is not contractually enforced in practice, creating room for greenwashing.[3] Second, they benefit from a greenium, reflecting green investors' willingness to accept lower financial returns in exchange for exposure to labeled green assets. Section 3.8 describes how it falls with the size of the tranche. Third, the government incurs a greenwashing penalty $\xi \geq 0$ when its labeled proceeds exceed its total green spending, including adjustment costs. The penalty reflects the reputational cost of greenwashing.[4]

Formally, the government designates a tranche $d_t^{\mathrm{GB}} \leq d_t$ of its total debt as green-labeled, chosen alongside the total debt level d_{t+1} each period, subject to $d_{t+1}^{\mathrm{GB}} \geq \lambda d_t^{\mathrm{GB}}$. It cannot be repurchased faster than its own coupon decay. When the government issues net green debt $d_{t+1}^{\mathrm{GB}} - \lambda d_t^{\mathrm{GB}}$, it raises proceeds $q^{\mathrm{GB}}(d_{t+1}, d_{t+1}^{\mathrm{GB}}, K_{t+1}, y_t, z_t, n_t) \cdot (d_{t+1}^{\mathrm{GB}} - \lambda d_t^{\mathrm{GB}})$, where q^{GB} embeds the greenium $\phi(d_{t+1}^{\mathrm{GB}})$ defined in Section 3.8, but remains free to choose any

[3] Prevailing green bond standards, such as the International Capital Market Association's Green Bond Principles, are voluntary rather than contractually enforceable. Reviewing sovereign green bond documentation, Panizza et al. (2025) find no legally enforceable commitments regarding the use of proceeds or environmental outcomes, so the green promise rests on issuer reputation and voluntary reporting. Because proceeds are fungible with general budget resources, sovereign issuers frequently finance projects already included in the national investment program, making it difficult to assess whether labeled bonds fund genuinely additional green spending. Definitions of eligible green activities have also at times been permissive. China's 2015 Green Bond Endorsed Projects Catalogue, for instance, treated certain "clean coal" upgrades as eligible green projects, a categorization that international green bond taxonomies do not recognize. The catalogue was revised in 2021 to remove fossil-fuel-related activities.

[4] This parallels evidence from the corporate green bond market, where issuers receive more media coverage of their environmental performance following issuance, with a pronounced increase in negative coverage for issuers later involved in environmental controversies (Lu 2026). Gao and Schmittmann (2022) similarly model greenwashing as costly in a rational asset-pricing framework of the corporate green bond market. There is also anecdotal evidence of sovereign reputational consequences. After the United Kingdom approved a new coal mine and weakened carbon market rules following its 2021 green gilt issuance, Insight Investment downgraded its in-house rating of the UK's green gilts, citing slow net-zero implementation and a lack of impact reporting.

physical green investment $x_t \geq 0$. The greenwashing penalty is quadratic in the shortfall,

$$\frac{\xi}{2} \max\left(q_t^{\mathrm{GB}} \cdot (d_{t+1}^{\mathrm{GB}} - \lambda d_t^{\mathrm{GB}}) - \left(x_t + \tfrac{\eta}{2} x_t^2\right), 0\right)^2, \tag{3.9}$$

and enters the government's budget constraint directly. Under a linear penalty, every unit of shortfall would carry the same cost, so the government would either match the proceeds fully with green spending or disregard the label altogether. The quadratic form raises the marginal cost of each additional unit of shortfall and thereby allows partial greenwashing.

3.7.3 Sustainability-linked bond (SLB)

A sustainability-linked bond (SLB) is an outcome-based debt instrument. Unlike green bonds, SLBs place no restrictions on the use of proceeds. Instead, the contractual debt service is tied to a measurable sustainability performance indicator (Key Performance Indicator, KPI), such as an emissions-reduction target. The coupon steps up when the target is missed and steps down when it is exceeded. Some contracts instead raise the redemption amount if the target is missed.[5] SLBs also carry a greenium $\phi(d_{t+1}^{\mathrm{SLB}})$, described in Section 3.8.

In this paper, the KPI is an emissions threshold $\bar{e}$. The target is met whenever current emissions fall at or below $\bar{e}$. The baseline analysis focuses on the coupon step-up specification, where the repayment obligation rises when the KPI is not met. Alternative designs, such as larger step-ups, looser thresholds, annual tests and a KPI on green capital, are explored in Section 7.

Formally, the government designates a tranche $d_t^{\mathrm{SLB}} \leq d_t$ as sustainability-linked, chosen alongside the total debt level d_{t+1} each period, subject to $d_{t+1}^{\mathrm{SLB}} \geq \lambda d_t^{\mathrm{SLB}}$. When the government issues net sustainability-linked debt $d_{t+1}^{\mathrm{SLB}} - \lambda d_t^{\mathrm{SLB}}$, it raises proceeds $q^{\mathrm{SLB}}(d_{t+1}, d_{t+1}^{\mathrm{SLB}}, K_{t+1}, y_t, z_t, n_t, m_t, s_t) \cdot (d_{t+1}^{\mathrm{SLB}} - \lambda d_t^{\mathrm{SLB}})$, where q^{SLB} embeds the greenium $\phi(d_{t+1}^{\mathrm{SLB}})$ introduced above, and m_t and s_t are the KPI clock and step-up status defined below.

SLB contracts have their own KPI clock. Let $m_t \in \{0, 1, \ldots, M-1\}$ denote the number

[5] Among sovereign issuers, Chile's 2022 SLB specifies a 12.5 basis-point coupon step-up if Chile misses either its 2030 emissions target or its 2032 renewable-energy target, and a 25 basis-point step-up if it misses both. Uruguay's 2022 SLB employs a symmetric mechanism with a coupon step-up when its Paris-aligned KPIs are missed and a step-down when they are exceeded. Corporate SLBs display a wider variety of penalty structures. For example, Enel's large-scale SLB programs apply a 25 basis-point coupon step-up upon KPI failure. Odfjell's SLB is instead redeemed at 101.5 percent of face value at maturity if the issuer misses its CO2 emissions reduction target.

of periods remaining until the next test, with

$$m_{t+1} = \begin{cases} m_t - 1, & \text{if } m_t \geq 1, \\ M - 1, & \text{if } m_t = 0. \end{cases} \tag{3.10}$$

The clock evolves deterministically, is unaffected by any decision, and runs independently of the government's own term counter n_t. At $m_t = 0$, a test compares current emissions to the threshold, and the coupon step-up status s_t records whether the test was missed. The step-up persists once triggered. It remains in force, potentially across a change in government, until a later test is passed, and it is switched off whenever no tranche is outstanding. The step-up status therefore evolves as

$$s_{t+1} = \begin{cases} \mathbf{1}\{e_{t+1} > \bar{e}\}, & \text{if } d_{t+1}^{\text{SLB}} > 0 \text{ and } m_{t+1} = 0, \\ s_t, & \text{if } d_{t+1}^{\text{SLB}} > 0 \text{ and } m_{t+1} \geq 1, \\ 0, & \text{if } d_{t+1}^{\text{SLB}} = 0. \end{cases} \tag{3.11}$$

The step-up applies only to the tranche, not the government's whole debt stock. Each period the tranche is outstanding, the government pays an additional

$$s_t \, \delta \, d_t^{\text{SLB}} \tag{3.12}$$

on top of its regular coupon.

Through the green investment choice x_t, the government raises next period's green capital stock K_{t+1}, which lowers next period's emissions and raises the probability of passing the next test. This is the incentive channel unique to SLBs. Because an SLB tranche issued today can persist into a successor's term, the incumbent's issuance decision constrains its successor's own green investment choices, since a future test can still activate the step-up and raise even a weaker-mandate successor's incentive to abate.

This setup parallels existing models of corporate SLBs, in which managers exert costly effort to raise the likelihood of meeting a KPI (Berrada et al. 2022). In the sovereign context, green capital investment plays the role of such effort.

3.8 Investors

Two groups of investors buy the government's bonds. Both are risk neutral but differ in their green preferences. Conventional investors have none and buy conventional bonds. They are perfectly competitive and have unlimited funds, so they require an expected gross return of $1 + r^*$, where r^* is the constant world interest rate. Green investors have heterogeneous green preferences and buy labeled bonds, the GB and the SLB.

Each unit of a labeled tranche sells at $1+\phi$ times its fair value, where the greenium ϕ is set by the marginal green investor. Since the investors with the strongest green preferences buy first, the greenium falls as the tranche grows,

$$\phi(d^j_{t+1}) = \phi_0 \left(1 - \frac{d^j_{t+1}}{\bar{G}}\right), \qquad j \in \{\text{GB}, \text{SLB}\}, \tag{3.13}$$

where $\phi_0 > 0$ is the greenium on the first unit and $\bar{G} > 0$ measures the size of the green investor base. A tranche larger than $\bar{G}$ sells at a discount.

Each regime has a single labeled tranche, and the GB and the SLB face the same demand, with the same ϕ_0 and $\bar{G}$, so that differences between the CB-GB and CB-SLB regimes come from contract design alone.

3.9 Default, finite exclusion, and output losses

On default, the country is temporarily excluded from credit markets and suffers an output loss, following Arellano (2008) and Chatterjee and Eyigungor (2012). Specifically, the country begins each period in good financial standing if it did not default in the previous period. In good standing, the government either repays the coupon obligation d_t in full or defaults. Default cancels all outstanding bonds, and the country enters bad financial standing, losing part of its endowment for as long as it remains excluded. Each period in bad standing, it regains market access with probability $\theta \in [0, 1)$, at which point it returns to good standing with no outstanding debt.

The endowment received by the country, $\tilde{y}_t$, is defined as

$$\tilde{y}_t = \begin{cases} y_t, & \text{if the country is in good financial standing,} \\ y_t - L(y_t), & \text{if the country is in bad financial standing} \end{cases} \tag{3.14}$$

where $L(y_t)$ is an exogenous output loss function which is non-negative and non-decreasing. This is consistent with the empirical association between default and sizable, prolonged contractions in output (Borensztein and Panizza 2009; Mendoza and Yue 2012).

$L(y_t)$ takes the quadratic form as in Chatterjee and Eyigungor (2012),

$$L(y_t) = \max\{0, a_1 y_t + a_2 y_t^2\} \tag{3.15}$$

Green investment is permitted during financial autarky. The government retains the ability to self-finance green capital accumulation from its available output $\tilde{y}_t$, paying the resource cost $x_t + \frac{\eta}{2} x_t^2$ directly. Emissions in bad standing are computed from the reduced output, $e_t = \mu_y \tilde{y}_t \, e^{-\mu_K K_t / \tilde{y}_t}$, since output lost to default is not produced.

3.10 Timing

The timing within each period follows the standard Eaton–Gersovitz structure, extended to accommodate the perpetuity bond structure, government turnover, and the environmental dimension of the model.

Conditional on the country entering the period t in good financial standing, the government observes the current endowment y_t, the coupon obligation d_t inherited from the previous period, the green capital stock K_t, its own type $z_t \in \{H, L\}$, and the number of periods n_t remaining in its term. Under GB financing, it additionally observes the green tranche d_t^{GB}. Under SLB financing, it additionally observes the sustainability-linked tranche d_t^{SLB}, the KPI clock m_t, and the step-up status s_t. Current-period emissions e_t are determined immediately from y_t and K_t.

Under SLB financing, if $m_t = 0$, a test compares current emissions to the threshold and sets s_t.[6] Otherwise s_t carries over from the previous period. The step-up status governs whether the penalty δ applies to the current payment on the tranche, $s_t \delta d_t^{\mathrm{SLB}}$.

The government then decides whether to repay or default. Upon repayment, the sovereign retains access to international financial markets and jointly chooses a next-period total coupon d_{t+1} and physical green investment $x_t \geq 0$, with the implied next-period green capital stock $K_{t+1} = (1-\nu)K_t + x_t$. Under GB or SLB financing, it also chooses the next-period tranche, d_{t+1}^{GB} or d_{t+1}^{SLB}. In the CB regime, bonds are issued in quantity $d_{t+1} - \lambda d_t$ at the price q^{CB}, yielding proceeds $q_t^{\mathrm{CB}} \cdot (d_{t+1} - \lambda d_t)$. Under GB or SLB financing, the net issuance of the tranche is sold at the tranche's own price, and only the remaining net issuance is sold at q^{CB}. The resource cost of green investment, $x_t + \frac{\eta}{2} x_t^2$, is paid from current output. Consumption is the residual of income, the current coupon obligation, the green investment cost, and bond proceeds.

If the government defaults, it incurs the output loss described above, chooses $x_t \geq 0$ out of the reduced output $\tilde{y}_t$, and the country enters financial autarky for a stochastic duration.

4 Recursive equilibrium under each regime

I now characterize the recursive equilibrium under each regime. To abstract from the endogenous choice of instrument, the analysis compares three regimes. In the baseline, all debt is conventional. In the other two, the government can additionally designate part

[6] Since e_t depends on the inherited green capital stock K_t rather than the current green investment choice K_{t+1}, the outcome of a test at $m_t = 0$ is determined by past green investment decisions, not by green investment made in the same period. This matches practice, where green capacity takes time to build and a government cannot avoid an imminent step-up through last-minute abatement.

of its debt as a green or sustainability-linked tranche. I study how each regime affects allocations, default, and abatement behavior. I drop time subscripts in this section whenever no confusion arises. Unprimed variables refer to the current period, while primed variables refer to the next period.

4.1 CB regime

The bond price $q^{\mathrm{CB}}(d', K', y, z, n)$ depends on the next-period coupon level d' and green capital stock K', chosen in the current period, together with the current endowment y, the incumbent's type z, and the periods n remaining in its term. The conditional expectation $\mathbb{E}_{y',z'|y,z,n}$ collapses to $\mathbb{E}_{y'|y}$ except at a handover ($n = 0$), when the successor's type z' is drawn independently of the incumbent's and equals H with probability p.

The government's budget constraint under repayment is

$$c = y - d - \left(x + \tfrac{\eta}{2}x^2\right) + q^{\mathrm{CB}}(d', K', y, z, n)\,(d' - \lambda d) \tag{4.1}$$

where $K' \equiv (1-\nu)K + x$ is the next-period green capital stock implied by green investment x, and all other objects are as defined in Section 3.

Each type cares about consumption and emissions in every future period, including periods in which the other type holds office. Each type $i \in \{H, L\}$ therefore has its own value function, which weights emissions by γ_i, while only the incumbent, of type z, chooses policy. When the sovereign chooses to repay, the value of repayment is

$$\begin{aligned} V_c^{\mathrm{CB},i}(d, K, y, z, n) = \max_{d'\geq 0,\, x\geq 0} \Big\{ & u(c) - \gamma_i\, \mu_y y\, e^{-\mu_K K/y} \\ & + \beta\, \mathbb{E}_{y',z'|y,z,n}\big[V_g^{\mathrm{CB},i}(d', K', y', z', n')\big]\Big\}, \qquad i = z. \end{aligned} \tag{4.2}$$

Let $d'^*(d, K, y, z, n)$ and $x^*(d, K, y, z, n)$ denote the incumbent's policy functions, the maximizers of this problem for $i = z$. For $i \neq z$, $V_c^{\mathrm{CB},i}$ is the expression in braces evaluated at these policies, using type i's own weight γ_i and continuation value $V_g^{\mathrm{CB},i}$ but without the maximization.

If the country defaults, it enters bad financial standing, in which it has no debt, is excluded from credit markets, and receives the reduced output $\tilde{y}$. Each period it regains market access with probability θ and returns to good standing, in which it can borrow and must

service its debt. The value of bad financial standing is

$$
\begin{aligned}
V_b^{\mathrm{CB},i}(K,y,z,n) = \max_{x\geq 0} \Big\{ & u\big(\tilde{y} - (x + \tfrac{\eta}{2}x^2)\big) - \gamma_i\, \mu_y \tilde{y}\, e^{-\mu_K K/\tilde{y}} \\
& + \beta\theta\, \mathbb{E}_{y',z'|y,z,n}\big[V_g^{\mathrm{CB},i}(0,K',y',z',n')\big] \\
& + \beta(1-\theta)\, \mathbb{E}_{y',z'|y,z,n}\big[V_b^{\mathrm{CB},i}(K',y',z',n')\big]\Big\}, \qquad i = z,
\end{aligned} \tag{4.3}
$$

again evaluated at the incumbent's autarky policy $x_b^*(K,y,z,n)$ without maximizing when $i \neq z$.

The value of good standing is

$$
V_g^{\mathrm{CB},i}(d,K,y,z,n) = \big(1 - D^{\mathrm{CB}}\big)\, V_c^{\mathrm{CB},i}(d,K,y,z,n) + D^{\mathrm{CB}}\, V_b^{\mathrm{CB},i}(K,y,z,n), \tag{4.4}
$$

where D^{CB} is the default decision. The incumbent defaults whenever its own value of bad standing exceeds its own value of repayment,

$$
D^{\mathrm{CB}}(d,K,y,z,n) \equiv \mathbf{1}\big\{V_b^{\mathrm{CB},z}(K,y,z,n) > V_c^{\mathrm{CB},z}(d,K,y,z,n)\big\}, \tag{4.5}
$$

with ties resolved in favor of repayment. Because only the incumbent decides, this same default decision enters the good-standing value of both types, including the type not in office, which might have chosen differently.

Under risk-neutral pricing,

$$
q^{\mathrm{CB}}(d',K',y,z,n) = \frac{1}{1+r^*}\, \mathbb{E}_{y',z'|y,z,n}\Big[\big(1 - D'^{\mathrm{CB}}\big)\big(1 + \lambda\, q^{\mathrm{CB}}(d''^*,K''^*,y',z',n')\big)\Big], \tag{4.6}
$$

where D'^{CB} is shorthand for $D^{\mathrm{CB}}(d',K',y',z',n')$, and $d''^* \equiv d'^*(d',K',y',z',n')$ and $K''^* \equiv (1-\nu)K' + x^*(d',K',y',z',n')$ are the policies chosen at the next-period state. The term in square brackets is what the lender receives next period for each unit of the bond bought today. If the government defaults, the lender receives nothing. If it repays, the lender receives the unit coupon and still holds the remaining bond. Under geometric coupon decay, that remaining bond pays λ times the coupon stream of a freshly issued bond, so it can be sold at $\lambda\, q^{\mathrm{CB}}(d''^*,K''^*,y',z',n')$.

4.2 CB-GB regime

Green bonds add a tranche d^{GB} to the state, with $d^{\mathrm{GB}\prime} \in [\lambda d^{\mathrm{GB}}, d']$, chosen alongside the total debt level d' each period. Because the composition of debt, not only its total, affects future repayment, both prices depend on the tranche as well as the total, $q^{\mathrm{CB}}(d',d^{\mathrm{GB}\prime},K',y,z,n)$ and $q^{\mathrm{GB}}(d',d^{\mathrm{GB}\prime},K',y,z,n)$.

The government's budget constraint under repayment is

$$c = y - d - \big(x + \tfrac{\eta}{2}x^2\big) + q^{\mathrm{CB}}\big[(d' - \lambda d) - (d^{\mathrm{GB}\prime} - \lambda d^{\mathrm{GB}})\big] + q^{\mathrm{GB}}\big(d^{\mathrm{GB}\prime} - \lambda d^{\mathrm{GB}}\big) - \frac{\xi}{2}\max\Big(q^{\mathrm{GB}}\big(d^{\mathrm{GB}\prime} - \lambda d^{\mathrm{GB}}\big) - \big(x + \tfrac{\eta}{2}x^2\big),\, 0\Big)^2, \tag{4.7}$$

where the non-tranche portion of net issuance is priced at q^{CB} and the tranche itself at q^{GB}.

As under the CB regime, each type $i \in \{H, L\}$ carries its own value functions, with only the incumbent, of type z, choosing policy. When the sovereign chooses to repay, the value of repayment is

$$V_c^{\mathrm{GB},i}(d, d^{\mathrm{GB}}, K, y, z, n) = \max_{d' \geq 0,\, d^{\mathrm{GB}\prime},\, x \geq 0} \Big\{ u(c) - \gamma_i\, \mu_y y\, e^{-\mu_K K/y} + \beta\, \mathbb{E}_{y',z'|y,z,n}\big[V_g^{\mathrm{GB},i}(d', d^{\mathrm{GB}\prime}, K', y', z', n')\big] \Big\}, \qquad i = z, \tag{4.8}$$

and for $i \neq z$, evaluated at the incumbent's chosen $(d'^{*}, d^{\mathrm{GB}\prime *}, x^{*})$ without maximizing.

If the country defaults, d and d^{GB} are cancelled together, with the same output loss and exclusion consequences as under the CB regime. The value of bad financial standing is

$$V_b^{\mathrm{GB},i}(K, y, z, n) = \max_{x \geq 0} \Big\{ u\big(\tilde{y} - (x + \tfrac{\eta}{2}x^2)\big) - \gamma_i\, \mu_y \tilde{y}\, e^{-\mu_K K/\tilde{y}} + \beta\theta\, \mathbb{E}_{y',z'|y,z,n}\big[V_g^{\mathrm{GB},i}(0, 0, K', y', z', n')\big] + \beta(1-\theta)\, \mathbb{E}_{y',z'|y,z,n}\big[V_b^{\mathrm{GB},i}(K', y', z', n')\big] \Big\}, \qquad i = z, \tag{4.9}$$

where re-entry resets both d and d^{GB} to zero. For $i \neq z$, it is evaluated at the incumbent's autarky policy x_b^{*} without maximizing.

The value of good standing and the default decision follow the same pattern as under the CB regime,

$$V_g^{\mathrm{GB},i}(d, d^{\mathrm{GB}}, K, y, z, n) = \big(1 - D^{\mathrm{GB}}\big)\, V_c^{\mathrm{GB},i}(d, d^{\mathrm{GB}}, K, y, z, n) + D^{\mathrm{GB}}\, V_b^{\mathrm{GB},i}(K, y, z, n), \tag{4.10}$$

$$D^{\mathrm{GB}}(d, d^{\mathrm{GB}}, K, y, z, n) \equiv \mathbf{1}\big\{V_b^{\mathrm{GB},z}(K, y, z, n) > V_c^{\mathrm{GB},z}(d, d^{\mathrm{GB}}, K, y, z, n)\big\}. \tag{4.11}$$

The two prices share the same default indicator,

$$q^{\mathrm{CB}} = \frac{1}{1 + r^{*}}\, \mathbb{E}_{y',z'|y,z,n}\Big[\big(1 - D'^{\mathrm{GB}}\big)\big(1 + \lambda\, q^{\mathrm{CB}\prime}\big)\Big], \tag{4.12}$$

$$q^{\mathrm{GB}} = \frac{1 + \phi(d^{\mathrm{GB}\prime})}{1 + r^{*}}\, \mathbb{E}_{y',z'|y,z,n}\Big[\big(1 - D'^{\mathrm{GB}}\big)\big(1 + \lambda\, q^{\mathrm{GB}\prime}\big)\Big], \tag{4.13}$$

where D'^{GB} is shorthand for D^{GB} evaluated at the next-period state, and $q^{\mathrm{CB}\prime}, q^{\mathrm{GB}\prime}$ are the price functions evaluated at the incumbent's own policy at that state. The greenium $\phi(d^{\mathrm{GB}\prime})$ scales q^{GB} upward while the tranche is smaller than $\bar{G}$ and downward beyond it.

4.3 CB-SLB regime

Sustainability-linked bonds add a tranche d^{SLB}, with $d^{\mathrm{SLB}\prime} \in [\lambda d^{\mathrm{SLB}}, d']$, together with two state variables, the KPI clock m and the step-up status s, both introduced in Section 3. The clock m' is deterministic, and s' is a function of y', the current state, and the current choices through the transition rule in Section 3. The only uncertainty therefore still comes from (y', z'), and the conditional expectation $\mathbb{E}_{y',z'|y,z,n}$ is the same as under the CB and CB-GB regimes. Both prices also depend on m and s, $q^{\mathrm{CB}}(d', d^{\mathrm{SLB}\prime}, K', y, z, n, m, s)$ and $q^{\mathrm{SLB}}(d', d^{\mathrm{SLB}\prime}, K', y, z, n, m, s)$, because how soon the next test falls and whether the step-up is currently active affect future repayment.

The government's budget constraint under repayment is

$$\begin{aligned} c = y - d - s\,\delta\,d^{\mathrm{SLB}} - \big(x + \tfrac{\eta}{2}x^2\big) \\ + q^{\mathrm{CB}}\big[(d' - \lambda d) - (d^{\mathrm{SLB}\prime} - \lambda d^{\mathrm{SLB}})\big] + q^{\mathrm{SLB}}\big(d^{\mathrm{SLB}\prime} - \lambda d^{\mathrm{SLB}}\big), \end{aligned} \tag{4.14}$$

where $s\,\delta\,d^{\mathrm{SLB}}$ is the current step-up payment on the tranche, as established in Section 3.

As under the CB and CB-GB regimes, each type $i \in \{H, L\}$ carries its own value functions, with only the incumbent, of type z, choosing policy. When the sovereign chooses to repay, the value of repayment is

$$\begin{aligned} V_c^{\mathrm{SLB},i}(d, d^{\mathrm{SLB}}, K, y, z, n, m, s) = \max_{d'\geq 0,\, d^{\mathrm{SLB}\prime},\, x\geq 0} \Big\{ u(c) - \gamma_i\,\mu_y y\, e^{-\mu_K K/y} \\ + \beta\,\mathbb{E}_{y',z'|y,z,n}\Big[V_g^{\mathrm{SLB},i}\big(d', d^{\mathrm{SLB}\prime}, K', y', z', n', m', s'\big)\Big]\Big\}, \\ i = z, \end{aligned} \tag{4.15}$$

and for $i \neq z$, evaluated at the incumbent's chosen $(d'^{*}, d^{\mathrm{SLB}\prime *}, x^{*})$ without maximizing.

If the country defaults, the tranche and its step-up status are cancelled along with the rest of the debt, with the same output loss and exclusion consequences as under the CB regime. The value of bad financial standing is

$$\begin{aligned} V_b^{\mathrm{SLB},i}(K, y, z, n, m) = \max_{x\geq 0} \Big\{ u\big(\tilde{y} - (x + \tfrac{\eta}{2}x^2)\big) - \gamma_i\,\mu_y \tilde{y}\, e^{-\mu_K K/\tilde{y}} \\ + \beta\theta\,\mathbb{E}_{y',z'|y,z,n}\big[V_g^{\mathrm{SLB},i}(0, 0, K', y', z', n', m', 0)\big] \\ + \beta(1-\theta)\,\mathbb{E}_{y',z'|y,z,n}\big[V_b^{\mathrm{SLB},i}(K', y', z', n', m')\big]\Big\}, \qquad i = z, \end{aligned} \tag{4.16}$$

where re-entry resets d, d^{SLB}, and s together, while the KPI clock m continues running even in autarky. For $i \neq z$, it is evaluated at the incumbent's autarky policy x_b^* without maximizing.

The value of good standing and the default decision follow the same pattern as before,

$$V_g^{\text{SLB},i}(d, d^{\text{SLB}}, K, y, z, n, m, s) = \big(1 - D^{\text{SLB}}\big)\, V_c^{\text{SLB},i}(d, d^{\text{SLB}}, K, y, z, n, m, s) + D^{\text{SLB}}\, V_b^{\text{SLB},i}(K, y, z, n, m), \tag{4.17}$$

$$D^{\text{SLB}}(d, d^{\text{SLB}}, K, y, z, n, m, s) \equiv \mathbf{1}\big\{V_b^{\text{SLB},z}(K, y, z, n, m) > V_c^{\text{SLB},z}(d, d^{\text{SLB}}, K, y, z, n, m, s)\big\}. \tag{4.18}$$

The two prices share the same default indicator,

$$q^{\text{CB}} = \frac{1}{1 + r^*}\, \mathbb{E}_{y',z'|y,z,n}\Big[\big(1 - D'^{\text{SLB}}\big)\big(1 + \lambda\, q^{\text{CB}\prime}\big)\Big], \tag{4.19}$$

$$q^{\text{SLB}} = \frac{1 + \phi(d^{\text{SLB}\prime})}{1 + r^*}\, \mathbb{E}_{y',z'|y,z,n}\Big[\big(1 - D'^{\text{SLB}}\big)\big(1 + s'\delta + \lambda\, q^{\text{SLB}\prime}\big)\Big], \tag{4.20}$$

where D'^{SLB} is shorthand for D^{SLB} evaluated at the next-period state, and $q^{\text{CB}\prime}, q^{\text{SLB}\prime}$ are the price functions evaluated at the incumbent's own policy at that state.

Relative to the CB and CB-GB regimes, the lender's next-period payoff on the tranche now includes the step-up $s'\delta$, paid whenever the step-up is active next period. Abatement today, through the transition rule for s' established in Section 3, lowers the expected step-up and therefore the lender's payoff, which lowers the tranche's price. Lower expected step-up payments also lighten the government's future debt service and reduce the probability of default, which raises the price. The net effect on the price is a quantitative question.

4.4 Equilibrium definition

I focus on Markov perfect equilibria, in which each incumbent takes the policy functions of every later incumbent as given, and policy functions depend only on the current state defined for each regime above.

For each regime, a Markov perfect equilibrium consists of value functions V_c^i, V_b^i, and V_g^i for each type $i \in \{H, L\}$, the incumbent's policy functions for debt and green investment in good standing and for green investment in bad standing, a default decision D, and the price function q^{CB}. The CB-GB and CB-SLB regimes add a policy function for the tranche and its price function, q^{GB} or q^{SLB}. These objects satisfy three conditions. First, given the price functions, the incumbent's policy functions and default decision

solve the problem of type z stated above. Second, the value functions of the type not in office are evaluated at the incumbent's policy functions and default decision. Third, the price functions satisfy the lenders' zero-profit conditions stated above, given the default decision and policy functions.

5 Calibration

[Draft note. Numbers in red are provisional. The green-block values, $\bar{e}$, the KPI pass rate and $\bar{G}$ are computed with $\gamma_L = 0.35\,\gamma_H$ and will be recomputed with the baseline $0.36\,\gamma_H$. ϕ_0 will be recalibrated together with $\bar{G}$ and ξ.]

The model period is one quarter, and its parameters fall into three groups. Parameters in the first group are set directly, either from external data or from values established in the literature, without solving the model. Parameters in the second group are chosen by solving the model repeatedly and selecting the values that make simulated moments come as close as possible to real-world targets. Parameters in the third group describe the political environment and the design of the SLB, which are the objects of the analysis. The political parameters are set to benchmark values. The contract parameters follow Chile's sovereign SLB where it provides a value and are otherwise set to benchmark values. The analysis also varies the contract parameters around these values. Table 1 summarizes the values, with one panel for each group, and the rest of this section explains how each is chosen.

Risk aversion σ is set to 2, the standard value in the literature. The remaining parameters of the sovereign default block follow the quarterly calibration to Argentina in Chatterjee and Eyigungor (2012), hereafter CE. Without green preferences, $\gamma_H = \gamma_L = 0$, no government in the model invests in green capital, and the model reduces to that of CE. This version of the model matches CE's data, which come from the 1980s and 1990s, when Argentina invested almost nothing in green capital.[7] CE's parameter values, chosen to fit these data in their model, are therefore used here without recalibration. The endowment parameters $\rho = 0.948503$ and $\sigma_\epsilon = 0.027092$ are estimated in that calibration from linearly detrended quarterly real GDP over the period 1980 to 2001. The risk-free rate $r^* = 0.01$ is roughly the quarterly real return on a three-month US Treasury bill. The re-entry probability $\theta = 0.0385$ implies an average exclusion of 26 quarters, or 6.5 years, based mainly on how long Argentina took to settle its 1982 and 2001 defaults.

CE measure debt by its face value. Each unit of CE debt repays its principal when it matures and pays a coupon of 0.03 in each quarter before that. It matures with

[7] Green capital is measured by solar PV and wind capacity, as explained below. Argentina did build the Yacyretá hydropower dam with Paraguay, in operation from 1994, but under a 1973 treaty for electricity, navigation and flood control, not to reduce emissions.

probability 0.05 per quarter, matching the median maturity of Argentine bonds of 20 quarters. This paper instead uses the equivalent geometric description, in which a bond has no principal and debt is measured by the coupon currently due. To compare the two, consider CE debt with face value b, which in the following quarter pays $0.05\,b$ in principal on the 5 percent that matures and $0.95 \times 0.03\,b$ in coupons on the 95 percent that does not, $0.0785\,b$ in total. Since 95 percent of units remain outstanding each quarter, this payment then shrinks by the factor 0.95 every quarter. Debt d in this paper pays d in the following quarter and then shrinks by the factor λ every quarter, so with $\lambda = 0.95$, CE debt b generates the same payments as $d = 0.0785\,b$. The conversion is used below for the CE debt target and for Chile's SLB step-up, which is stated in basis points of face value.

The discount factor $\beta = 0.95402$ and the output-loss parameters $a_1 = -0.18819$ and $a_2 = 0.24558$ are also taken from CE. CE choose them so that their model matches three Argentine moments over 1993 to 2001, an average spread of 8.15 percent, a spread standard deviation of 4.43 percent, and external debt of 0.70 times quarterly output at face value. The debt target counts only 70 percent of Argentina's external debt, because creditors eventually recovered about 30 cents per dollar after the 2001 default, while the model, like CE's, has no recovery. Solved at these values with $\gamma_H = \gamma_L = 0$, the model gives an average spread of 8.53 percent against 8.15 percent in CE, a spread standard deviation of 4.84 percent against 4.43 percent, debt of 0.682 times quarterly output against 0.70, and an annual default frequency of 7.1 percent against 6.8 percent. The gaps in the three targeted moments are all within one sampling standard error of the targets in CE's data, and they come solely from the different numerical solution methods described in Appendix X.

The term length $N = 16$ quarters corresponds to a four-year presidential term, as in Argentina, whose data discipline the default block, and Chile, the first sovereign SLB issuer.

The environment block has six parameters. The emissions scale μ_y is normalized to 1 and the depreciation rate $\nu = 0.01$ per quarter is set to match the 25-year economic life of solar PV and wind.

The brown government's weight on emissions is set to $\gamma_L = 0.36\,\gamma_H$. This ratio is computed from Manifesto Project data, which give the share of each party's election manifesto devoted to environmental protection. I use the manifesto of the prime minister's party in each year from 1990 to 2023 in 36 EU and OECD countries. Each share is divided by its mean across countries in the same year to detrend it. Within each country, the years are ranked by this relative share, and the upper half is treated as green and the lower half as brown, since each type holds office half of the time on average in the model. Pooled over

countries, the mean relative share in brown years is 0.36 times that in green years.

The remaining three, μ_K, γ_H and η, are calibrated jointly from three matching conditions, each of which requires a statistic of the simulated model to equal its counterpart in the data.

I choose solar PV and wind capacity as the proxy for green capital for three reasons. First, among renewables, IEA (2025) estimate avoided emissions only for solar PV and wind, so only for these two technologies can the green capital stock and the emissions it avoids be measured on the same basis. Since grids and storage are left out, the value of μ_K below is an upper bound. Second, solar PV and wind plants both have an economic life of 25 years (IRENA 2024), so the model's single green capital stock can use one depreciation rate. Third, they dominate the current buildout. According to the IEA's World Energy Investment data, they account for 87 percent of investment in renewable power in 2024, and they account for 2.3 of the 2.6 Gt of annual emissions avoided by the clean energy technologies deployed since 2019, with nuclear power, electric cars and heat pumps accounting for the rest.

The first matching condition for calibration concerns the emissions avoided per dollar spent on solar PV and wind capacity. IEA (2025) estimate that global CO_2 emissions in 2024 would have been 2.3 Gt higher than the actual 37.8 Gt if the electricity from the solar PV and wind capacity deployed since 2019 had instead come from fossil fuels, so this capacity lowered log emissions by $\ln(40.1/37.8) \approx 0.059$. In the IEA's World Energy Investment data, investment in solar PV and wind between 2019 and 2024 totals about USD 2.5 trillion in 2024 prices, and depreciated at rate $\nu = 0.01$ per quarter it leaves a stock of about USD 2.3 trillion at the end of 2024, or 0.084 times quarterly world GDP in 2024. Dividing the fall in log emissions by this capacity relative to quarterly output gives $0.059/0.084 \approx 0.70$ per dollar spent. In the model, $\ln e_t = \ln(\mu_y y_t) - \mu_K K_t/y_t$, so μ_K is the fall in log emissions per unit of green capital relative to output, rather than per dollar spent. The two differ because of the adjustment cost. Of the green spending $x_t + \frac{\eta}{2}x_t^2$, only x_t adds to K_t, so a unit of green capital costs more than a dollar. The model's effect per dollar spent is therefore μ_K divided by the average cost of a unit, measured as total green spending over total physical green investment in the simulated model. The first matching condition requires this effect to equal 0.70.

The second and third matching conditions for calibration concern the level and the volatility of global solar PV and wind investment from 2015 to 2025. For the level, the ratio of solar PV and wind investment in the IEA's World Energy Investment data to same-year world GDP averages 0.361 percent over 2015 to 2025. For the volatility, the annual log growth of solar PV and wind capacity additions has a standard deviation of 0.180 in IRENA's IRENASTAT capacity statistics. Capacity is used rather than spending be-

cause, unlike spending, it is unaffected by the steep fall in unit costs over the period. In the model, the level corresponds to mean green spending relative to output over all simulated quarters, and the volatility to physical green investment x_t summed over each year. The second and third matching conditions require these model statistics to equal 0.361 percent and 0.180.

Four differences between the model and the data remain. First, the volatility is computed only over consecutive years in which a green government holds office throughout both years. The reason is that a brown government invests in green capital in only 29 percent of the quarters in which it repays, and the log growth of investment cannot be computed for a year in which it invests nothing. Second, the data cover private as well as public green investment, while the model attributes all of it to the government. I interpret the government in the model as also driving private green investment through policies such as auctions and subsidies. Third, capacity is recorded when a plant is commissioned and green spending while it is built, so the two series differ in timing, although each target uses only one of them. Fourth, the targets aggregate many countries, while the model describes one. Aggregation could smooth the volatility, but the effect appears small, since the series for Central and South America, where Brazil accounts for 72 percent of capacity additions, has a volatility of 0.219, not far from the global 0.180.

The three parameters are solved jointly. Since the marginal cost of green investment is $1+\eta x_t$, the average cost in the first matching condition rises with green investment, which in turn depends on μ_K, γ_H and η. In addition, γ_H and η each move both the level and the volatility. The solution stops once the level and the volatility lie within a quarter of their targets' sampling standard errors of 0.030 percentage points and 0.042. The first matching condition has no sampling standard error and holds to within 0.2 percent. It gives $\mu_K = 1.277$, $\gamma_H = 0.1623$ and $\eta = 406.9$.

Three parameters concern labeled bonds, the two of the demand curve and the greenwashing penalty of the GB. For the greenium, Panizza et al. (2025) estimate small but statistically significant sovereign premia, roughly 2 basis points for advanced economies and 13 basis points for emerging markets. Since the default block is calibrated to Argentina, the baseline sets ϕ_0 to the emerging-market value, 13 basis points a year or 0.000325 a quarter. This value is provisional. The estimate is an average realized greenium, whereas ϕ_0 is the greenium on the first unit, so ϕ_0 will be recalibrated to make the model's average realized GB greenium match it.

The size of the green investor base $\bar{G}$ is calibrated to Chile's SLBs. Cumulative SLB issuance to 2024 is 7.9 percent of Chile's general government debt in 2024, according to the IMF's Climate Indicators and World Economic Outlook data. $\bar{G}$ is chosen so that the SLB tranche has the same mean share of debt in the CB-SLB regime, with the contract

terms set below. The calibrated value is $\bar{G} = 0.0033$. At this value the SLB tranche makes up 8.05 percent of debt, against 7.9 percent in the data.

The greenwashing penalty ξ is to be calibrated in the same way, so that the GB tranche makes up 5.2 percent of debt in the CB-GB regime, the share of Chile's cumulative green bond issuance to 2024 in its general government debt in 2024. Until then, $\xi = 1$ is a placeholder.

The third group begins with the political parameters. The probability that a successor is green is set to $p = 0.5$, a symmetric benchmark.

Three parameters relate to the SLB. In the baseline, the step-up follows Chile's sovereign SLB, whose coupon rises by 12.5 basis points a year, or 0.0003125 a quarter per unit of face value, if one of its two KPIs is missed. Since one unit of d corresponds to $1/0.0785$ units of CE face value, the step-up per unit of d is $\delta = 0.0003125/0.0785 \approx 0.004$. The KPI threshold $\bar{e}$ also follows Chile's SLB, whose 2030 emissions target of 95 $MtCO_2e$ is 14.4 percent below Chile's emissions of 111.0 $MtCO_2e$ in 2019, the last year before issuance not affected by the pandemic, both excluding land use and forestry. The threshold is therefore set 14.4 percent below mean emissions in good standing under the CB regime, $\bar{e} = 0.677$. Under the CB regime, emissions are at or below it at 9 percent of the dates on which a test would fall. The KPI is tested once per government term, $M = N$, at mid-term. Section 7 varies δ, $\bar{e}$ and M.

6 Baseline results

Table 2 compares the CB and CB-SLB regimes, with the step-up and the KPI threshold of the SLB set as in Chile's SLB. Under the CB regime, the average spread is 8.86 percent a year with a standard deviation of 5.00 percent, debt is 0.61 times quarterly output at face value, and the annual default frequency is 7.7 percent. Green investment comes mostly from green governments. In good standing, a green government invests 0.41 percent of output in green capital each quarter and a brown government 0.025 percent, so emissions are 4 percent higher under a brown government.

Under Chile's contract an SLB tranche is outstanding in 99 percent of quarters in good standing and makes up 8.05 percent of debt. Since emissions rarely meet the threshold, the government fails 91 percent of tests and pays the step-up in 79 percent of quarters. Green investors price the expected step-up, so the SLB sells at 0.3 percent above the price of the CB.

Although an SLB is almost always outstanding and its step-up is in force most of the time, it hardly changes what governments do. Relative to the CB regime, brown governments'

Table 1: Parameter values

Parameter		Value	
Panel A. Parameters selected directly			Source
σ	Risk aversion	2	Standard value in the literature
ρ	Output autocorrelation	0.948503	Chatterjee and Eyigungor (2012)
σ_ϵ	Std. dev. of output innovations	0.027092	Chatterjee and Eyigungor (2012)
r^*	Risk-free rate (quarterly)	0.01	Chatterjee and Eyigungor (2012)
θ	Probability of market re-entry	0.0385	Chatterjee and Eyigungor (2012)
λ	Perpetuity coupon survival rate	0.95	Chatterjee and Eyigungor (2012)
β	Discount factor	0.95402	Chatterjee and Eyigungor (2012)
a_1	Default cost, linear coefficient	-0.18819	Chatterjee and Eyigungor (2012)
a_2	Default cost, quadratic coefficient	0.24558	Chatterjee and Eyigungor (2012)
N	Term length (quarters)	16	Four-year presidential term, as in Argentina and Chile
ν	Green capital depreciation	0.01	IRENA (2024), 25-year economic life
μ_y	Emissions scale	1.0	Normalization
γ_L	Brown government's weight on emissions	0.36 γ_H	Environmental share of governing parties' manifestos, Manifesto Project and ParlGov
ϕ_0	Greenium on the first unit of a labeled tranche	0.000325	13 basis points a year, emerging markets, Panizza et al. (2025), provisional
Panel B. Parameters matched to data moments			Target
μ_K	Emissions semi-elasticity w.r.t. green capital to output ratio	1.277	Fall in log emissions per dollar of green spending, 0.70 (model 0.70), IEA (2025), World Energy Investment and World Development Indicators
γ_H	Green government's weight on emissions	0.1623	Global solar PV and wind investment over world GDP, 0.361 percent (model 0.361), 2015 to 2025
η	Green investment adjustment-cost curvature	406.9	Volatility of global solar PV and wind capacity additions, 0.180 (model 0.181), 2015 to 2025
$\bar{G}$	Size of the green investor base	0.0033	Chile's SLB share of general government debt, 7.9 percent (model 8.05), IMF Climate Indicators and World Economic Outlook
ξ	Greenwashing penalty coefficient	1.0	Placeholder, to be matched to Chile's GB share of general government debt, 5.2 percent
Panel C. Design parameters, baseline values			Note
p	Probability the successor is green	0.5	Symmetric benchmark
δ	SLB coupon step-up	0.004	Chile's 12.5 basis points a year, in units of d
$\bar{e}$	SLB KPI emissions threshold	0.677	14.4 percent below mean emissions under the CB regime, Chile's 2030 target
M	Periods per KPI cycle	16	One test per term, at mid-term

Table 2: Baseline results

	CB	CB-SLB	Change (%)	t
Panel A. Credit				
Average spread (percent a year)	8.86	8.87	+0.09	0.8
Standard deviation of the spread	5.00	5.01	+0.26	0.9
Debt over quarterly output, face value	0.611	0.611	−0.08	−3.3
Annual default frequency (percent)	7.66	7.68	+0.17	0.4
Panel B. Green governments in good standing				
Green investment over output (percent)	0.406	0.406	0.00	0.1
Emissions	0.775	0.775	−0.01	−0.8
Panel C. Brown governments in good standing				
Green investment over output (percent)	0.025	0.025	+0.04	0.2
Emissions	0.806	0.806	0.00	−0.2
Panel D. SLB tranche				
Share of debt (percent)		8.05		
Quarters outstanding (percent)		99.2		
Step-up in force (percent of quarters)		78.9		
Tests failed (percent)		91.1		
under green governments		88.2		
under brown governments		93.9		
Price relative to the CB		1.003		

Note. Simulated over 5 replications of 20000 quarters, with the same random draws in both regimes. Change is the difference from the CB regime in percent of its CB value, and t is the paired difference over its standard error across replications. Debt is at the face value of CE, $d/0.0785$. The default frequency counts quarters more than 20 quarters after re-entry, as in CE. Panel D refers to quarters in good standing.

green investment rises by 0.04 percent, with a paired t-statistic of 0.2, their emissions do not move, and neither the default frequency nor the spread changes significantly. There are two reasons. First, the step-up is small, costing the government about 0.001 percent of output a quarter. Second, the threshold lies 13 percent below mean emissions under a green government and 16 percent below those under a brown one, so a little more green investment barely raises the chance of passing a test. The step-up then works as a fixed cost rather than as an incentive at the margin. Section 7 shows that a looser threshold strengthens the SLB.

7 Additional analysis

This section varies the terms of the SLB contract one at a time, with the other parameters at their baseline values. Table 3 reports the results. Changes are in percent of their values under the CB regime, and the paired t-statistics show whether a change can be told apart from simulation noise.

7.1 SLB contract design: the penalty

Panel A of Table 3 keeps the baseline KPI and raises the step-up from Chile's 12.5 basis points a year to 79, 157 and 314 basis points, or $\delta = 0.025$, 0.05 and 0.1. Brown governments' green investment rises by 0.9, 1.9 and 6.2 percent, and their emissions fall by 0.04, 0.07 and 0.16 percent, the first of these within simulation noise. At the largest step-up, the fall in emissions closes about 4 percent of the gap between brown and green governments.

A larger step-up also makes the SLB more attractive to issue. Its share of debt rises from 8.1 percent at Chile's step-up to 10.2 and 11.5 percent at 157 and 314 basis points. Green investors price the expected step-up, so the SLB sells 4.2 and 8.4 percent above the CB. In exchange, the government pays the step-up more often when output is high, which partly insures it, a point taken up below with the KPI on green capital. These tranches exceed the green investor base, so their greenium is negative, -4.8 and -7.1 basis points a year on average. The default frequency rises from 7.66 percent a year under the CB regime to 7.77 and 7.83 percent.

7.2 SLB contract design: the KPI test

The threshold of the KPI matters as well. Panel B of Table 3 keeps the step-up at 157 basis points a year and sets the threshold 20, 14.4, 5 and 0 percent below mean emissions in good standing under the CB regime, levels that the CB regime meets on 2, 9, 34 and 53 percent of test dates. The looser the threshold, the stronger the same step-

Table 3: SLB contract designs

	SLB share (%)	Tests failed (%)	Change from the CB regime (%)		
			Green investment, brown	Emissions, brown	Default frequency
Panel A. Step-up, baseline KPI					
13 bp a year (Chile)	8.1	91	+0.04	0.00	+0.17
			(0.2)	(−0.2)	(0.4)
79 bp a year	9.1	91	+0.92	−0.04	+1.80
			(2.5)	(−1.5)	(2.4)
157 bp a year	10.2	91	+1.90	−0.07	+1.39
			(4.8)	(−2.1)	(2.3)
314 bp a year	11.5	90	+6.20	−0.16	+2.14
			(22.4)	(−5.1)	(2.6)
Panel B. KPI design, step-up of 157 bp a year					
Threshold 20% below	8.9	98	+1.69	−0.02	+2.56
			(5.8)	(−0.6)	(4.2)
Threshold 14.4% below (baseline)	10.2	91	+1.90	−0.07	+1.39
			(4.8)	(−2.1)	(2.3)
Threshold 5% below	11.5	65	+3.99	−0.09	+1.20
			(27.7)	(−3.9)	(3.1)
Threshold at mean emissions	11.3	47	+4.67	−0.09	+0.61
			(27.9)	(−6.0)	(0.7)
Annual tests	11.5	91	+2.77	−0.11	+1.65
			(6.0)	(−2.6)	(2.4)
KPI on green capital	7.7	90	+0.78	−0.02	+1.82
			(2.0)	(−0.5)	(1.6)
Panel C. KPI design, step-up of 79 bp a year					
Threshold 5% below	9.5	65	+1.23	−0.05	+0.31
			(7.9)	(−2.2)	(0.4)
Threshold at mean emissions	9.4	47	+2.05	−0.05	+0.16
			(8.4)	(−3.0)	(0.2)
Annual tests	9.8	91	+1.24	−0.04	+1.19
			(4.2)	(−1.5)	(1.8)
Panel D. KPI design, step-up of 31 bp a year					
Threshold 5% below	8.6	65	+0.32	−0.02	+0.30
			(1.1)	(−1.1)	(0.6)

Note. Paired t-statistics in parentheses. Green investment over output and emissions are for brown governments in good standing, and the default frequency is annual. Step-ups are in basis points a year of face value, and thresholds in percent below mean emissions in good standing under the CB regime. Simulated as in Table 2.

up. Brown governments' green investment rises by 1.7, 1.9, 4.0 and 4.7 percent, and their emissions fall by 0.02, 0.07, 0.09 and 0.09 percent, of which only the first is not significant. Loosening the threshold from 14.4 to 5 percent doubles the effect on green investment without a larger step-up, and the loosest threshold raises the default frequency least, by 0.6 percent against 2.6 percent under the tightest. A threshold that governments can meet puts them at the margin, where a little more green investment decides the test. A threshold out of reach turns the step-up into a fixed cost, as under Chile's contract.

Panel C shows the same pattern at 79 basis points a year. With the threshold 5 percent below and at mean emissions, brown governments' green investment rises by 1.2 and 2.1 percent, their emissions fall by 0.05 percent in both cases, and the default frequency barely moves. With the loosest threshold, half the step-up raises their green investment by more than 157 basis points do under the baseline threshold. At 31 basis points a year, with the threshold 5 percent below mean emissions, both effects are within simulation noise.

Testing every year instead of once a term, $M = 4$, raises the effects of 157 basis points a year by about half, to 2.8 percent for brown governments' green investment and -0.11 percent for their emissions. At 79 basis points a year annual tests add less. Green investment rises by 1.2 percent instead of 0.9 percent, and emissions fall by 0.04 percent in both cases.

A KPI on green capital, in the spirit of Chile's second KPI on the renewable share of electricity, is weaker. The test fails when green capital at the test date lies below a threshold, set so that the CB regime passes as often as under the baseline emissions KPI. At 157 basis points a year this SLB raises brown governments' green investment by 0.8 percent, lowers their emissions by 0.02 percent and makes up 7.7 percent of debt, against 1.9, 0.07 and 10.2 percent under the emissions KPI. One reason is that brown governments are further from passing the capital test.[8] They pass it or come within 10 percent of its threshold on 17 percent of their test dates, against 28 percent for the emissions test. The other is that emissions rise with output, so emissions tests fail more often when output is high and the step-up falls in good times. The correlation between a failed test and log output is 0.44 for the emissions KPI and -0.15 for the capital KPI. An emissions-linked SLB therefore partly insures the government, while a capital-linked one does not and is less valuable to issue.

[Draft note. Not yet computed, to be added or dropped before submission: the cross-government commitment effect against the within-government incentive effect; SLB issuance after a failed test; tests every eight years ($M = 32$); test timing within the term; random monitoring; step-down designs; a penalty linear in the shortfall; callable labeled

[8] From one simulation of 20000 quarters for each KPI.

bonds (Ul Haq and Doumbia 2022, to be verified); the win probability p; the CB-GB regime once ξ is calibrated; the zero floor on the greenium.]

8 Robustness

Planned checks.

- No weight on emissions for the brown government, $\gamma_L = 0$, with γ_H, η and μ_K re-matched.
- η at the volatility target plus and minus one sampling standard error (0.180 ± 0.0425), with γ_H and μ_K re-matched.
- No greenium, $\phi_0 = 0$.
- Demand side: $\bar{G}$ matched to Uruguay's SLB share of debt, 4.0 percent, instead of Chile's 7.9 percent.
- Persistent types: the probability that the successor is green depends on the incumbent's type.

9 Extensions

9.1 Government turnover

The baseline draws the successor's type at the handover, independently of the incumbent's, with $\Pr\{z_{t+1} = H\} = p$. In practice the vote takes place several months before the inauguration, so the outgoing government knows its successor during that interval. The extension realizes the election outcome before the handover. Let $\ell \geq 1$ denote the length of this transition window in model periods, and let z_t^+ denote the type that takes office at the next handover, drawn as in the baseline with $\Pr\{z^+ = H\} = p$ at the end of the period in which $n_t = \ell$. For $n_t < \ell$ the incoming type is known and enters the state. The incumbent stays in office until the handover, $z_{t+1} = z_t$ for $n_t \geq 1$, and the successor takes over at the handover, $z_{t+1} = z_t^+$ when $n_t = 0$.

In the transition window the outgoing government knows the type of its successor, so its motive to constrain that successor is conditioned on the successor's identity rather than on its distribution. Chile's 2022 issuance took place in exactly such a window. The runoff was decided on 19 December 2021, the SLB was issued on 2 March 2022, and the incoming administration took office on 11 March 2022.

9.2 Re-election and green investment

Planned. The probability that the successor is green depends on the incumbent's cumulative green investment since the last handover, which becomes a state variable. A constant probability nests the baseline. Functional form and slope to be decided.

9.3 Risk-averse green investors

Planned. Green investors price labeled bonds with risk aversion instead of risk neutrality, so the greenium also depends on the risk profile of each bond, for example an SLB step-up that is triggered mostly in booms.

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