Asset Stranding, Credit Risk and Capital Structure Design under Global Warming

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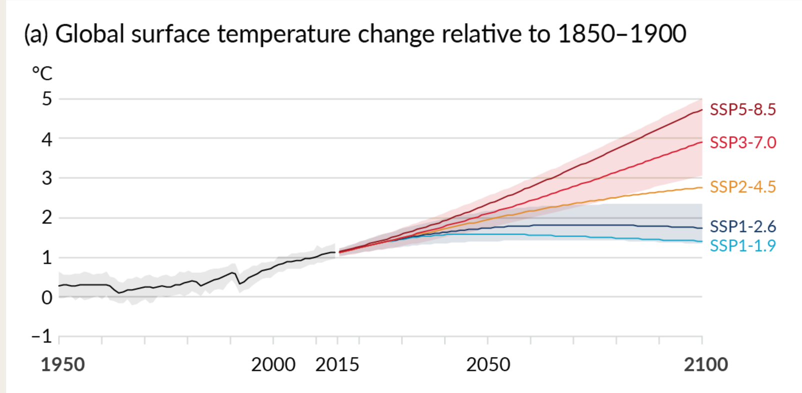
Climate Change : A global Concern

– **Human activities** affect all the major climate system components (see right graph), with some responding over decades and others over centuries.
– **Climate-related events** increase in **Frequency** and **Intensity**.
– **Climate risks** harm firms and economies through physical damages to assets and transitions in business 'game'.
– **Global Warming** (GW) becomes a **serious concern** (cf. IPCC (2013a p. 81, 2013b, 2018) and USGCRP (2018)) with rise in temperature to be

- *"likely in the range 1.5 to 4.5C°"* $\rightarrow$ probability 66-100%.
- *"very unlikely greater than 6C°"* $\rightarrow$ probability 0-10 %.
- *"extremely unlikely less than 1C°"* $\rightarrow$ probability 0-5 %

⚠ Right graph $\Longrightarrow$ a deterministic dynamics for GW driven by CO2, GHG emissions and growth.



Goal, Contributions and Findings

Goal : Plug **GW**-related asset stranding into financing issues (via time-varying bankruptcy costs) and evaluate how this impacts credit risk i) *ex post* i.e. given a capital structure and ii) *ex ante* i.e. in financing decisions.

Contributions :
– A quantitative continuous-time model *à la* Leland 1994 for corporate finance with taxes, liquidation costs and corporate climate exposure :

- **asset stranding at default** : channel through which GW materializes and impacts the stakeholders' wealth.
- **Financiers endogenize GW**

  Tax Shield vs GW-dependent Liq. costs $\overset{Trade-off}{\Longrightarrow}$ Optimal Capital Structure.

– Analytical formulae for pricing corporate securities and evaluating credit risk metrics.
– Investigating whether/ how GW exposure affects credit risk for a given capital structure and via the design of the capital structure.
– A possible disciplinary affect of GW.

Findings :
– GW has direct and indirect impacts on creditors and the firm's value (i.e., stakeholders and society) and **only** an indirect impact on the shareholders' wealth.
– Price response of securities to GW is driven by the level of exposure, the IPCC scenario and the design of the capital structure.
– Consistent Findings with Ginglinger and Moreau 2023 for a given capital structure and novel insights results With endogenised GW.

Ex-post impact of GW exposure (given a capital structure)

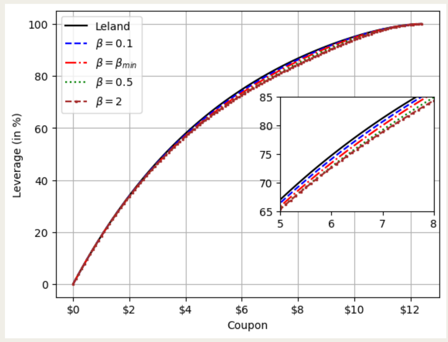


Figure 1. Leverage $\frac{D(V;c,\beta)}{v(V;c,\beta)}$

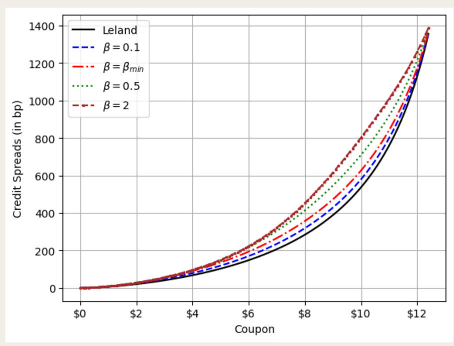


Figure 2. Credit Spreads

Graphs conform to the empirical findings of Ginglinger-Moreau. **Left chart**: climate risk exposure correlates negatively with leverage. **Right chart**: positively with credit spreads.

Capital Structure Design

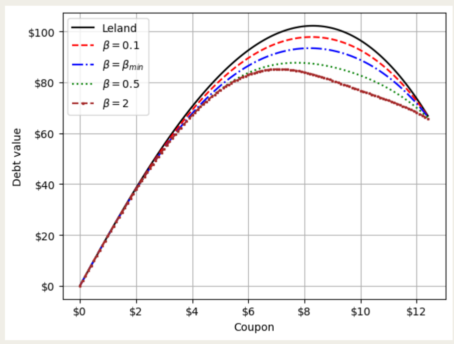


Figure 3. Debt Value

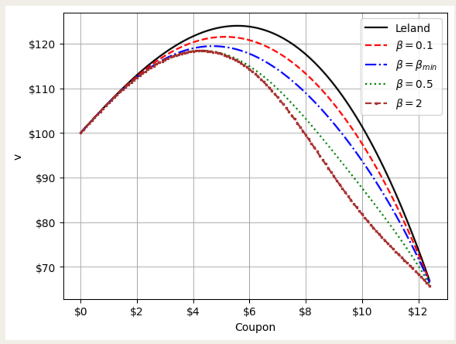
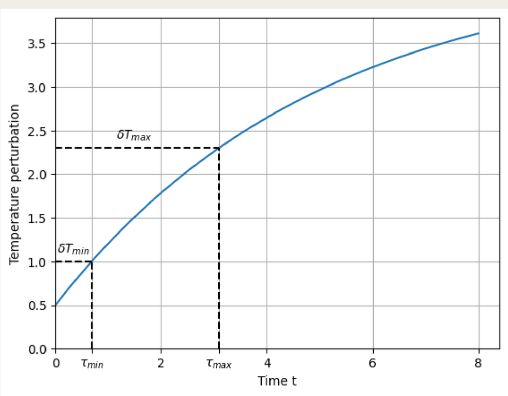


Figure 4. Firm Value

The firm dimensions its debt to exhaust debt capacity or achieve an optimal capital structure (which maximizes its value). One has : $C_{\max} = \arg\max_c D(V;c,\beta)$ and $C^* = \arg\max_c v(V;c,\beta)$

The Framework

The temperature perturbation : A GW model described in Hassler et al. 2016.



With T_{init} the initial pre-industrial temperature, θ° the **long-run temperature perturbation** put forward by IPCC and κ the convergence speed, the temperature perturbation $\delta T^\circ(t) = T(t) - T_{init}$ satisfies Eq. (1):

$$\frac{d(\delta T^\circ(t))}{dt} = \kappa(\theta^\circ - \delta T^\circ(t)) \qquad (1)$$

Firm & business environment :
– **Economic, financial & legal environments** with taxes and a riskless asset paying a constant interest rate r.
– **Firm** is financed by **equity** and one **perpetual debt** promising a continuous coupon c.
– The risk-neutral value of the firm's productive assets follows:

$$dV_t = \mu V_t dt + \sigma V_t dW_t \qquad (2)$$

with $(W_t)_t$ a standard Brownian motion, $\mu \leq r$ and σ constants.
⚠ Shareholders can choose to default and initiate immediate liquidation of the firm's assets at any time, defined as the default time τ_B.

Firm's exposure to Global Warming :
– **Liquidation costs** α depend on the temperature prevailing at the default/ liquidation time.
– The deterministic nature of the temperature dynamics makes **liquidation costs time-dependent** $\Longrightarrow \alpha(T^\circ(\tau_B)) = \alpha(\tau_B)$.
– Consider some **firm-specific** parameters $\delta T_{\min}, \delta T_{\max}, \alpha_0$ and β (exposure to GW), then

$$\alpha(\delta T^\circ; \delta T_{\min}, \alpha_0, \beta) = \begin{cases} 100\% & \text{if } \delta T_{\max} < \delta T^\circ \\ \alpha_0 + \beta(\delta T^\circ - \delta T_{\min}) & \text{if } \delta T_{\min} < \delta T^\circ \leq \delta T_{\max} \\ \alpha_0 & \text{if } \delta T^\circ < \delta T_{\min} \end{cases}$$

with

$$\delta T_{\max} = \delta T_{\min} + \frac{1-\alpha_0}{\beta} \equiv \delta T_{\max}(\delta T_{\min}, \alpha_0, \beta).$$

Analytical pricing formulae

The **default threshold** V_B (used to model the shareholders' decision) remains constant over time. Debt value D, firm value v and equity Eq satisfy

$$\begin{aligned} D(V;c,\beta) &= D_L(V;c) + \Psi_\beta V_B \\ v(V;c,\beta) &= v_L(V;c) + \Psi_\beta V_B \end{aligned} \quad \Longrightarrow \quad Eq(V;c,\beta) = Eq_L(V;c)$$

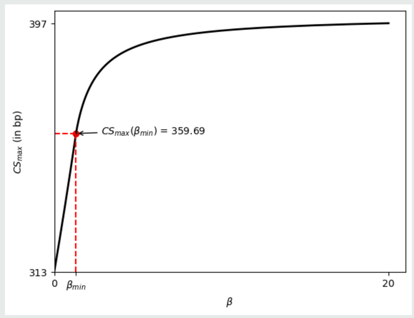
where subscript L refers to Leland and $\Psi_\beta = \beta(\theta^\circ - \delta T^\circ(0))\left(G^{r+\kappa}_{\tau_B}(\tau_{\max}) - G^{r+\kappa}_{\tau_B}(\tau_{\min})\right) - \beta(\theta^\circ - \delta T_{\min})\left(G^r_{\tau_B}(\tau_{\max}) - G^r_{\tau_B}(\tau_{\min})\right) + (1-\alpha_0)\left(G^r_{\tau_B}(\tau_{\max}) - (V_0/V_B)^{-X}\right)$

Proposition 1: Equityholders' choice of default threshold

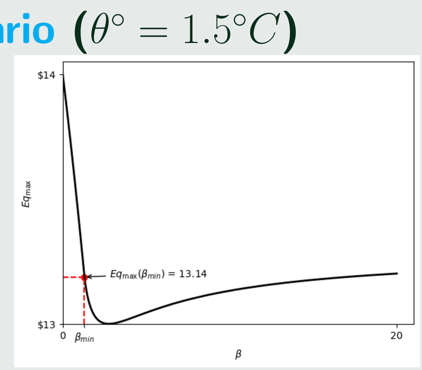
The default threshold is $V_{B,L}(c)$ (i.e, the shareholders follows the default policy put forward by **Leland 1994**). *The shareholders' wealth* **is not directly** *impacted by GW, but* **indirectly** *through the coupon level c and V_B (when c endogeneizes risk exposures).*

Credit Spreads & Equity : Debt Capacity

Net-Zero Scenario ($\theta^\circ = 1.5°C$)

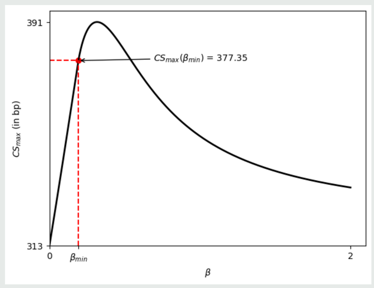


Credit Spread

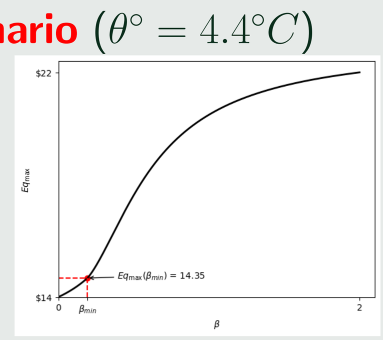


Equity

Pessimistic Scenario ($\theta^\circ = 4.4°C$)



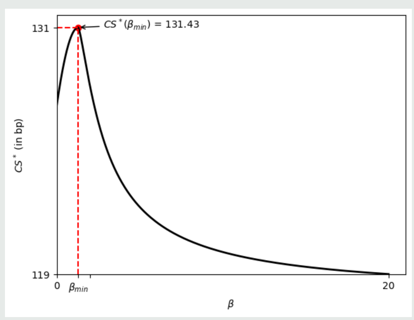
Credit Spread



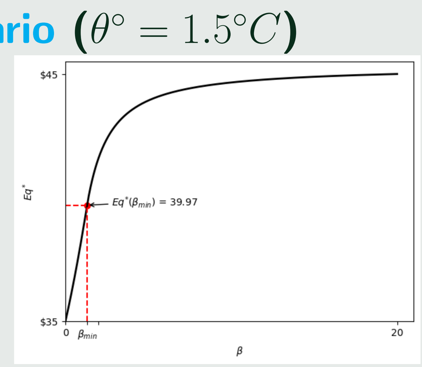
Equity

Credit Spreads & Equity : Optimal Capital Structure

Net-Zero Scenario ($\theta^\circ = 1.5°C$)

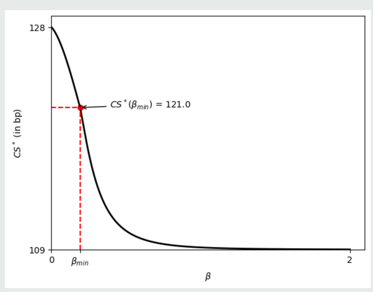


Credit Spread

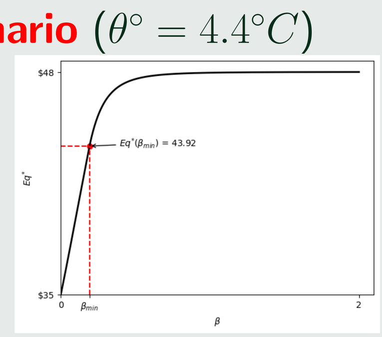


Equity

Pessimistic Scenario ($\theta^\circ = 4.4°C$)



Credit Spread



Equity

Additional Remarks

Default Probability : GW influences the coupon level c, that in turn affects the default threshold V_B and hence the probabilities of defaulting at any horizon.
Loss Given Default : GW impacts the LGD via the default threshold V_B which is dependent on the coupon c.

Decomposing credit insurance costs

Total Insurance Costs: $Ins_0^{Tot}(c;\beta) = Ins_0^{Lel}(c) + [D(V;c,\beta) - D_L(V;c)]$

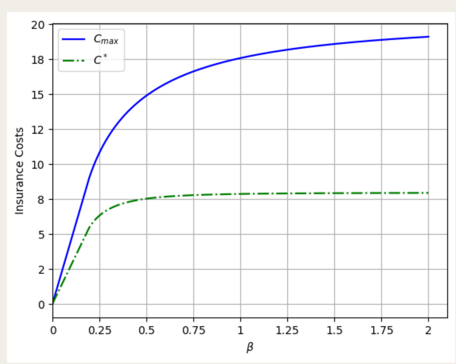


Figure 5. Direct GW Effect

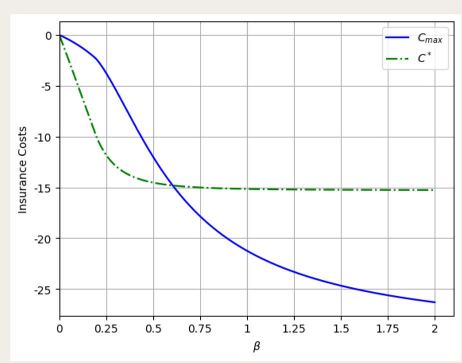


Figure 6. Indirect GW Effect

Left chart: "+" direct effects (measured by $Ins^{Tot}(C(0);\beta) - Ins^{Tot}(C(0);0)$) $\Longrightarrow$ direct costs. **Right chart**: "−" indirect effects ($Ins^{Tot}(C(\beta);\beta) - Ins^{Tot}(C(0);\beta)$) $\Longrightarrow$ indirect benefits (that quantify the disciplinary effect).

References

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