Sovereign debt sustainability, the carbon budget and climate damages

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Contribution

- Two contemporaneous challenges: managing the risk of growing public indebtedness and dealing with the consequences of climate change
- First paper to address this critical issue by estimating national *fiscal* (or *debt*) *limits* in advanced economies under the Paris Agreement's carbon constraints, while taking into account:
  - the economic costs of reducing carbon emissions,
  - climate damages,
  - the degree of political coordination of the transition.
- At the intersection of two literature domains: macro-financial research on fiscal limits and debt sustainability, and macro-climate research on the economic costs of environmental policies and climate change.

Model

- Fiscal Limit: the maximum debt-to-GDP ratio a government can accumulate without losing its repayment credibility.

- Extension of the model by Collard, Habib, and Rochet, 2015 [1], incorporating a reduced-form growth rate function related to carbon emissions:

$$b_t^M = \max_{d_t} b(d_t) = \max_{d_t} \frac{d_t}{R(d_t)} = \max_{d_t} \frac{d_t}{R}[1 - \mathrm{PD}(d_t)] \quad \text{(risk-neutral investors)}$$

$$\text{Default if: } g_{t+1} \equiv \frac{\eta(E_{t+1})}{\eta(E_t)} e^{\mu_0 + \epsilon_{t+1}} < \frac{d_t}{\alpha + b_{t+1}^M}, \quad \text{where} \quad \epsilon_j \sim_{i.i.d.} N(0, \sigma_0^2)$$

d: face value of debt-to-GDP, b: govt. borrowing-to-GDP, α: maximum primary surplus,
PD: prob. of default, R: gross risk-free rate, g: gross GDP growth rate,
μ_0 and σ_0: "green" post-transition growth rate and volatility, E: carbon emissions.

- The abatement cost function $\eta(\cdot)$ is adapted and calibrated for 31 advanced economies by referencing the OECD's empirical results in developing the "Environmentally Adjusted Multifactor Productivity" (Rodríguez et al., 2018 [3]):

$$\eta(E_t) = E_t^\beta = e_t \bar{E}^\beta \approx [(c + e_t)\bar{E}]^\beta \tag{1}$$

β: short-term abatement cost parameter, c: CCS parameter, $\bar{E}$: national carbon budget

- Maximum sustainable borrowing (MSB):

$$b_t^M = \max_{d_t} \frac{d_t}{R}[1 - F(x_t)] = \frac{\gamma e^{\mu_0}}{R}(\alpha + b_{t+1}^M)\frac{\eta(E_{t+1})}{\eta(E_t)} = \frac{\alpha}{\eta(E_t)} \sum_{j=1}^{+\infty} \left(\frac{\gamma e^{\mu_0}}{R}\right)^j \eta(E_{t+j}) \tag{2}$$

$$\text{where} \quad \gamma \equiv \max_x x[1 - F(x)] = x_M[1 - F(x_M)],$$
$$x_t \equiv \frac{d_t}{[\alpha + b_{t+1}^M] e^{\mu_0} \frac{\eta(E_{t+1})}{\eta(E_t)}}$$

$F(\cdot)$: c.d.f. of the log-normally i.i.d. random shock $\exp(\epsilon)$,
γ: constant borrowing factor (net of growth)

- Fiscal limit/ maximum sustainable debt (MSD):

$$d_t^M = x_M(\alpha + b_{t+1}^M) e^{\mu_0} \frac{\eta(E_{t+1})}{\eta(E_t)} \equiv \frac{R}{1 - F(x_M)} b_t^M. \tag{3}$$

Data

Country	μ	σ	μ_0	σ_0	β	Debt/GDP$_{2020}$	MPS(α)	NDC 2021-25 (E_0)	CB 2026 ($\bar{E}_1$)
France	1.57	1.48	1.88	1.43	6.4	115.2	3.65	2.035	7.329
Italy	0.73	1.94	1.03	1.68	10.1	155.3	6.55	1.880	6.769

Table 1: Columns 1-4 (%), based on Rodríguez et al., 2018, [3] (period 1990-2013): average GDP growth rate (μ), its volatility (σ), average "green" GDP growth rate adjusted for pollution increase/reduction (μ_0), and its volatility (σ_0).
Columns 5-6 (%), IMF data: historical maximum primary surplus ($\alpha = \max_t \frac{s_t}{Y_t}$) and debt-to-GDP in 2020.
Columns 7-8 ($GtCO_2$): based on EU "National Determined Contribution" and IPCC 2°C-67% prob. scenario global carbon budget 2020 (1150 $GtCO_2$) on a per-capita basis.

5-year period, $r = R - 1 = 2.44\%$, $c = 1\%$.

Results

Government's maximization problem:

$$\max_{\{E_t\}} \; b_0^M \quad \text{s.t.} \quad \sum_{t=1}^{+\infty} E_t \leq \bar{E}_1, \quad E_t \geq 0 \tag{4}$$

Three long-term scenarios on the green growth rate

(1) optimistic: $\mu_0 \neq \mu$, $\sigma_0 \neq \sigma$;
(2) parallel hypothesis (PL): $\mu_0 = \mu$, $\sigma_0 = \sigma$;
(3) pessimistic: $\mu_0 = \mu[1 - m(E_t)]$, where $m(E_t) = \sqrt{\theta \sum_1^t e_t}$, $\theta = 0.0121$.

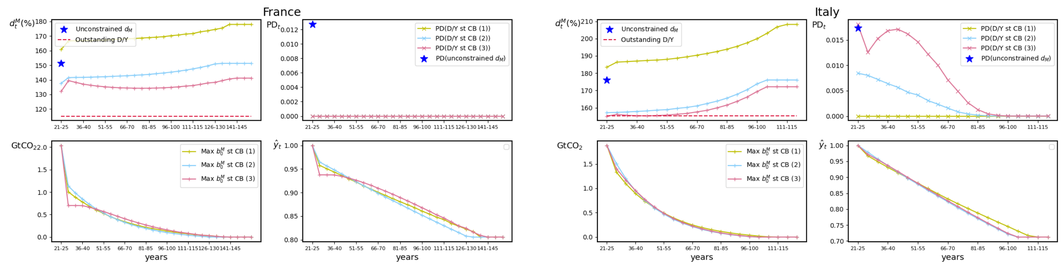

Figure 1: Long-term green growth prospects: Italian sustainability at risk?

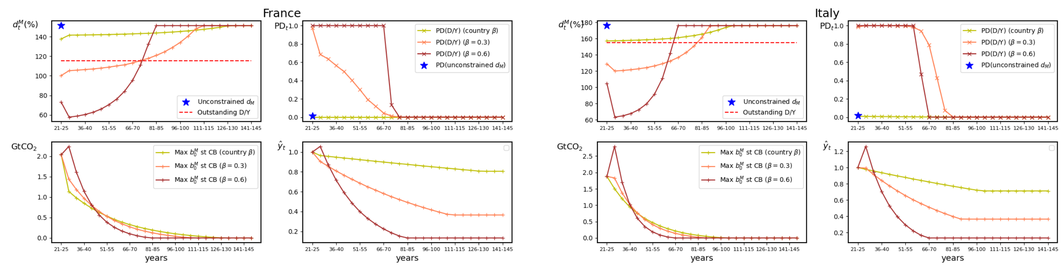

Figure 2: Higher values of short-term abatement cost β imply unsustainable debt for Italy and France. PL scenario.

Current debt sustainability versus "welfare" maximization

$$\max_{\{E_t\}} \sum_{t=0}^{+\infty} \frac{\mathbb{E}_0[Y_t]}{R^t} = \frac{Y_0}{\eta(E_0)} \sum_{t=0}^{+\infty} \left(\frac{\bar{g}}{R}\right)^t \eta(E_t) \quad \text{s.t.} \quad \sum_{t=1}^{+\infty} E_t \leq \bar{E}_1, E_t \geq 0 \tag{5}$$

$\bar{g} = e^{\mu_0 + 1/2\sigma_0^2}$: expected green gross growth rate. $\gamma e^{\mu_0} < \bar{g}$

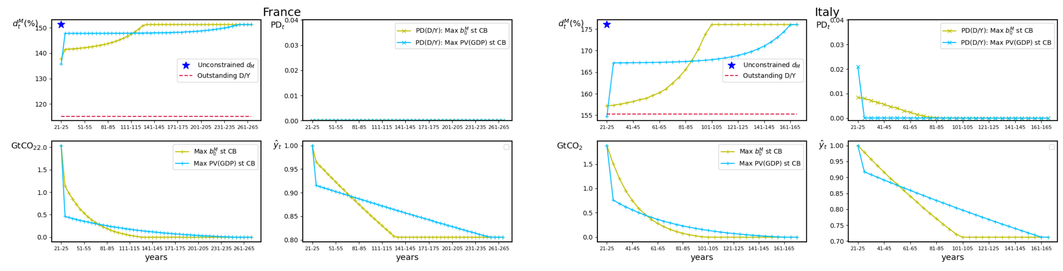

Figure 3: Maximizing welfare under the carbon budget, instead of the current MSB, leads to an initial faster transition, to save carbon budget for the future. PL scenario.

Climate damages and the need for global coordination

Climate damages are introduced through the exponential function proposed by Dietz and Venmans, 2019 [2]:

$$D(T_t) = \exp\left(-\frac{\rho}{2} T_t^2\right), \text{ where } T_t = \zeta C_t. \tag{6}$$

T_t: global average temperature increase, C_t: global cumulative emissions since 1850

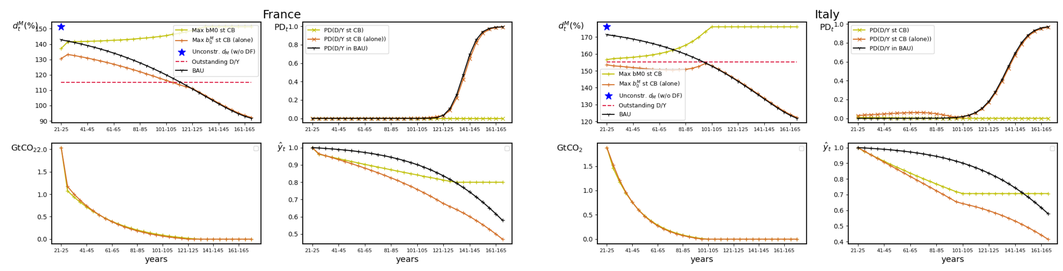

Figure 4: A globally coordinated transition (light green) stabilizes climate damages and growth, then avoiding the plummeting fiscal limits of a business-as-usual scenario (black) or a "solitary" transition (orange). PL scenario.

Conclusions

- During the early stages of the transition, fiscal limits are lower than their long-term stationary values, assuming a successful transition scenario (2°C).
- High short-term costs for reducing emissions can push countries like Italy and France from sustainable to unsustainable current debt-to-GDP ratios.
- A coordinated transition initially results in lower fiscal limits than in a BAU scenario, due to the negative impact of emission cuts on GDP growth.
  However, by 2080, these coordinated actions prove more advantageous for all countries than in a BAU or uncoordinated transition scenario, where currently outstanding debt-to-GDP becomes unsustainable for many countries.
- Coordinated efforts stabilize climate damages, economic growth and fiscal limits, supporting sustainable public debt and the green transition financing.

References

[1] Fabrice Collard, Michel Habib, and Jean-Charles Rochet. Sovereign debt sustainability in advanced economies. *Journal of the European Economic Association*, 13(3):381–420, 2015.

[2] Simon Dietz and Frank Venmans. Cumulative carbon emissions and economic policy: In search of general principles. *Journal of Environmental Economics and Management*, 96:108–129, 2019.

[3] Miguel Rodríguez, Ivan Haščič, and Martin Souchier. Environmentally adjusted multifactor productivity: Methodology and empirical results for oecd and g20 countries. *Ecological Economics*, 153:147–160, 11 2018.