

Debt sustainability and monetary policy: An assessment model using simulation and optimization

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DSA - Overview

- ▶ **Debt Sustainability Analysis (DSA):** Assesses a country's debt service capacity.
- ▶ IMF, EU Commission, and ECB: Utilize a baseline and alternative scenarios for DSA.
- ▶ EU member states will establish medium-term fiscal-structural plans using DSA - April 2023.
- ▶ **Key Indicators:**
 - ▶ **Debt-to-GDP** ratio
 - ▶ **Gross Financing Needs-to-GDP** (GFN-to-GDP)

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Where X is the debt amount, D represents debt dynamics, and r is the debt service rate.

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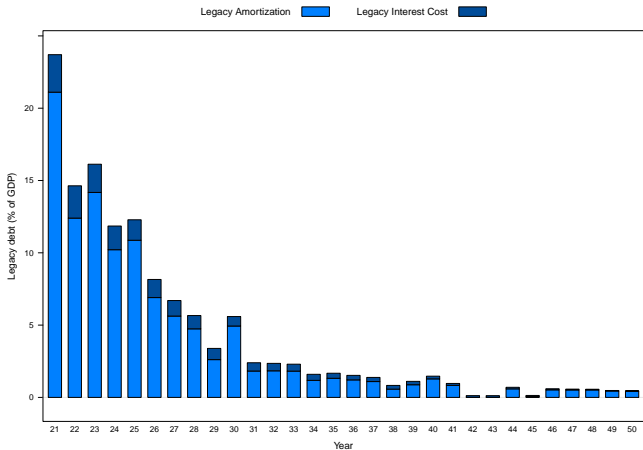
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- ▶ **Debt Breakdown (Example):** If the initial debt, D_0 , is 10,000 euros:
 - ▶ 3,000 euros: 5-year bond issued 5 years ago, maturing in 5 years.
 - ▶ 5,000 euros: 3-year bond issued 2 years ago, maturing in 3 years.
 - ▶ 2,000 euros: Bond issued 3 years ago, maturing today.



Debt and interest amortization





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Note: The variables $EndA_t$ and $EndI_t$ depend on the financing strategy decisions.

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Endogenous debt and interest

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- ▶ **Debt at Time 1:**

$$GFN_1 = A_1 + I_1 - PB_1 + X_{0,a} \mathbb{1}_{0,a}^1 + X_{0,b} \mathbb{1}_{0,b}^1 \\ + X_{0,a} r_{0,a} \mathbb{1}_{0,a}^1 + X_{0,b} r_{0,b} \mathbb{1}_{0,b}^1$$

$$GFN_1 = X_{1,a} + X_{1,b}$$

General dynamics

- Assume we have \mathcal{I} instruments. At the generic time step t , we have:

General dynamics

- Assume we have \mathcal{J} instruments. At the generic time step t , we have:

$$D_t = D_{t-1} + GFN_t - A_t - EndA_t$$

$$GFN_t = A_t + I_t - PB_t + EndA_t + EndI_t$$

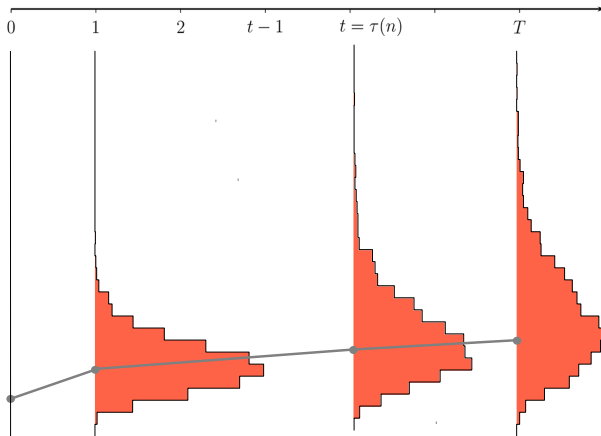
$$GFN_t = \sum_{j \in \mathcal{J}} X_{t,j}$$

$$EndA_t = \sum_{k=0}^{t-1} \sum_{j \in \mathcal{J}} X_{k,j} \mathbb{1}_{k,j}^t$$

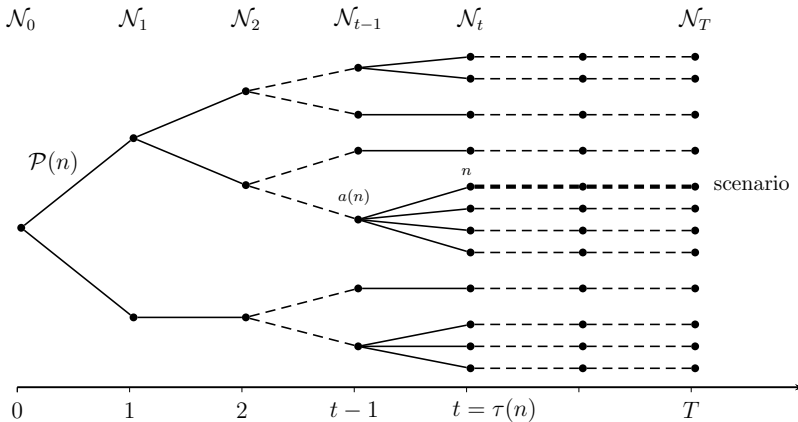
$$EndI_t = \sum_{k=0}^{t-1} \sum_{j \in \mathcal{J}} X_{k,j} r_{k,j} \mathbb{1}_{k,j}^t$$



Economic Uncertainty



Stochastic Trees



Stochastic dynamics

- ▶ Let \mathcal{N} the set of nodes and $a(n)$ the ancestor of the generic node $n \in \mathcal{N}$.
- ▶ Let $\mathcal{P}(n)$ the path leading from root to n .

$$D^n = D^{a(n)} + GFN^n - A^n - EndA^n$$

$$GFN^n = A^n + I^n - PB^n + EndA^n + EndI^n$$

$$GFN^n = \sum_{j \in \mathcal{J}} X_j^n$$

$$EndA^n = \sum_{m \in \mathcal{P}(n)} \sum_{j \in \mathcal{J}} X_j^m \mathbb{1}_{m,j}^n$$

$$EndI^n = \sum_{m \in \mathcal{P}(n)} \sum_{j \in \mathcal{J}} X_j^m r_j^m \mathbb{1}_{m,j}^n$$

Expected cost

- ▶ Let π^n the probability of being in node n , and

$$\sum_{n \in \mathcal{N}} \pi^n = 1$$

- ▶ The expected cost of servicing debt is given by:

$$\sum_{n \in \mathcal{N}} \pi^n \left(\sum_{m \in \mathcal{P}(n)} \sum_{j \in \mathcal{J}} x_j^m r_j^m \mathbb{1}_{m,j}^n \right)$$

ESM stochastic programming model

Minimize
 $X_j^n, n \in \mathcal{N}, j \in \mathcal{J}$

$$\mathbb{E}[C] = \sum_{n \in \mathcal{N}} \pi^n \left(\sum_{m \in \mathcal{P}(n)} \sum_{j \in \mathcal{J}} X_j^m r_j^m \mathbb{1}_{m,j}^n \right)$$

s.t.

$$GFN^n = A^n + I^n - PB^n + EndA^n + EndI^n$$

$$GFN^n = \sum_{j \in \mathcal{J}} X_j^n$$

$$gfn^n = GFN^n / Y^n$$

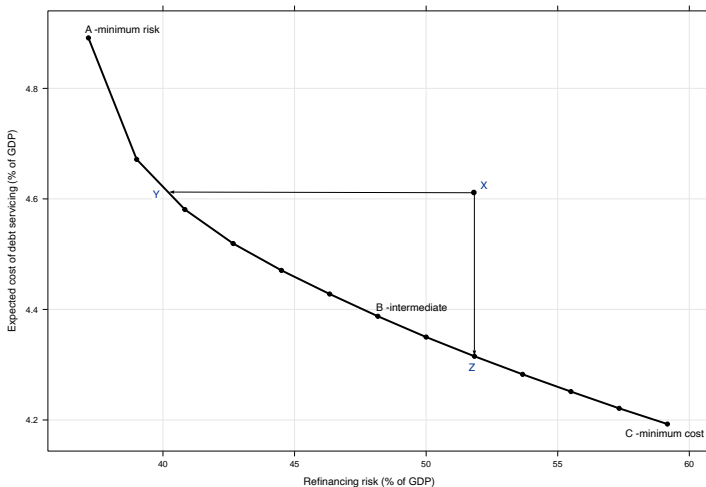
$$gfn^* + \frac{1}{1 - \alpha} \sum_{n \in \mathcal{N}} \pi^n z^n \leq \omega$$

$$z^n \geq gfn^n - gfn^*, \text{ for all } n \in \mathcal{N}$$

$$z^n \geq 0, \text{ for all } n \in \mathcal{N}.$$

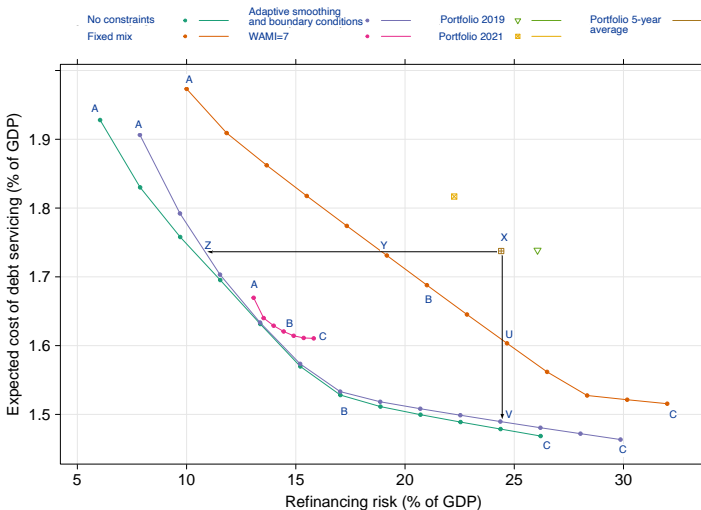


Efficient frontiers



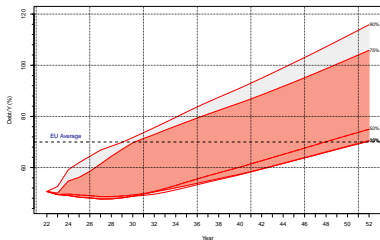


A real assessment

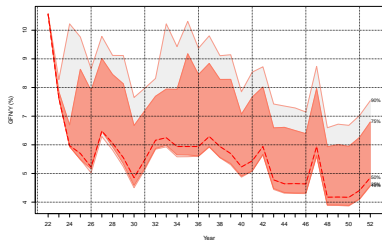




Debt stock and flow — Minimum risk



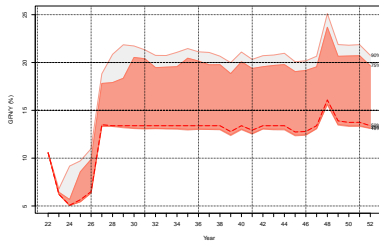
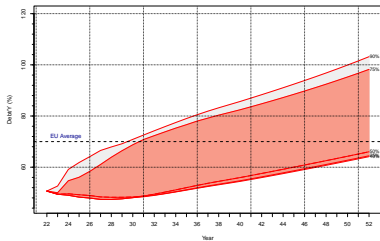
(a) Debt stock



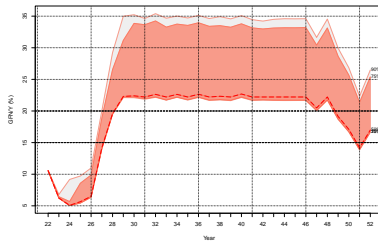
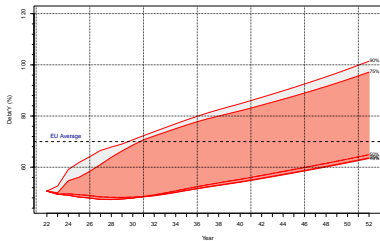
(b) Gross financing needs



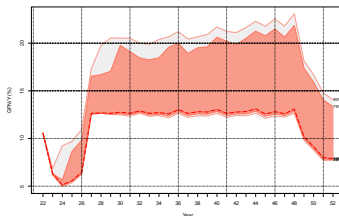
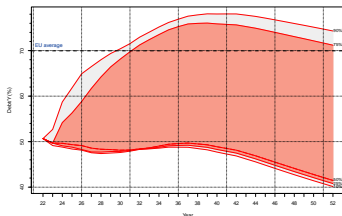
Debt stock and flow — Intermediate risk



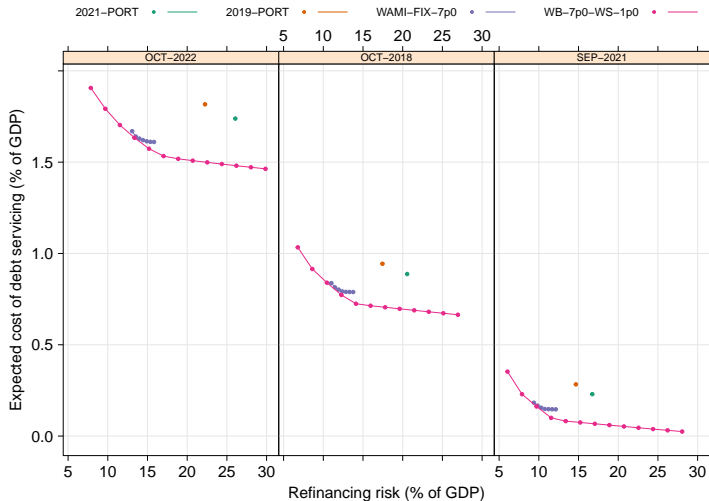
Debt stock and flow — Minimum cost



Policy recommendations — Balanced budget



Stress tests - Shifting yield curves



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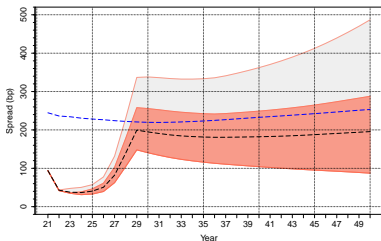
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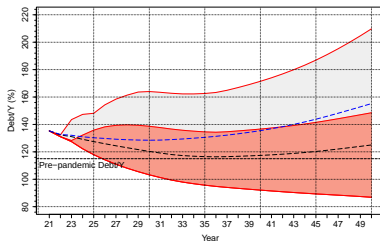
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Early Quantitative Tightening



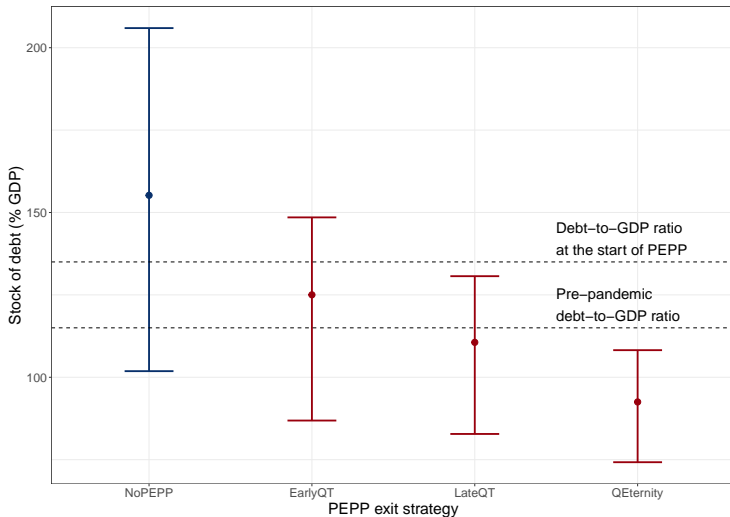
(c) Spread



(d) Debt stock



Quantitative Tightening Scenarios





Conclusions

- ▶ DSA Tech
- ▶ Embed Stochastic Scenarios
- ▶ Flexible to Assess Policies
- ▶ Stress Testing
- ▶ Strategic Financing