Bug or Feature?
Central Bank Bond Purchases and Price Informativeness *

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February 2026

Abstract

This paper proposes a theory of large-scale government bond purchases by central banks in an environment with endogenous information acquisition. Information production has two competing effects: it lowers risk premia by reducing uncertainty, but makes prices more sensitive to news. Central bank purchases crowd out private information acquisition by shifting risk off private balance sheets. When the sovereign can face self-fulfilling roll-over crises, however, this can be beneficial: impairing price informativeness prevents bond prices from falling below crisis-triggering thresholds. A key property of the model is that substantial purchases may be required to eliminate equilibrium multiplicity. Anticipation of such programs leads to excessive indebtedness, forcing the central bank to maintain an inflated balance sheet with prices disconnected from fundamentals. Evidence from Italian bonds around the ECB's 2015 program shows several informativeness measures fall after purchases begin and rise when purchases are reduced.

JEL Codes: E58, G14, H63

*I am extremely grateful to Jean Barthélemy and Stéphane Guibaud for detailed comments that significantly improved the paper, as well as to Guillermo Ordoñez for sharing his data. I also thank Julien Alcalin, Nick Barberis, Marco Bassetto, Matthieu Bouvard (discussant), Chris Clayton, Nicolas Coeurdacier, Zhengyang Jiang, Maria Fayos Herrera, Carlo Galli, Stefano Giglio, Gary Gorton, Zhiguo He (discussant), Paul Hubert, Zhen Huo, Luigi Iovino (discussant), Enisse Kharroubi, Hanno Lustig, Andrew Metrick, Juan Pablo Nicolini, Galo Nuño, Cecilia Parlatore, Guillaume Plantin, Juan M. Sánchez (discussant), Dejanir Silva, Alp Simsek, Adi Sunderam, Victoria Vanasco and seminar participants at Yale SOM, 2023 Ridge Financial Stability Forum, Copenhagen Business School, University Carlos III, Virtual Israel Macro Meeting, DebtCon 7, SED, YPFS Fighting a Financial Crisis Conference, Emerging Voices in Finance Research Conference at Notre Dame, T2M 2025, Barcelona Summer Forum: Safety, Liquidity and the Macroeconomy, EFA 2025, SITE Fiscal Sustainability, Oxford Financial Intermediation Theory, IMF and Monetary-Fiscal Workshop at the Banque de France for helpful discussions and comments. *Refine.ink* was used to check the paper for consistency and technical details.

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The key to stability — for the pricing of corporate as well as public debt — is a liquid and ***transparent*** *government debt market.*

- Alexandre Lamfalussy, 1999

1 Introduction

In January 2015, the ECB announced it would add the purchase of sovereign bonds to its existing private sector asset purchase programs. These purchases expanded further over time, so much so that in April 2023 the ECB was holding more than a quarter of the total stock of Italian government debt (Figure 1). The scale of this intervention, however, raised questions (Cochrane 2019; Bank for International Settlements 2019). While asset purchases can be a way to avoid negative self-fulfilling sovereign default, the benchmark view is that it is enough for a central bank to merely state its intention to make such purchases; it does not actually need to make them (Calvo 1988).[1] Furthermore, asset purchases would seem to reduce the incentive of private investors to gather and aggregate information into prices, impairing the price discovery process in sovereign bond markets (Taylor 2014; Bond and Goldstein 2015; Lustig 2022).

This paper proposes a theory of sovereign debt pricing and default with information production, and provides a new mechanism through which central bank asset purchases can help prevent roll-over crises. The central insight of the paper rests on the fact that information production has two natural effects: by reducing the uncertainty faced by investors, it lowers the risk premium on sovereign bonds. At the same time, it makes bond prices more sensitive to new information. By purchasing sovereign bonds directly, the central bank effectively transfers some risk away from private balance sheets, which reduces the incentives to invest in order to acquire information about future risks of default. As a consequence, asset purchases do indeed distort information production decisions, resulting in higher uncertainty and bond prices being less sensitive to fundamentals.

In some cases, however, this paper shows that this is a *feature* of such programs rather than a bug. In the event that a large share of private investors acquires information, and this information is negative, bond prices can fall substantially. If the price drop exceeds some threshold level, this can in turn trigger self-fulfilling roll-over crises later on (Cole

[1] This is the common interpretation attached to the 2012 announcement by Mario Draghi, where he promised to do "whatever it takes" to preserve stability in the Eurozone. Without implementing any transaction, this sole announcement lowered the spreads of sovereign bonds issued by the distressed European countries.

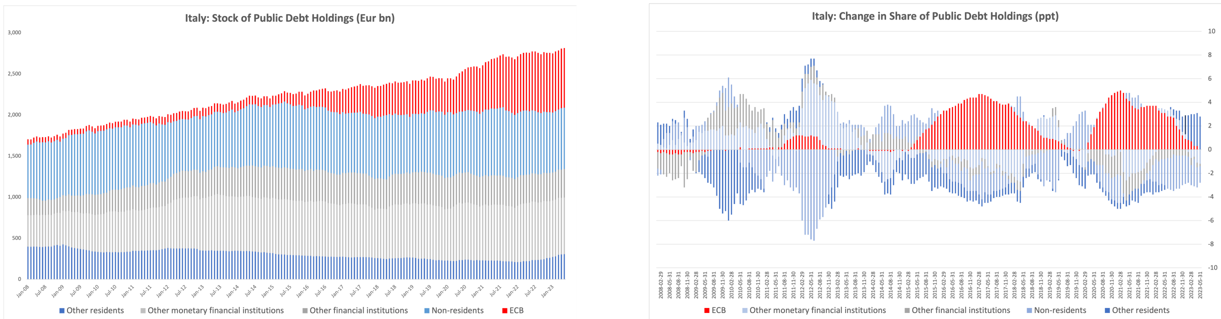


Figure 1: Italian Sovereign Debt Holdings.

and Kehoe 2000) by making it too expensive for the sovereign to refinance itself. By purchasing enough sovereign bonds, the central bank can diminish information production such that the occurrence of bad news does not trigger roll-over crises anymore: impairing price discovery is precisely what helps to prevent these crises.

Section 2 presents the basic 3-period model used in the analysis. A government must issue (risky) bonds in period 1 to finance some expenditures. In periods 2 and 3, the government seeks to smooth consumption by rolling over some of its debt. When the government runs a new auction at time 2, it is vulnerable to self-fulfilling roll-over crises when the debt burden is higher than a certain level: if investors believe that the government is going to default on its newly issued debt, bond prices are zero, and it can then be optimal for the government to default also on its past debt (Cole and Kehoe 2000). As a consequence, the country is subject to multiple equilibria when its debt issued in the previous period is priced below a threshold.[2] Taking this into account, mean-variance investors trade debt in the initial period. Investors can also invest ex-ante in order to acquire information about the fundamental component of sovereign bond payoffs. By paying a fixed cost, investors receive a partially informative signal that allows them to trade with less uncertainty, and with an updated payoff expectation.

When a larger number of investors are acquiring information, the risk premium on government bonds is lower, making it easier for the sovereign to finance its project on average. On the other hand, bond prices are now more sensitive to new information since more investors are trading on this information. When the signal received by informed

[2]This model of roll-over crises seeks to capture the situation of countries like Italy in the Eurozone. Rising yields on Italian debt were a concern for the ECB as they worsened the financial situation of the country, leading to fear of roll-over crises down the road. The "anti-fragmentation tool" allows the ECB to implement secondary "market purchases of securities issued in jurisdictions experiencing a deterioration in financing conditions not warranted by country-specific fundamentals" (European Parliament 2022, Cochrane, Garicano and Masuch 2025). In my model, these non-fundamental movements are interpreted as yield increases caused by a fear of (self-fulfilling) roll-over crises.

investors is negative, and a large enough number of investors is informed, bond prices can fall below the threshold triggering roll-over crises and multiple equilibria in the second period. While optimal from the point of view of an isolated investor, information acquisition can thus be "excessive" from the perspective of the sovereign.[3]

The effect of asset purchases by the central bank in this environment is studied in Section 3. I start by showing that asset purchases do crowd out private information production, consistent with recent critiques (Lustig 2022). This is intuitively because, taking into account the central bank's actions, investors realize that they will hold fewer bonds on their balance sheet, which makes it less worthwhile to pay a fixed cost. Because the central bank also transfers some risk away from private balance sheets, there is also a direct positive effect on prices. The two effects compete against each other: less information acquisition increases the risk premium, but by having to hold less debt, investors also require a lower compensation. It is nevertheless unambiguous that, by discouraging information acquisition, bond prices become less responsive to news. This is crucial in the case where, without action by the central bank, information production is above the threshold and roll-over crises are thus possible in the event of negative news.

When information production in equilibrium is high enough that multiple equilibria are possible next period, large enough asset purchases can rule out self-fulfilling crises by ensuring that the amount of information production is so weak that, even in the event of bad news, prices would still be above the unique equilibrium threshold. This size-dependence is the second key insight of this paper: the actions of the central bank must be large enough to shift the equilibrium information production from the right of the roll-over threshold to the left of it. This also contrasts my model with the well-known result that the central bank only needs to be able to commit to intervene in order to avoid multiple equilibria, and thus never has to actually intervene (Aguiar and Amador 2019). I also show, however, that this new mechanism also has limits. When information is relatively cheap to acquire, buying an excessive amount of bonds can ultimately lead to speculation *against* the central bank, raising incentives to acquire information again.

Section 4 provides suggestive evidence that the proposed mechanism is at play in the data. Using the case of Italian bonds and the start of ECB purchases in 2015, I construct various measures linked to information acquisition and price informativeness. In the first

[3] This feature of financial markets was noted by the 1988 Delors Committee, which set out the blueprint for the Economic and Monetary Union (EMU) (later structured in the Maastricht Treaty in 1992): "Market views about the creditworthiness of official borrowers tend to change abruptly and result in the closure of access to market financing. The constraints imposed by market forces might either be too slow and weak or too sudden and disruptive" (Delors Committee 1989). For a thorough analysis of the ECB market-based approach to government debt, see Van't Klooster (2023).

exercise, I construct the relative price informativeness measures proposed by Dávila and Parlatore (2023) for Italian sovereign bonds, using data on the expected probability of default of Italy provided by LSEG StarMine. In the second, I follow Cole, Neuhann and Ordonez (2025) by comparing the yields of sovereign bonds at auctions and in the secondary market, again constructing a price informativeness measure as well as the elasticity of secondary market prices to auction news. All three measures show that price informativeness significantly declined with the start of ECB purchases, and started to increase again at the end of 2018 when the ECB reduced its purchases and paused the program in 2019.[4]

Section 5 then presents a variety of extensions and robustness checks of the analysis. In particular, it shows that my results are not driven by the simplifying assumption that the government must issue bonds to finance expenditures. I show that the government can still willingly expose itself to roll-over crises, even while realizing that information production is going to be excessive (for usual consumption smoothing reasons). Asset purchases by the central bank ex-post will then work in the same way, reducing price volatility and potentially eliminating multiplicity. A crucial difference is that the sovereign can then anticipate that the central bank will step in, which also distorts debt issuance incentives. I show that this can result in much larger debt issuance levels, even if the government would normally issue debt at some lower level precisely to avoid the occurrence of multiple equilibria. The central bank is then forced to run an inflated balance sheet to avoid roll-over crises, with low information content in prices.

Related Literature: This paper is related to three broad strands of the literature: self-fulfilling defaults; information production and aggregation in market prices; and central bank asset purchases.

Self-fulfilling defaults: The first study of multiplicity of equilibria in models of sovereign debt is due to Calvo (1988): beliefs about a high probability of default translate into high yields, which makes it optimal next period for the sovereign to indeed default on this debt.[5] My model uses a different type of multiplicity, due to Alesina, Prati and Tabellini (1989), Giavazzi and Pagano (1989), and Cole and Kehoe (2000), named "roll-over crises."

[4] Appendix E provides additional empirical evidence consistent with the theory, using survey data forecast errors from private analysts and the European Commission, as well as abnormal returns around ECB Events from Istrefi, Odendahl and Sestieri (2022).

[5] See also Aguiar, Amador, Farhi and Gopinath (2013), Corsetti and Dedola (2016), Ayres, Navarro, Nicolini and Teles (2018), Bassetto and Galli (2019) and Ayres, Navarro, Nicolini and Teles (2023) among others for setups using the Calvo (1988) multiplicity.

These models feature two distinct pairs of equilibrium prices and *contemporaneous* default decisions, with multiplicity reminiscent of a bank run.[6] He, Krishnamurthy and Milbradt (2019) propose a model of safe asset determination that uses roll-over risk as a key ingredient, but use global games techniques to find which asset emerges as safe in equilibrium.[7]

Information production and aggregation: The crucial mechanism in my model comes from endogenous information acquisition, building on the overview provided by Vives (2010) and Veldkamp (2023). Barlevy and Veronesi (2000), Hellwig and Veldkamp (2009), Hellwig, Kohls and Veldkamp (2012) and Yang (2015) study multiple equilibria in *information choice*. In contrast, I make assumptions to avoid multiplicity in information choice, and study when multiple equilibria arise in bond prices later on.[8] A key insight of my model is that high levels of information acquisition can be excessive and lead to costly (and inefficient) roll-over crises. This is closely related to the idea that crises occur when debt becomes "information-sensitive" (Gorton and Pennacchi 1990; Dang, Gorton and Holmstrom 2009; Gorton and Metrick 2009; Dang, Gorton, Holmström and Ordoñez 2017; Gorton and Ordoñez 2022), and hence that opacity might be optimal in some situations (Gorton and Ordoñez 2014; Gorton and Ordoñez 2020; Parlatore 2024; Gorton, Li and Ordoñez 2025). Bouvard, Chaigneau and Motta (2015) show, in a setting with bank runs, that disclosing information is valuable in crisis times, but is destabilizing in booms. Ahnert and Kakhbod (2017) propose an amplification mechanism of financial crises based on the information choice of investors, *after* the arrival of bad news. Relatedly, Vanasco (2017) highlights a similar tension between information production and market functioning, showing that screening improves asset quality but worsens adverse selection. Another complementary theory is provided by Cole et al. (2025). They show that the structure of price auctions in the primary market leads to strategic complementarities in information acquisition. As a result, shocks to default risk in one country may spill over and trigger crisis episodes with widespread information acquisition in other risky

[6] See also Chatterjee and Eyigungor (2012), Aguiar, Chatterjee, Cole and Stangebye (2016), Conesa and Kehoe (2017), Roch and Uhlig (2018), and Bocola and Dovis (2019a) for quantitative models featuring roll-over crises. Broner, Erce, Martin and Ventura (2014), Aguiar and Amador (2020), Galli (2021), and Aguiar, Chatterjee, Cole and Stangebye (2022) also offer alternative sources of multiplicity in sovereign debt models. Alternatively, Bi, Foerster and Traum (2025) study the case of Italy in 2012 focusing on liquidity risk.

[7] Roll-over risk is also prominent in corporate finance, starting with Diamond (1991), and more recently Brunnermeier and Yogo (2009), Acharya, Gale and Yorulmazer (2011), He and Xiong (2012a;b), Cheng and Milbradt (2012), He and Milbradt (2014).

[8] Online Appendix D.4 then studies the model with alternative assumptions when multiple information acquisition equilibria can happen. Importantly, asset purchases can also help on this front, to ensure a unique equilibrium in information choice.

countries, and falling yields in safe countries.[9]

Central bank asset purchases: The early seminal paper on this policy instrument is by Wallace (1981), who shows that asset purchases by the central bank are irrelevant in a frictionless and closed economy benchmark. This is because taxes need to adjust to compensate for possible losses, therefore exposing debt holders to exactly the same risk. In my paper, debt holders are not concerned by future tax adjustments.[10] Alternatively, Iovino and Sergeyev (2023) show that when agents are boundedly rational, they cannot think through the equilibrium effects of asset purchases on future taxes, so that central bank interventions become relevant. The closest related paper is by Gaballo and Galli (2022), who instead propose a model without endogenous information acquisition but with learning from prices instead. They show that asset purchases can be beneficial by altering the way agents learn from prices. As such, both papers study the interaction of asset purchases with how information is incorporated into prices, but the mechanisms are distinct and complementary.[11] Bond and Goldstein (2015) study the impact on price informativeness when government intervention influences future cash flows. Kohlhas (2022) shows that the disclosure of central bank's information helps reduce higher-order uncertainty and hence improves monetary policy effectiveness. Brunnermeier, Sockin and Xiong (2022) offer a closely related theory of government intervention in financial markets: leaning against noise traders reduces volatility but at the expense of introducing policy noise into the market. In contrast, in my framework worsening price efficiency is the objective of the policymaker.

[9] Gaballo and Ordoñez (2022) show that in an incomplete markets environment, the use of information technologies tends to be excessive. This is in the tradition of Hirshleifer (1971), where the release of information limits risk-sharing opportunities and thus reduces welfare (see Kurlat and Veldkamp (2015) for a recent review). Relatedly, there is a literature studying the general efficiency properties of models with information acquisition, e.g., Colombo, Femminis and Pavan (2014), Rahi and Zigrand (2018), Angeletos, Iovino and La'O (2020), Dávila and Parlatore (2021), Llosa and Venkateswaran (2022), Pavan, Sundaresan and Vives (2022), Hébert and La'O (2023). Khorrami and Thereze (2026) instead study information acquisition and aggregation in the Kyle model.

[10] This is in the same spirit as the market segmentation literature, where asset purchases have an effect (Curdia and Woodford 2011; Vayanos and Vila 2021; Caballero and Simsek 2021; Costain, Nuno and Thomas (2025)). Iovino and Sergeyev (2023) by contrast does not rely on market segmentation. See Online Appendix C.3 for a more detailed discussion.

[11] An interesting feature of the model of Gaballo and Galli (2022) is that a small amount of purchases is beneficial, but the welfare effects become negative for large programs because they increase the precision of market information in default states. On the contrary, my model argues for large enough asset purchases in order to discontinuously affect equilibrium pricing by shifting information production below some threshold. The interaction of these effects is outside of the scope of this paper, but suggests that large-scale programs might only be warranted in some specific situations. Finally, Sockin and Neuhann (2023) show that asset purchases can also impair market functioning by worsening liquidity and risk-sharing.

2 Model

This section presents a tractable model stripped down to its core in order to focus on the main insights. Section 5 presents extensions and robustness analyses. The model has three periods: $t \in \{1, 2, 3\}$. At time 1, informed investors can acquire information about future fundamental payoff risk on sovereign bonds, and invest in newly issued bonds. At time 2, the government tries to roll over its debt, and can be subject to roll-over crises and default (Cole and Kehoe 2000) if its debt burden is too high. At time 3, the model ends, and the country repays its remaining debt.

2.1 Government

Debt Issuance: The government consumes only in periods 2 and 3. It has the following utility function:

$$V_2 = u(c_2) + \beta u(c_3) \tag{1}$$

with endowments y_2 and y_3 in periods 2 and 3. In the first period, the government has to finance some expenditures. It can only issue short-term (one period) and non-contingent bonds. Facing bond prices of q_1, the government has a downward-sloping demand for funds: it raises $B_1 q_1 - \phi q_1^2$, meaning that it will have to reimburse $b_1 = B_1 - \phi q_1$ in the next period.[12]

Rollover crises: In period $t = 2$, the country attempts to roll over its debt by auctioning new short-term bonds. Following Cole and Kehoe (2000), if the country's debt burden b_1 exceeds a threshold b^*, a self-fulfilling roll-over crisis becomes possible. If investors expect a default, they refuse to lend, making it impossible for the government to roll over its debt, and making a default indeed optimal. This validates investors' expectations and thus creates a "bad" equilibrium with zero bond prices. We take this roll-over block as standard and relegate the micro-foundation details to Appendix A.1 for conciseness.

[12] This reduced form is taken for tractability only, but does not alter the results: since asset demands are linear in the price, this will yield closed-form solutions for equilibrium prices. In Section 5.1 I instead assume that the country has to finance a fixed set of public programs, and so needs to raise a fixed B_1. This means that it will have to sell B_1/q_1 bonds, i.e. a decreasing function of q_1. The reduced-form $b_1 = B_1 - \phi q_1$ captures the same intuition but keeps a convenient linear formulation, which can also be seen as a first-order approximation. Section 5.2 also studies the case where the government consumes at $t = 1$ and optimally decides how much to issue in period $t = 1$ in order to maximize welfare. The insights developed in the tractable version with linear supply are robust to these variations.

Fundamental payoff risk: Independently of roll-over risk, sovereign bonds are subject to fundamental partial default risk. Conditional on the country avoiding a roll-over crisis, one unit of debt delivers to investors a payoff $1-\delta$, where $\delta \in [0,1]$ is a stochastic loss rate.[13]

Sunspots: In the event that there is a possibility of a roll-over crisis at $t=2$ in the sense of Cole and Kehoe (2000) (when $b_1 > b^*$), a stochastic process governs the equilibrium selection. Specifically, with probability λ the equilibrium selected is the crisis one: the price of bonds is 0 for all levels of issuance, the country defaults on its obligations b_1, and bondholders receive nothing. With probability $1-\lambda$, the good equilibrium is selected, the country rolls over its debt, and the bond payoff remains $1-\delta$. The value of λ is common knowledge to all agents in the economy.

We denote by χ the repayment variable. Given the payoff structure described above:

$$\chi = \begin{cases} 1-\delta, & \text{if } b_1 \leq b^*, \\ 1-\delta, & \text{with probability } 1-\lambda \text{ if } b_1 > b^*, \\ 0, & \text{with probability } \lambda \text{ if } b_1 > b^*. \end{cases} \tag{2}$$

2.2 Investors and Demand

The country trades its bonds in the first period $t=1$ with two types of investors. First, uninformed passive investors, present with a fixed mass of 1. Second, informed investors who update their expectations depending on the information they receive, and whose mass ψ is endogenously determined in equilibrium. The mass ψ intuitively corresponds to the amount of information acquisition. We start by describing the demand of passive uninformed investors, and the equilibrium price when only these investors are present as a preliminary to build intuition.

2.2.1 Uninformed Passive Investors

Uninformed investors have a prior δ_0 over the exogenous and fundamental loss rate δ, but do not acquire any more information about δ. Since the price is part of their demand function, however, they observe when the sovereign issues "too much" and will thus face

[13] This ensures that government debt is never fully risk-free, even outside the crisis zone, so that investors have incentives to acquire information. It can be interpreted as capturing fundamental risks that lower the realized value of the bond to investors without affecting the government's roll-over decision. We will assume that investors seek to learn about δ, i.e. about the fundamental risk of defaulting.

potential roll-over crises at $t = 2$ when the price is too low. As a consequence, their expected payoff is:

$$\mathbb{E}_U[\chi] = \begin{cases} 1-\delta_0, & \text{if } b_1 \leq b^*. \\ (1-\lambda)(1-\delta_0), & \text{otherwise.} \end{cases} \tag{3}$$

We will denote by $1/\tau$ their conditional variance over the payoff when $b_1 \leq b^*$, and by $1/\tau_\lambda$ when roll-over crises are possible.[14]

We assume that uninformed investors have mean-variance preferences with risk-aversion γ:

$$U_U(q_1) = \mathbb{E}_U[b\chi] - bq_1 - \frac{\gamma}{2}\mathbb{V}_U[b\chi] \tag{4}$$

To ensure a stable equilibrium, I assume that $\tau/\gamma > \phi$, i.e. that the demand of passive investors is more elastic than the supply of bonds by the government. The price of bonds q_1 when $b_1 \leq b^*$ is then determined by the market clearing condition:

$$\underbrace{B_1 - \phi q_1}_{\text{Supply}} = \underbrace{\frac{\tau}{\gamma}((1-\delta_0) - q_1)}_{\text{Demand}} \tag{5}$$

Solving for the equilibrium price is then straightforward, and we obtain:

$$q_1 = \frac{\tau(1-\delta_0) - B_1\gamma}{\tau - \phi\gamma} \tag{6}$$

I make the following assumption for the rest of the core of the paper, to ensure that without any informed investors, self-fulfilling defaults are ruled out:[15]

Assumption 1. *The parameters of the model are such that:*

$$b^*\left(1 - \frac{\phi\gamma}{\tau}\right) \geq B_1 - \phi(1-\delta_0) \geq 0 \tag{7}$$

which implies that, when no investor is informed, prices are high enough to sustain a single equilibrium at $t = 2$.

This condition can be understood as passive uninformed investors being optimistic

[14] Other modeling assumptions can be considered for uninformed investors. For instance, uninformed investors could not update their payoff expectation in the crisis zone, or not change their conditional variance. These assumptions are qualitatively innocuous on equilibrium behavior, and only slightly alter the algebra.

[15] When this is not the case, the implications of information acquisition are different: this is because more volatility can help the sovereign escape the crisis zone in some cases. We discuss this in more details in Online Appendix C.2 and in Section 3.3.

enough about the expected payoff of the bond, $1-\delta_0$. In what follows, I will make use of the following shortened notation:

$$\underline{b} = B_1 - \phi(1-\delta_0) \tag{8}$$

This corresponds to the average amount of debt issued by the government in the absence of any risk premium, i.e. when the price of bonds is equal to the expected payoff $1-\delta_0$.

2.3 Informed Traders

We start by describing the introduction of a mass ψ of informed investors. We will then characterize ψ in equilibrium through the endogenous entry condition, where informed traders can choose to enter the market by paying a fixed cost. Upon entry, informed investors observe a common signal informative about the fundamental δ before trading. We assume that informed investors also have mean-variance preferences with risk-aversion γ:

$$U_I(b;q_1) = \mathbb{E}_I[b\chi] - bq_1 - \frac{\gamma}{2}\mathbb{V}_I[b\chi] \tag{9}$$

Information Structure: The signal $\tilde{s} \in \{-s, s\}$ is realized with equal probability, and is informative about the fundamental loss rate of the bond. Specifically, it shifts the expectation of repayment:

$$\mathbb{E}_I[\chi|\tilde{s}] = \begin{cases} 1-\delta_0+\tilde{s}, & \text{if } b_1 \le b^*. \\ (1-\lambda)(1-\delta_0+\tilde{s}), & \text{otherwise.} \end{cases} \tag{10}$$

A positive signal is thus good news and raises the expected payoff of the bond, while a negative signal is bad news.[16] We model the information technology as reducing the conditional variance of δ to a constant $1/\tau'$, independent of the signal realization : the signal tells investors about the *direction* of payoff risk, but the residual uncertainty is the same regardless of which direction is revealed.[17] We denote by τ'_λ the associated precision over the final payoff when sunspots equilibria are possible, i.e. when $b_1 > b^*$.

[16] It is not essential that both types of agents share the same unconditional prior mean over δ, but it simplifies the algebra and reduces the amount of notation to keep track of. We assume $s < \delta_0$ so that the expected payoff remains well-defined.

[17] This property holds exactly under Gaussian learning about δ, and is a standard approximation for interior values of δ_0. In Online Appendix C.1, I show that it also exactly holds if informed investors have a symmetric prior over the loss rate, and receive signals that are parametrized to keep the $\{-s, s\}$ structure.

Equilibrium when $b_1 \leq b^*$: The demand for bonds of an informed investor, conditional on signal $\tilde{s}$ and price q_1, is thus:

$$b_I(\tilde{s}) = \tau' \cdot \frac{1 - \delta_0 + \tilde{s} - q_1}{\gamma} \tag{11}$$

For a given mass ψ of informed investors and signal realization $\tilde{s}$, the market clearing condition is:

$$B_1 - \phi q_1(\tilde{s}) = \psi\tau' \cdot \frac{1 - \delta_0 + \tilde{s} - q_1(\tilde{s})}{\gamma} + \tau \cdot \frac{(1 - \delta_0) - q_1(\tilde{s})}{\gamma} \tag{12}$$

The equilibrium price is thus linear in the signal:

$$q_1(\tilde{s}) = \bar{q} + \Psi\tilde{s} \tag{13}$$

where:

$$\bar{q} = \frac{(1 - \delta_0)(\tau + \psi\tau') - \gamma B_1}{\tau + \psi\tau' - \phi\gamma}, \qquad \Psi = \frac{\psi\tau'}{\tau + \psi\tau' - \phi\gamma} \tag{14}$$

Both the average price $\bar{q}$ and price sensitivity Ψ are increasing in ψ.

Two Competing Effects of Information: These two properties create the key tension of the model. When more investors are informed, it lowers the average risk premium investors charge for holding bonds, making it less costly for the sovereign to finance its public expenditures. This can simply be seen through the following derivation:

$$\frac{\partial \bar{q}}{\partial \psi} \propto \tau'\gamma\underline{b} > 0 \tag{15}$$

If this were the only effect of more information, it would thus have a positive effect for the sovereign. More information acquisition however also increases price volatility, by increasing the sensitivity of prices to new information, i.e. a higher Ψ:

$$\frac{\partial \Psi}{\partial \psi} \propto \tau' (\tau - \phi\gamma) > 0 \tag{16}$$

This can be a cause of concern for the sovereign when the volatility effect is stronger than the risk-premium effect. We make the following assumption ensuring that this is the case:

Assumption 2. *The magnitude of the signal is large enough that:*

$$s > \frac{\gamma\big(B_1 - (1-\delta_0)\phi\big)}{\tau - \phi\gamma} \tag{17}$$

which implies that the price in the event of bad news is decreasing in the mass of informed investors:

$$\frac{\partial q_1(-s;\psi)}{\partial \psi} < 0 \tag{18}$$

In the opposite case where bond prices are instead increasing with ψ even with a negative signal, then more information acquisition will be unambiguously beneficial for the sovereign, and there is no tension between the two effects of information. Indeed, since the sovereign is outside the crisis zone if $\psi = 0$ (Assumption 1), it will stay above for any ψ in this case. This suggests that the novel mechanism highlighted in this paper will be relevant only in countries that already have some degree of fragility: here it is necessary that there is enough uncertainty about fundamental default risk.[18]

Equilibrium when $b_1 > b^*$: In that case, investors update their beliefs about the bond's expected payoff, and with probability λ expect a crisis equilibrium to be selected at $t = 2$. Both types of investors then face additional uncertainty through the sunspot realization, so uninformed traders use precision τ_λ while informed traders use precision τ'_λ. This leads to an equilibrium price of:

$$q_{1,\lambda}(\tilde{s}) = \frac{(1-\lambda)(1-\delta_0)(\tau_\lambda + \psi\tau'_\lambda) + (1-\lambda)\tilde{s}\psi\tau'_\lambda - \gamma B_1}{\tau_\lambda + \psi\tau'_\lambda - \phi\gamma} \tag{19}$$

2.4 Roll-Over Crisis Threshold

Under Assumption 1, when no investor is informed, the country is safe from roll-over crises. As more informed investors enter the market, however, the bad-news price $q_1(-s;\psi)$ falls (Assumption 2). There thus exists a critical mass of informed investors above which the price drops low enough to push the debt burden $b_1 = B_1 - \phi q_1(-s)$ above the crisis threshold b^*. We denote by $q^* = (B_1 - b^*)/\phi$ the price below which the country enters the crisis zone.

[18] When Assumption 1 is not satisfied, then more information helps the sovereign exit the crisis zone, irrespective of whether Assumption 2 is satisfied or not. See Online Appendix C.2 and the associated discussion in Section 3.3.

Definition 1 (Information Acquisition Threshold)**.** *The information acquisition threshold ψ_s is the maximum mass of informed investors such that the unique equilibrium at $t = 2$ is sustained even under bad news. It is defined by $q_1(-s; \psi_s) = q^*$, which yields:*

$$\psi_s = \frac{\tau\left(1 - \delta_0 - q^*\right) - \gamma(B_1 - \phi q^*)}{\tau'\left(q^* - (1 - \delta_0 - s)\right)} \tag{20}$$

1. *If $\psi \leq \psi_s$, the equilibrium is unique at $t = 2$ for any signal realization.*

2. *If $\psi > \psi_s$, sunspot equilibria are possible at $t = 2$ with probability λ whenever the signal realization is $\tilde{s} = -s$.*

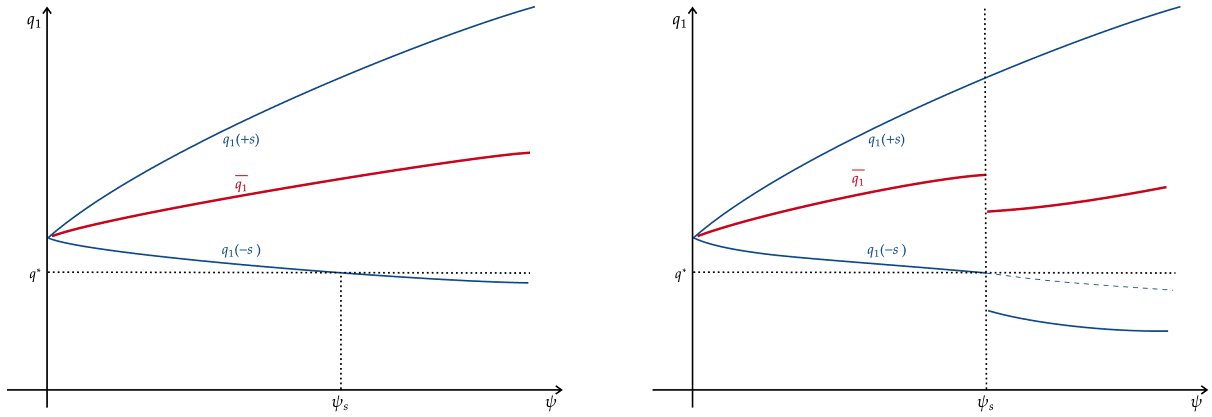
Importantly, note that this threshold also depends on the fundamentals of the country issuing bonds, through δ_0 and b^*. Roll-over crises are indeed self-fulfilling, but only happen when there is already some fragility (as highlighted in Assumption 2).

A Graphical Illustration of the Intuition: Most of the intuition of this paper can be contained in a simple graph, as illustrated in Figure 2. Consider a simple asset, for instance a stock. When the number of investors acquiring information, ψ, increases, this is unambiguously beneficial for the average asset price: less average uncertainty about future payoffs means that investors on average require a smaller risk premium to hold the asset, leading to a higher price. When the signal realization is negative, the price is decreasing in ψ under Assumption 2, since the information effect dominates the risk premium effect.

When the asset can be subject to runs, however, a new force appears on the right panel. For a low enough price, here denoted by q^* in Figure 2, multiple equilibria can appear ex-post. Risky sovereign debt is such an asset (because of the Cole and Kehoe (2000) mechanism in the present paper, but possibly also because of runs similar to the Calvo (1988) mechanism for instance). The contribution of this paper is to show that hampering price discovery can then be beneficial in such an environment, and that large-scale asset purchases are one way to achieve this.

2.5 Information Acquisition

We now close the model by endogenizing the mass ψ of informed investors. We assume that informed investors enter as long as their expected utility is above their reservation utility $\bar{U}$, a parameter that captures the fixed costs of acquiring information. The following formally characterizes the information-acquisition equilibrium, being careful that the expected utility of informed investors might be discontinuous at the threshold ψ_s (when



(a) Without runs

(b) With runs

Figure 2: Equilibrium Price of an Asset. This figure plots the equilibrium price on an asset as a function of the number of investors that acquire information. The blue lines are the equilibrium price in the event of two different signals, a positive signal and a negative signal. The red line plots the average equilibrium price. The threshold q^* represents the cutoff at which runs become possible, for example because of roll-over crises as in Cole and Kehoe (2000).

sunspots equilibria appear), and a graphical representation is provided in Figure 3.[19]

Definition 2 (Information-Acquisition Equilibrium)**.** *Let $\mathbb{E}[U_I](\psi)$ denote the expected utility of an informed investor when the mass of informed investors is ψ. An information-acquisition equilibrium is a mass $\psi^* > 0$ such that*

$$\mathbb{E}[U_I](\psi^{*-}) \geq \bar{U}, \qquad \textit{and} \qquad \mathbb{E}[U_I](\psi^{*+}) \leq \bar{U}. \tag{21}$$

That is, acquiring information is profitable just before ψ^* and unprofitable just after ψ^*. Whenever $\mathbb{E}[U_I]$ is continuous at ψ^*, this reduces to $\mathbb{E}[U_I](\psi^*) = \bar{U}$.

Expected Utility when $\psi \leq \psi_s$: To build intuition, I flesh out the algebra in the case where self-fulfilling defaults are not a possibility. Using the optimal demand in (11), the expected utility of an informed investor can be written as:

$$\mathbb{E}[U_I] = \frac{\tau'}{2\gamma}\left[(1 - \delta_0 - \bar{q})^2 + (1 - \Psi)^2 s^2\right] \tag{22}$$

The first term captures the value of the average excess return: even without any signal, informed investors benefit from trading to capture a risk premium, which is the difference between the average payoff $(1 - \delta_0)$ and the average price $(\bar{q})$. The second term is the

[19] In Section 2.6 and in Online Appendix C.5 I show that this discontinuity is an artifact of the binary signal structure. Continuity is ensured with continuous signals.

additional gain from *trading on the signal*: it is proportional to $(1-\Psi)^2$, the share of the information not yet incorporated in the price.

Both terms are clearly *decreasing* in ψ, using (14). First, the more informed investors there are, the closer is the average price $\bar{q}$ to the expected payoff, reducing the expected profits of capturing the average risk premium. Second, the more informed investors there are, the more prices respond to information (Ψ closer to 1), reducing the benefits of trading on this information. This highlights that information choices are strategic substitutes.

Equilibrium: Because the expected utility loses its symmetric structure in the crisis zone ($\psi > \psi_s$, so sunspots equilibria appear only in the case of a negative signal), the expressions become more involved. Nonetheless, it remains decreasing in ψ for the same reasons as previously highlighted, and the jump in expected utility at ψ_s is downward as long as the probability of the crisis equilibrium is not too high. The following proposition gives a sufficient restriction.

Proposition 1 (Unique ψ-Equilibrium)**.** *A sufficient condition for a unique information-acquisition equilibrium is:*

$$\frac{|\gamma B_1 - (1-\lambda)\left[s\tau_\lambda + \phi\gamma(1-\delta_0-s)\right]|}{\tau_\lambda - \phi\gamma} < q^* - (1-\delta_0-s). \tag{23}$$

Proof. All proofs and derivations are relegated to Appendix A. □

In these conditions, if $\bar{U}$ does not lie in the jump between the expected utilities at ψ_s, the equilibrium is the unique solution to $\mathbb{E}[U_I](\psi) = \bar{U}$. If instead $\mathbb{E}[U_I](\psi_s^-) \geq \bar{U} \geq \mathbb{E}[U_I](\psi_s^+)$, the unique equilibrium is the boundary equilibrium $\psi^* = \psi_s$ (Figure 3). We only study the unique ψ-equilibrium in the core of the paper, and relegate the multiple ψ-equilibria case to the appendix (see also the discussion in Section 3.3).

From here on, we restrict attention to parameter values ensuring that the information-acquisition equilibrium is unique. While $\mathbb{E}[U_I]$ depends on ψ through $\bar{q}$ and Ψ in multiple places, this formulation is actually tractable and delivers a closed-form solution for the equilibrium mass of informed investors ψ^* in the safe zone case.

Proposition 2 (Information Production)**.** *If $\psi^* < \psi_s$, it is uniquely pinned down by:*

$$\psi^* = \frac{1}{\tau'}\left(\sqrt{\frac{\tau'}{2\gamma}\left[\frac{\gamma^2\underline{b}^2 + (\tau-\phi\gamma)^2 s^2}{\bar{U}}\right]} - (\tau - \phi\gamma)\right)^+ \tag{24}$$

The equilibrium level of information production behaves as follows with the parameters of the model:

1. ***Increasing in*** B_1*: more bond supply depresses prices, widening the gap between fundamentals and the price, and thus raising the expected profit from entering.*
2. ***Increasing in*** s*: if new information can meaningfully shift the expected payoff of the bond, then there is more profit to be made from trading on this information.*
3. ***Decreasing in*** $\bar{U}$*: when information is harder to acquire, fewer investors choose to become informed.*

Excessive Information Production If instead the equilibrium level of information production ψ^* is above ψ_s, then the equilibrium features *excessive information production*. Too many investors become informed and push the price below the crisis threshold in the case of bad news, exposing the sovereign to self-fulfilling roll-over crises in the future. Roll-over crises thus happen at $t = 2$ with probability $\lambda/2$ (bad signal with probability $1/2$ and sunspot crisis with probability λ).

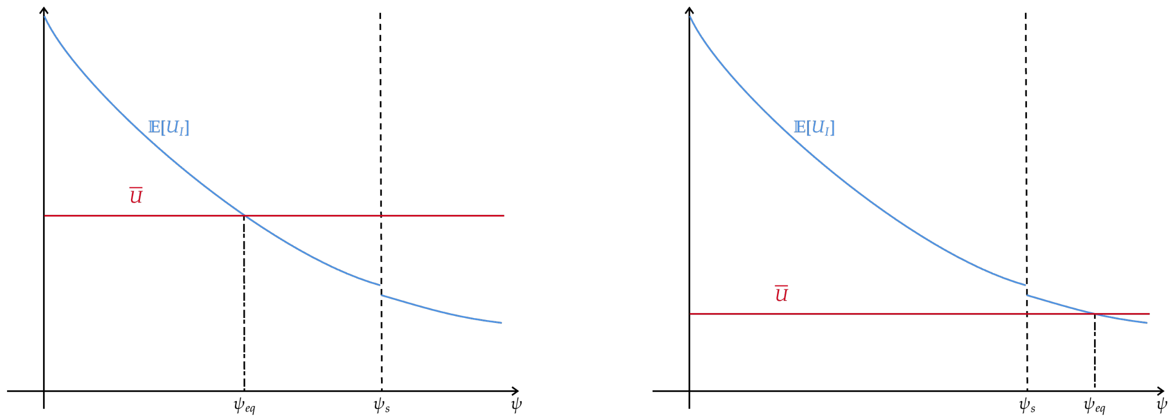
Proposition 3 (Ruling Out Roll-Over Crises at $t = 2$)**.** *The equilibrium features a level of information acquisition that is not excessive, i.e.* $\psi^* \leq \psi_s$*, if the cost of acquiring information* $\bar{U}$ *is high enough, such that:*

$$\bar{U} \geq \bar{U}_M = \tau' \frac{\gamma^2 \underline{b}^2 + (\tau - \phi\gamma)^2 s^2}{2\gamma \left(\tau + \tau' \psi_s - \phi\gamma\right)^2}. \tag{25}$$

The equilibrium determination is depicted in Figure 3. The left panel presents a case where equilibrium uniqueness is guaranteed when the country rolls its debt over at $t = 2$: the parameters are such that the crossing of the two expected utilities arises at a level ψ below the threshold ψ_s given in Definition 1. The right panel presents a case where the opposite is true: a share $\psi > \psi_s$ decides to acquire information in equilibrium, such that the equilibrium at $t = 2$ will feature multiplicity in the event that informed investors receive the low signal $-s$.

2.6 Discussion of Assumptions

Linear Supply: The government's bond supply $b_1 = B_1 - \phi q_1$ is a reduced form chosen for tractability: combined with linear asset demands, it delivers closed-form equilibrium prices. This formulation captures the natural property that the debt burden increases when bond prices fall. The parameter ϕ controls the price elasticity of supply, and



(a) Uniqueness at $t = 2$

(b) Roll-over crisis possible at $t = 2$

Figure 3: Equilibrium determination of ψ. The decreasing curve plots the expected utility of an informed investor, $\mathbb{E}[U_I]$, as a function of the mass of informed investors ψ. The horizontal line is the reservation utility $\bar{U}$, representing the fixed cost of acquiring information. The equilibrium mass ψ_{eq} is determined by their intersection. The dashed vertical line marks the information acquisition threshold ψ_s from Definition 1. In the left panel, $\psi_{eq} < \psi_s$: information acquisition is moderate enough that a unique equilibrium is sustained at $t = 2$. In the right panel, information is cheaper to acquire, so $\psi_{eq} > \psi_s$: the equilibrium features excessive information production, and the sovereign is exposed to roll-over crises when informed investors receive the negative signal $-s$.

the condition $\tau > \phi\gamma$ (required for Assumption 1) ensures that demand is more price-elastic than supply, so that equilibrium prices are stable and increasing in fundamentals. Section 5.1 verifies that the results are robust to an alternative specification where the sovereign must finance a fixed expenditure B_1, issuing B_1/q_1 bonds. While closed-form solutions are no longer available, the qualitative insights are identical. Section 5.2 further extends the model to allow the sovereign to optimally choose its issuance level, where again the qualitative insights are unchanged.

Informed vs. Uninformed Investors: The model assumes that the number of uninformed investors is fixed, while the number of informed investors is endogenous and depends on their free-entry condition. This is not the only way to model information acquisition. In Grossman and Stiglitz (1980), there is a fixed number of traders, and each trader decides whether to acquire information by comparing the expected utility of being informed or uninformed. In Hellwig et al. (2012), traders decide how many signals to acquire. The formulation used in the main text is similar in spirit, but is chosen for tractability. Because we are studying a sovereign bond with non-Gaussian payoffs, comparing the expected utility of being informed to the expected utility of being uninformed significantly complicates the problem. By fixing the number of uninformed investors, the free-entry condition reduces to comparing the expected utility of an informed trader to an exogenous parameter representing the cost of acquiring information, which delivers a closed-form solution for the equilibrium mass of informed investors. Online Appendix D.1 develops the case where information acquisition is modeled as in Grossman and Stiglitz (1980), and shows that it behaves similarly to our main framework.

Safety at $\psi = 0$: Assumption 1 ensures that when no investor is informed, the price of bonds is high enough to rule out self-fulfilling roll-over crises at $t = 2$. Otherwise, the implications of more information acquisition are different, as the two (previously competing) effects are going in the same direction. More information acquisition would then allow the sovereign to potentially *escape* roll-over crises in the case of a good signal. Volatility thus becomes beneficial. This highlights the fact that the desirable level of information acquisition from private investors depends on the underlying fragility of the sovereign. See Figure 12 for the graphical intuition of this case in Online Appendix C.2.

Information Acquisition Equilibrium: The model uses a binary signal structure for tractability. A downside of this assumption is that it generates a discontinuity in the expected utility of informed traders (see Figure 3). In the benchmark framework, Proposition 1 gives a sufficient restriction ensuring that this discontinuity remains a *downward* jump: this allowed us to avoid multiplicity at the *information acquisition stage*. Indeed, we show in Online Appendix D.4 that multiple equilibria in ψ (one where information acquisition is excessive and the other where it is not) can arise at this stage if this condition is not met. We keep the analysis of this case in the appendix, as it is not the focus of this paper and has been studied in previous work (see for instance Hellwig et al. 2012 or Veldkamp 2023). But importantly, we show in Online Appendix D.4 that asset purchases can also help eliminate this kind of multiplicity, reinforcing the main insight of the paper.

Finally, Online Appendix C.5 shows that with continuous signals, the expected utility of informed traders is continuous in ψ, while the paper's main results about asset purchases and informativeness are naturally unchanged.

3 Asset Purchases and Informativeness

We now explore the main implication of the model: large-scale bond purchases by the central bank interact with the market's incentives to invest in information production.[20]

[20] As is common in the segmented markets literature, we assume that any fiscal consequences of the central bank's balance sheet operations do *not* fall on the class of agents we are considering. This is crucial to break

3.1 Supply of Bonds and Information Acquisition Incentives

To understand how the central bank's footprint affects information acquisition, it is useful to go back to the (gross) expected utility expression we derived earlier, equation (22):

$$\mathbb{E}[U_I] = \frac{\tau'}{2\gamma}\left[\underbrace{(1-\delta_0-\bar{q})^2}_{\text{Investment size}} + \underbrace{(1-\Psi)^2 s^2}_{\text{Informed speculation}}\right] \tag{26}$$

The first term captures the value of harnessing the risk premium, while the second term captures the value of trading on the signal against uninformed traders. While the second term is not directly touched by the central bank's asset purchases, the first term is affected by changes in the supply of bonds through B_1. When the central bank takes up some share of the issued sovereign bonds, potential informed investors realize that they will have a smaller position but still have to pay the same fixed cost. This weakens incentives to pay the cost, which in turn reduces ψ. Equivalently, one can understand this effect in terms of risk premium. By taking out some quantity of risk from the market, the compensation for holding default risk in equilibrium will be smaller, which reduces the incentives for informed investors to enter.[21]

In the rest of the paper, we will denote by x_1 the amount of bonds purchased by the central bank, so that the supply of bonds to private investors is $B_1 - x_1 - \phi q_1$. We start by formalizing how central bank asset purchases alter the equilibrium amount of information production in the case of a single equilibrium at $t = 2$.

Proposition 4. *Assume that $\psi^* < \psi_s$. If the central bank purchases an infinitesimal amount dx_1 of sovereign bonds, the equilibrium share of informed investors decreases:*

$$\frac{d\psi^*}{dx_1} = -\frac{1-\delta_0-\bar{q}}{2\bar{U}} < 0 \tag{27}$$

The effect of asset purchases on information acquisition is thus exactly quantified by the two variables we identified: the average size of the position informed traders take in the numerator, against the fixed cost of acquiring information in the denominator.

Changing the available supply will then affect the compensation required by investors

the Wallace (1981) irrelevance result, as articulated in Curdia and Woodford (2011), and also assumed in, for instance, Caballero and Simsek (2021) and Vayanos and Vila (2021). If the central bank's losses were instead passed back to our investors, the risk transfer would be undone and asset purchases would be neutral. See Online Appendix C.3 for more discussion on this point, and Iovino and Sergeyev (2023) for a model where asset purchases are not neutral even without this assumption.

[21] The two views are equivalent because the average size of the investment of investors is proportional to $1 - \delta_0 - \bar{q}$ in this mean-variance world, which is the risk premium.

to hold default risk through two opposite channels: (i) a direct (quantity) balance sheet effect, as less risk is supplied to the private market; (ii) an indirect composition effect, as fewer informed investors with greater risk-bearing capacity are present.

Proposition 5 (Risk Premium and Asset Purchases)**.** *Assume that $\psi^* < \psi_s$. The balance sheet effect of asset purchases always reduces the risk premium attached to sovereign bonds, but is partially offset by the weakening of incentives to acquire information:*

$$\frac{d(1-\delta_0-\bar{q})}{dx_1} = -\frac{1}{\tau+\tau'\psi^*-\phi\gamma}\left(\underbrace{\gamma}_{\textit{Balance Sheet Effect}} - \underbrace{\tau'\frac{(1-\delta_0-\bar{q})^2}{2\bar{U}}}_{\textit{Information Effect}}\right) < 0 \qquad (28)$$

The balance sheet effect however always dominates, guaranteeing that the risk premium on sovereign bonds is decreasing when the central bank implements asset purchases.

Because of the balance sheet force, asset purchases have another indirect equilibrium effect, by shifting the roll-over information threshold ψ_s. Remember that information acquisition has two competing effects on prices: it reduces the risk premium, pushing up prices and thus making self-fulfilling default less likely, but also increases the response of prices to bad news, pushing down prices in this event and thus making self-fulfilling default more likely. Because of the balance sheet effect, asset purchases reinforce the risk-premium effect, which means that even more information acquisition is needed to push prices down enough in the $\tilde{s} = -s$ case to trigger a roll-over crisis. This can be seen formally by looking at the expression of ψ_s in the case with asset purchases x_1:

$$\psi_s(x_1) = \psi_s(0) + x_1\frac{\gamma}{\tau'\left(q^* - (1-\delta_0-s)\right)} \qquad (29)$$

Once again, the impact of asset purchases on the threshold ψ_s is controlled by the risk-bearing capacity of investors (γ) since this is a consequence of the balance sheet effect.

3.2 Preventing Roll-Over Crises

Section 2 showed how information acquisition can be excessive and lead to roll-over crises. We then showed in Section 3.1 that asset purchases reduce the incentives to acquire information.[22] Putting these two results together delivers the main insight of the

[22] Online Appendix C.4 studies the case where the market is uncertain about the precise size of asset purchases to be implemented by the central bank. I show that the introduction of uncertainty over it increases the expected utility of informed traders. As a result, this pushes for more information acquisition.

paper: when the sovereign is fragile (ψ_s is relatively low) and information acquisition is excessive, reducing the information content of sovereign bond prices can become a feature rather than a bug of asset purchases: it can prevent the possibility of roll-over crises by reducing the response of bond prices to new information.

Proposition 6 (Avoiding Roll-Over Crises)**.** *If the cost of acquiring information $\bar{U}$ is within $[\bar{U}_m, \bar{U}_M]$ where:*

$$\bar{U}_m = \frac{\tau'}{2\gamma} \cdot \frac{(\tau - \phi\gamma)^2 s^2}{(\tau + \psi_s \tau' + \frac{b\gamma}{(q^* - (1-\delta_0 - s))} - \phi\gamma)^2} \tag{30}$$

then the laissez-faire equilibrium features excessive information production but there exists a minimum level of asset purchases by the central bank that ensures that there is a single equilibrium without roll-over crises at $t = 2$.

The resulting minimum size of asset purchases x_1^* is a complicated function of all the underlying parameters because it is the result of two forces (going in the same direction): first, there is the direct effect of asset purchases on information acquisition incentives, that we fleshed out in Proposition 4. Second, there is the indirect effect of asset purchases on the threshold ψ_s through the balance sheet effect, that we characterized in Equation (29).

Finally, the model reveals a limit to what asset purchases can achieve through this mechanism, as encapsulated in the lower bound $\bar{U}_m$ in information costs. Purchases initially reduce information acquisition by compressing the risk premium and raising the roll-over threshold. But this force is not monotone. Once the central bank has absorbed enough bonds that the net supply left to private investors is very small, further purchases can make the bond expensive relative to its expected payoff. Informed investors then have an incentive to take the opposite side of the central bank's position. This renewed speculative motive can increase information acquisition again, raising the sensitivity of prices to signals.

3.3 Discussion of Mechanisms

The results presented in this section are the product of two key features of the environment. First, information acquisition can lead to self-fulfilling crises in the future. Second, asset purchases by the central bank weaken the incentives of private agents to engage in information acquisition. Government intervention is thus helpful to "make markets more boring" in order to prevent costly runs. The specific channel through which asset purchases affect information acquisition incentives in my model is through the equilibrium supply of bonds, as explained in Section 3.1. This is not, however, crucial for my results.

The main insight of this paper is to argue that government intervention (by virtue of being a large player) can be beneficial by precisely impairing the regular functioning of financial markets when assets can be subject to self-fulfilling runs. Other channels weakening information acquisition could be considered: for example in Brunnermeier et al. (2022), agents prefer to acquire information about the noise induced by policy actions rather than fundamentals. Relatedly, while not the focus of this paper, asset purchases can also eliminate multiplicity in information acquisition equilibria. This in turn eliminates the risk of roll-over crises. We keep the analysis of this channel in Online Appendix D.4.

Finally, note that here the central bank's intervention is targeted to avoid multiplicity, but is distinct from the one commonly found in the literature. Starting with the canonical model of Diamond and Dybvig (1983), the mere existence of a credible backstop eliminates the bad equilibrium. This logic also applies to the models of Reis (2013) and Corsetti and Dedola (2016), where the central bank does not have to use any resources on the equilibrium path.[23] By contrast, we do see the ECB routinely buying substantial amounts of sovereign debt, suggesting that this is not the whole story. Furthermore, Lorenzoni and Werning (2019) clarify that in their setup an interest rate ceiling requires a credible commitment to cut spending in this event, which seems implausible. In their words, "there appears to be no easy fix to the multiplicity problem." My paper suggests that actually carrying out asset purchases, under some conditions, can be a possible fix to the problem. Proposition 6 shows that, in my model, eliminating future sunspot equilibria requires the central bank to actually carry out asset purchases, and potentially by a substantial amount if ψ is far above the threshold ψ_s.[24]

4 Suggestive Empirical Evidence

A direct implication of the model is that asset purchases will lower the amount of information production in equilibrium. I provide here some consistent suggestive evidence. Because the data are limited, I look at different and unrelated measures.[25] All point to-

[23]In all these models featuring multiplicity, a seemingly simple solution (going back to Calvo 1988) to avoid the bad equilibrium is to credibly announce a ceiling on interest rates (for example by abstaining from issuance, or through a lender of last resort mechanism). By eliminating self-fulfilling beliefs about defaults, the bad equilibrium disappears and no action has to be taken in equilibrium. This is the common interpretation attached to the 2012 announcement by Mario Draghi, where he promised to do "whatever it takes" to preserve stability in the Eurozone (see also Bocola and Dovis (2019b) for a quantitative analysis of this episode). Without implementing any transaction, this sole announcement lowered the spreads of sovereign bonds issued by the distressed European countries. Cochrane et al. (2025) provide a critique.

[24]Kohlhas (2020) provides a complementary rationale for policy action over disclosure.

[25]Details on the data and the construction of the variables are provided in Appendix B.

wards the direction consistent with my theory: there is a drop in informativeness after 2015, which is when the ECB started to buy massive amounts of Italian bonds (Figure 1).[26]

4.1 Relative Price Informativeness

I construct the relative price informativeness measure proposed by Dávila and Parlatore (2023) for Italian sovereign bonds. This measure is based on the idea that, when prices contain relatively little information, their forecasting power for fundamentals should be relatively lower. In the literature, the fundamentals in question are usually taken to be firm earnings as a proxy for the cash flow of a stock. For sovereign bonds, however, cash flows are unrelated to fundamentals as long as defaults are not observed. To circumvent this issue, I obtain data on the expected probability of default of Italy, provided by LSEG (formerly Refinitiv) StarMine through their Structural Sovereign Risk Model (SR), evaluated at five horizons: one, three, five, seven, and ten years.[27] Data are available at a monthly frequency, and the sample runs from 2010 to 2022.

I then study how bond prices contain information about these expected probabilities. Figure 4 presents the 12-month rolling window estimates, showing that the informativeness of Italian sovereign bonds declines significantly after the ECB starts its asset purchase program in early 2015. The figure also shows an increase in information contained in market prices in 2018, when the ECB slows down its asset purchase program, and even stops buying bonds at the end of 2019.

4.2 Informativeness from Issuance Results

Cole et al. (2025) show how one can measure the intensity of information acquisition by comparing the yields of sovereign bonds at auctions and in the secondary market. They do this in two ways. First, one can estimate the unexplained variance of sovereign yields during auction day, and compute the share of it that can be explained by using

[26] A potential and important confounding factor is that the ECB would convey some information about fundamentals by engaging in large-scale asset purchases, for instance through the quantity it was buying of each country. While this would surely be a concern for purchases done through the PEPP in 2020, aimed at countering "fragmentation" and rising spreads, the PSPP launched in 2015 was aimed at deflation risk. The program was designed by looking at inflation expectations from inflation swaps at the Eurozone level, and purchases were allocated across euro-area jurisdictions using the ECB capital key. See Hubert, Blot, Bozou and Creel (2024) for the analysis of the signaling effect of the PSPP and PEPP programs. We thus view it as a relatively clean shock to outstanding supply, orthogonal to the fiscal fundamentals.

[27] Methodological details are available at https://www.lseg.com/en/data-analytics/financial-data/analytics/quantitative-analytics/starmine-sovereign-risk-model. What matters here is not necessarily that the expected probability of default is accurate, but rather that it reflects the expectations of market participants.

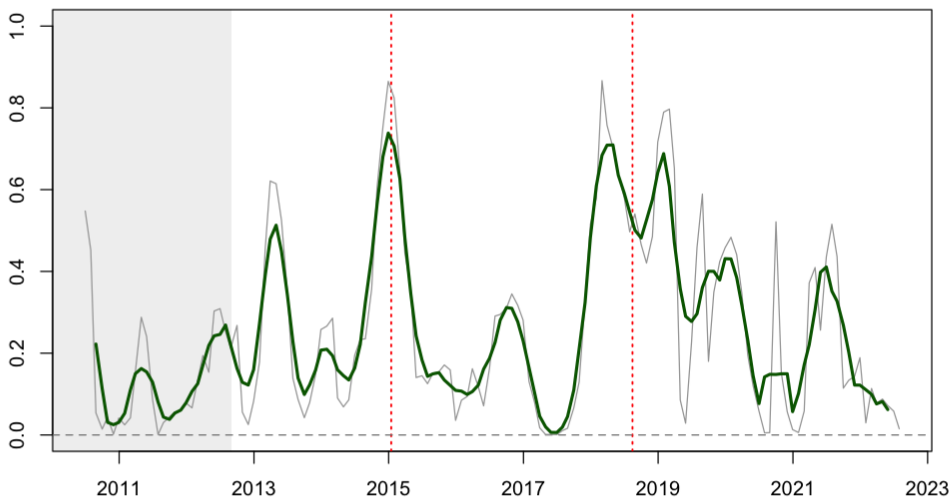


Figure 4: Relative Price Informativeness of Italian Sovereign Bonds. This Figure plots the 12-month rolling average of relative price informativeness (in light grey) and the smooth 5-month centered moving average (in green). The grey area indicates the Eurozone crisis. The first vertical line indicates the start of the asset purchase program by the ECB, and the second vertical line indicates the slowing down of the program followed by its halt (see Figure 1).

auction results. This is a measure of the amount of information contained in primary markets (where informed investors are assumed to participate) that is then incorporated in secondary markets. Second, one can estimate the elasticity of secondary market yields to primary market yields: secondary market yields should react more strongly to news in auctions when there are more informed investors.

I run these exact exercises also on 12-month rolling windows, for Italian sovereign bonds.[28] Figures 5 and 6 show a pattern consistent with the theory: a sharp drop in information content during the large-scale asset purchase program of the ECB, and a significant increase when the program is slowed down and eventually stopped. Again, the patterns are broadly consistent with the idea that asset purchases by the ECB have weakened the incentives to acquire information, and thus reduced the amount of information incorporated in bond prices.[29]

[28] I am very grateful to Guillermo Ordoñez for sharing his data on this. The details of the empirical exercises are included in Appendix B.2.

[29] Appendix E provides additional empirical evidence consistent with the theory, studying the variance of private analysts' forecast errors, and abnormal returns around ECB Events using recently released data from Istrefi et al. (2022).

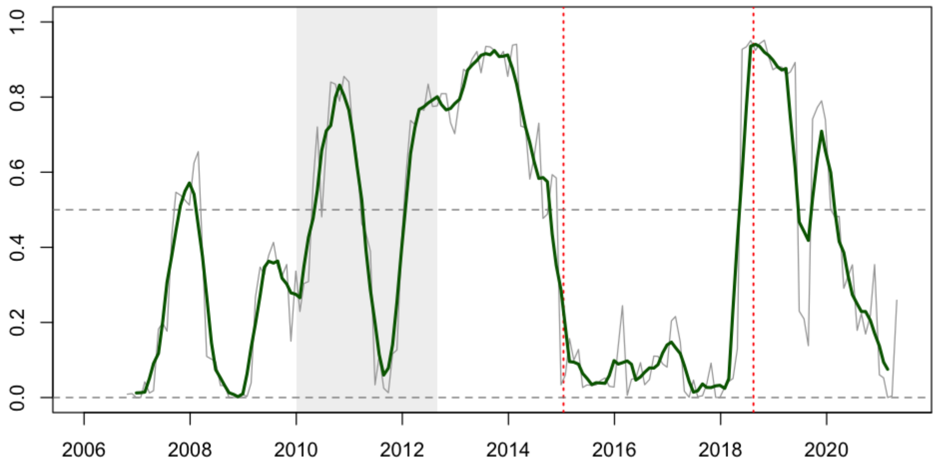


Figure 5: Marginal R^2 using auction yields. This statistic measures the fraction of unexplained secondary market yield variance explained by primary yields. The grey area indicates the Eurozone crisis. The first vertical line indicates the start of the asset purchase program by the ECB, and the second vertical line indicates the slowing down of the program followed by its halt (see Figure 1).

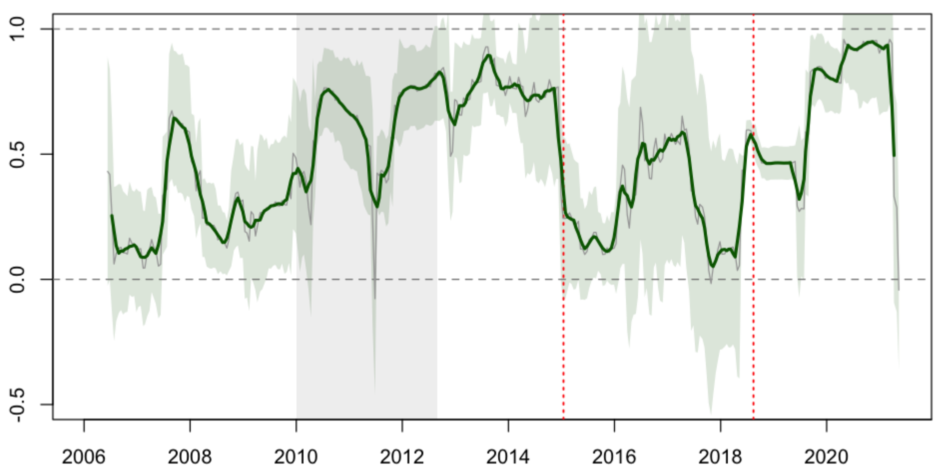


Figure 6: Elasticity of secondary yields to auction yields. This statistic measures the reaction of secondary yields to the surprise innovation in primary yields. The grey area indicates the Eurozone crisis. The first vertical line indicates the start of the asset purchase program by the ECB, and the second vertical line indicates the slowing down of the program followed by its halt (see Figure 1).

5 Extensions and Robustness

5.1 Fixed Expenditures at $t = 1$

The stylized model presented in the core of the paper assumed a convenient formulation for the supply of bonds, $b_1 = B_1 - \phi q_1$, in order to achieve analytical solutions. This section verifies that all the insights presented above go through when we instead assume that the sovereign must finance a fixed amount of expenditures B_1, such that the supply of bonds is given by $b_1 = B_1/q_1$. Figure 7 shows the equivalent behavior of prices with respect to information production, as in Figure 2. While closed-form solutions are not available anymore, the insights are similar.

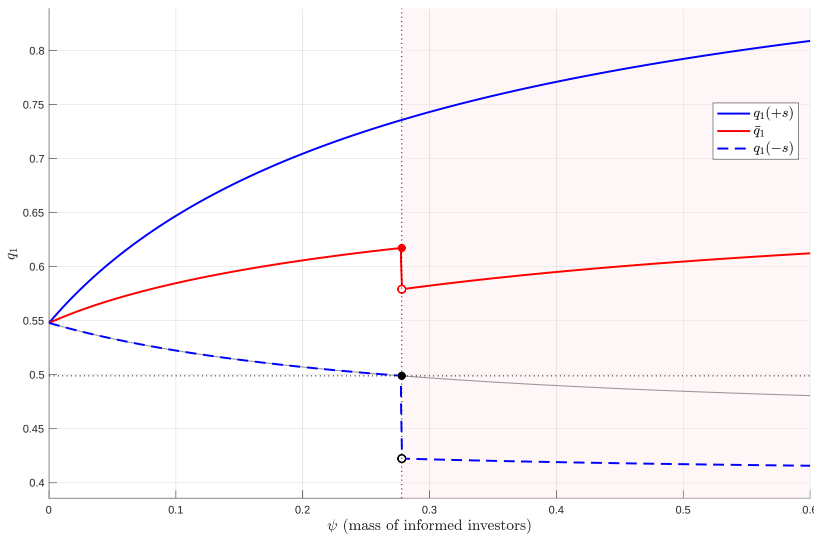
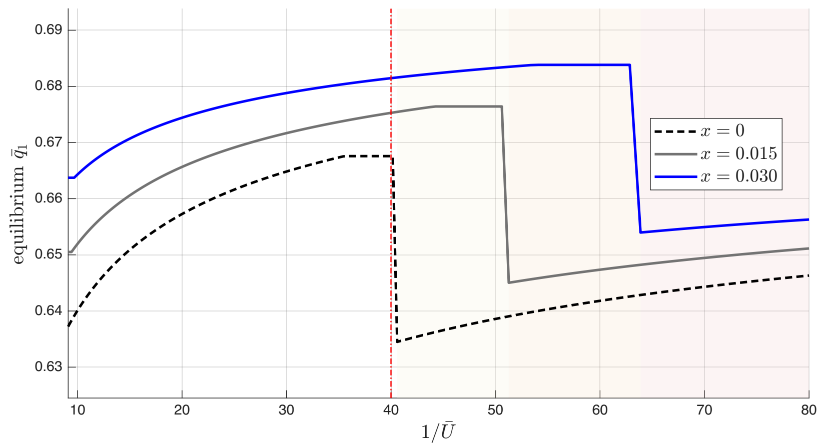


Figure 7: Equilibrium Prices and Information Acquisition. This figure plots the equilibrium price on the sovereign bond asset as a function of the number of investors that acquire information, in the case where $b_1 = B_1/q_1$. The black dotted line is the threshold price fleshed out in Section 2.1.

Figure 8 then verifies that asset purchases function in the same way. It presents the average price of the debt issued by the sovereign when the costs of acquiring information are changing. This exercise shows that, when the central bank purchases some fraction of the bonds issued by the sovereign, the debt can remain safe for a larger space of information acquisition costs. If information acquisition is excessive, in the sense that the bond is subject to self-fulfilling defaults in the event of a bad signal, the central bank can then intervene to make sure that, for the same costs of acquiring information, the incentives are reduced enough that the price in the bad-signal state of the world can still sustain the safe-zone equilibrium.

Figure 8: Bond Prices and Asset Purchases with Fixed Expenditures This figure plots the equilibrium average price on the sovereign bond asset, $\bar{q}_1$, as a function of $1/\bar{U}$, where $\bar{U}$ denotes the costs of information acquisition, in the case where $b_1 = B_1/q_1$. The lines correspond to different levels of asset purchases. The shaded regions indicate crisis zones.



5.2 Optimal Debt Issuance at $t = 1$

Both the main framework used to present the results and the previous extension assumed a mechanical relation between the price q_1 and the level of issuance by the sovereign b_1. It is natural to believe, however, that a country faced with such prices at issuance would reduce its indebtedness in order to avoid the occurrence of roll-over crises. This extension shows that this is not necessarily the case.

We thus assume for this part that the government also consumes at time $t = 1$, and maximizes life-time utility:

$$V_1 = u(c_1) + u(c_2) + \beta u(c_3) \tag{31}$$

where u is a CRRA utility function. The sovereign receives an endowment y_1 in period 1, and thus consumes $c_1 = y_1 + q_1 b_1$. The government decides how much to issue optimally, understanding how equilibrium prices are formed. In other words, the government realizes that for some levels of issuance, information acquisition in equilibrium is high enough such that the country will face roll-over crises in the future in some states of the world. Figure 9 plots the lifetime welfare level of the sovereign at $t = 1$ along different levels of issuance b_1. This figure shows clearly how, above some level of issuance, welfare drops discontinuously because of the possibility of self-fulfilling default at $t = 2$.

Figure 9 illustrates that the government must balance the costs of facing possible roll-over crises in the future with the benefits of consumption smoothing. For high levels of endowment y_1 in period 1, the consumption smoothing motive is muted. When y_1 be-

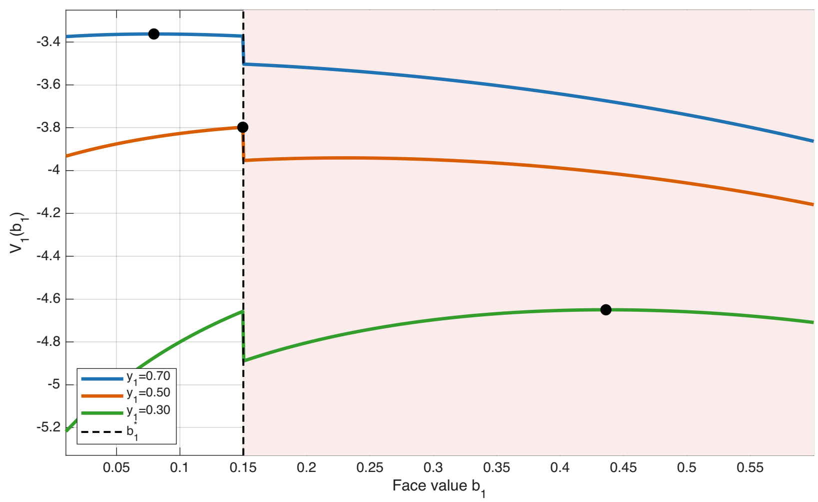


Figure 9: Sovereign's Issuance Strategy for different levels of endowment y_1. Each line represents the expected utility of the sovereign when the bond issuance level b_1 varies, using the assumption of a CRRA utility function. The black dots indicate the maximum utility level and thus the optimal issuance strategy of the sovereign in each case.

comes low enough, consumption smoothing becomes important enough for the sovereign to accept being exposed to self-fulfilling defaults later on.

5.3 Anticipated Asset Purchases and Moral Hazard

The previous section shows that, in this setup, sovereigns can willingly expose themselves to possible roll-over crises. Since we also showed that the central bank can play a stabilizing role by stepping in, this naturally leads to the question of moral hazard. If the sovereign realizes that the central bank will intervene, how does that change optimal debt issuance? We assume that the central bank intervenes by buying enough bonds to prevent the equilibrium ψ from crossing the crisis threshold.

Figure 10 shows the equilibrium issuance level with and without asset purchases, again for different levels of endowment y_1. The left and right panels illustrate a perhaps expected result. If the sovereign has enough resources in period 1, it does not need to issue too much debt, and the central bank backstop is irrelevant. In the case where the government exposes itself to roll-over crises irrespective of asset purchases, the anticipated action of the central bank leads the sovereign to issue even more. Indeed, the sovereign now faces higher bond prices which makes it more attractive to borrow.

The key result is depicted on the center panel of Figure 10. In the case where y_1 takes intermediate values between the cases we just described, the sovereign would normally not expose itself to self-fulfilling roll-over crises, but issue as much as possible before

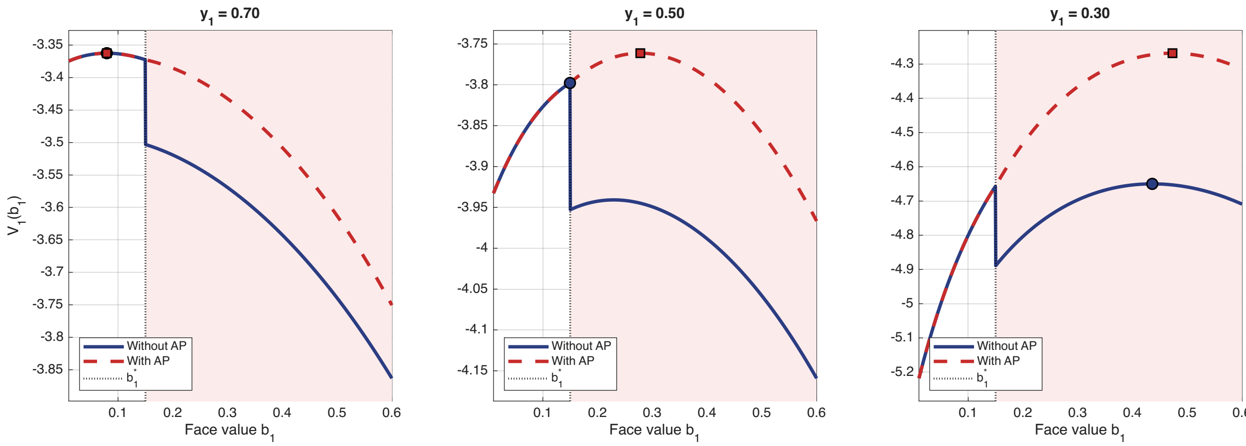


Figure 10: Sovereign's Welfare for different levels of issuance B_1, taking into account that the central bank can implement asset purchases. The red square indicates the optimal level of issuance when asset purchases are anticipated.

hitting this region. However, the anticipation of asset purchases leads the sovereign to issue more bonds: so many more that, without asset purchases, this level would lead to multiple equilibria at $t = 2$. This leads to "excessive" indebtedness, forcing the central bank to run an inflated balance sheet to avoid roll-over crises, with prices potentially disconnected from fundamentals (Cochrane et al. 2025).

6 Conclusion

This paper proposes a new theory of large-scale asset purchases of sovereign bonds by central banks. The key innovation of the model is to allow for endogenous information production. While information acquisition reduces the uncertainty faced by investors and thus lowers risk premia, it makes bond prices more sensitive to new information. When a large number of investors acquire information, bond prices fall substantially after negative information, which can precipitate the sovereign into costly roll-over crises.

The second key result of the paper is that asset purchases by the central bank can play a stabilizing role in this setup. By transferring risks away from private balance sheets, the central bank discourages information acquisition. While this hampers price informativeness, my paper argues that it could be a feature rather than a bug of such large-scale programs. By implementing (potentially substantial) purchases, the central bank can avoid the occurrence of roll-over crises in the event of bad news, potentially avoiding costly self-fulfilling defaults. Finally, when the sovereign expects the central bank to carry out such programs, it leads to excessive indebtedness, forcing the central bank to run an inflated balance sheet to avoid roll-over crises, with bond prices disconnected from fundamentals.

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Appendices

A Proofs and Derivations

A.1 Self-Fulfilling Default: Details

This part is standard and follows Aguiar and Amador (2019). The sovereign auctions new short-term debt b_2 and then decides whether to repay b_1 after the auction is completed, facing prices $q(b_1, b_2)$ for its newly issued bonds. The value of repayment, conditional on b_2, is:

$$V^R(b_1, b_2) = u(y_2 - b_1 + q(b_1, b_2)b_2) + \beta V_3(b_2) \tag{A.1}$$

The government repays its debt b_1 if and only if the value of repayment is above the value of defaulting V_2^D, which we take as exogenous: $V^R(b_1, b_2) \geq V_2^D$. If the country is faced with bond prices of 0 for the entire schedule and does not default on its debt b_1, its value function will be:

$$\underline{V}^R(b_1, 0) = u(y_2 - b_1) + \beta V_3(0) \tag{A.2}$$

If instead the country decides to default, it will enjoy V_2^D. There will thus be multiple equilibria if and only if:$\underline{V}^R(b_1, 0) < V_2^D$. Indeed, when that is the case, a zero price is consistent with individual lenders' optimization: they will not bid a positive price since the government will default.[30] We denote by b^* the threshold at which a higher issuance leads to multiple equilibria in the next period. Figure 11 shows graphically when multiplicity appears. Importantly, the exogenous default risk δ affects investors' payoffs conditional

[30] See Aguiar and Amador (2019) for a clear exposition of why the Cole and Kehoe (2000) timing assumptions can lead to multiplicity, and the comparison to the Eaton and Gersovitz (1981) model.

on repayment, but does not affect the government's roll-over decision here; accordingly, b^* is independent of δ, of the signal $\tilde{s}$, and of the informed investors mass ψ.

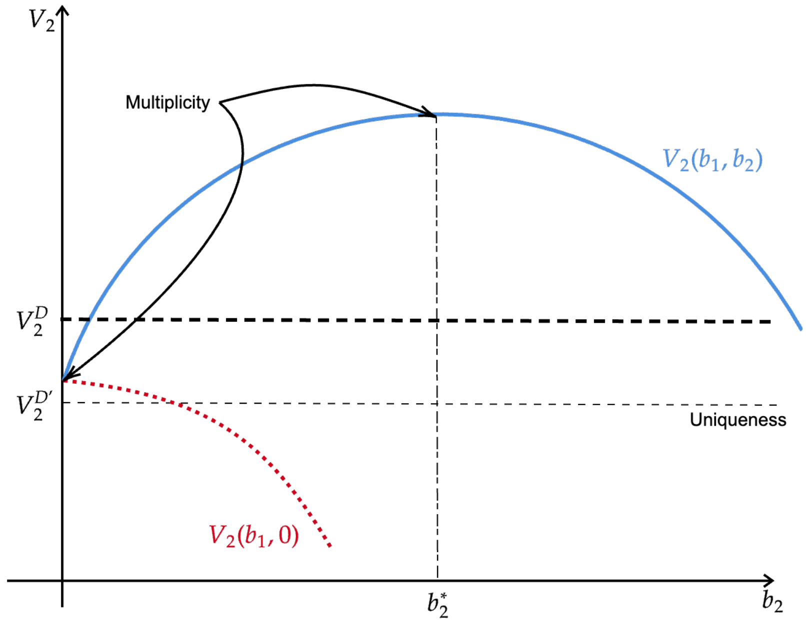

Figure 11: Multiplicity or Uniqueness at $t = 2$. The blue line is the value function when the country repays its debt and issues b_2 in new debt, with a positive price. The red dotted line is the value function when the country repays its debt but cannot issue new debt at a positive price. If this value is below the default value, then the country decides to default and two equilibria are possible. This graph is taken from Aguiar and Amador (2019).

A.2 Information Threshold (Definition 1)

Using the equilibrium price in case of a negative signal:

$$q^* = \frac{(1-\delta_0)(\tau + \psi_s \tau') - \gamma B_1}{\tau + \psi_s \tau' - \phi\gamma} - \frac{\psi_s \tau'}{\tau + \psi_s \tau' - \phi\gamma} s \tag{A.3}$$

which is re-arranged as:

$$q^*(\tau + \psi_s \tau' - \phi\gamma) = (1-\delta_0)(\tau + \psi_s \tau') - \gamma B_1 - \psi_s \tau' s \tag{A.4}$$

$$\implies \psi_s \tau' \left(q^* - 1 + \delta_0 + s\right) = (1-\delta_0)\tau - \gamma B_1 - q^*(\tau - \phi\gamma) \tag{A.5}$$

which yields the final formula in Definition 1:

$$\psi_s = \frac{\tau\left(1 - \delta_0 - q^*\right) - \gamma(B_1 - \phi q^*)}{\tau'\left(q^* - (1 - \delta_0 - s)\right)} \tag{A.6}$$

Note that the denominator is positive, since we are studying the case where Assumption 2 holds: ${}^{dq(-s;\psi)}/_{d\psi} < 0$, and as long as there is no sunspot $q(-s;\psi) \xrightarrow[\psi\to+\infty]{} 1-\delta_0-s$.[31]

A.3 Expressions for $\psi > \psi_s$

Multiple equilibria at $t = 2$ can only arise when informed investors receive the negative signal, since this is the only case where the price can be low enough to trigger a roll-over crisis. The market clearing condition in this case is given by:

$$B_1 - \phi q_1 = \psi\tau'_\lambda \frac{(1-\lambda)(1-\delta_0-s)-q_1}{\gamma} + \tau_\lambda \frac{(1-\lambda)(1-\delta_0)-q_1}{\gamma} \tag{A.7}$$

where we assumed that uninformed investors observe that the quantity of debt is higher than b^*, so update their expectations to include the sunspot default possibility. Solving for the equilibrium price yields:

$$q_{1,\lambda}(-s) = \frac{(1-\lambda)(1-\delta_0)(\tau_\lambda+\psi\tau'_\lambda) - \psi\tau'_\lambda(1-\lambda)s - \gamma B_1}{\tau_\lambda+\psi\tau'_\lambda-\phi\gamma} \tag{A.8}$$

A.4 Expected Utility when $\psi \leq \psi_s$

The optimal demand of an informed investor with precision τ', conditional on signal $\tilde{s}$ and price $q_1(\tilde{s})$, is:

$$b_I(\tilde{s}) = \tau' \cdot \frac{1-\delta_0+\tilde{s}-q_1(\tilde{s})}{\gamma} \tag{A.9}$$

Substituting back into the mean-variance objective $U = \mathbb{E}[b\chi] - bq_1 - \frac{\gamma}{2}\mathbb{V}[b\chi]$, the utility conditional on $\tilde{s}$ is:

$$U_I(\tilde{s}) = \frac{\tau'}{2\gamma}\left(1-\delta_0+\tilde{s}-q_1(\tilde{s})\right)^2 \tag{A.10}$$

Using $q_1(\tilde{s}) = \bar{q} + \Psi\tilde{s}$, we can write:

$$1-\delta_0+\tilde{s}-q_1(\tilde{s}) = (1-\delta_0-\bar{q}) + (1-\Psi)\tilde{s} \tag{A.11}$$

so that:

$$U_I(\tilde{s}) = \frac{\tau'}{2\gamma}\left[(1-\delta_0-\bar{q}) + (1-\Psi)\tilde{s}\right]^2 \tag{A.12}$$

[31] The fact that the limit price is the risk-neutral one arises because when ψ grows each trader has only an infinitesimal position, so the required compensation for risk vanishes. See Online Appendix D.1 for the study of the case where there is a fixed number of investors, and each one decides whether to acquire information or not. In that case, the limit price is different from the risk-neutral one, since with maximum information acquisition there is still limited balance sheet capacity.

Since $\tilde{s} \in \{-s, s\}$ with equal probability:

$$
\begin{aligned}
\mathbb{E}[U_I] &= \frac{1}{2}U_I(s) + \frac{1}{2}U_I(-s) \\
&= \frac{\tau'}{4\gamma}\left[\left((1-\delta_0-\bar{q}) + (1-\Psi)s\right)^2 + \left((1-\delta_0-\bar{q}) - (1-\Psi)s\right)^2\right] \qquad \text{(A.13)}
\end{aligned}
$$

Expanding both squares and using the identity $(A+B)^2 + (A-B)^2 = 2A^2 + 2B^2$:

$$
\mathbb{E}[U_I] = \frac{\tau'}{2\gamma}\left[(1-\delta_0-\bar{q})^2 + (1-\Psi)^2 s^2\right] \qquad \text{(A.14)}
$$

We now substitute the equilibrium objects $\bar{q}$ and Ψ:

$$
\begin{aligned}
1-\delta_0-\bar{q} &= \frac{\gamma \underline{b}}{\tau + \psi\tau' - \phi\gamma} \qquad \text{(A.15)} \\
1-\Psi &= \frac{\tau - \phi\gamma}{\tau + \psi\tau' - \phi\gamma} \qquad \text{(A.16)}
\end{aligned}
$$

where $\underline{b} \equiv B_1 - \phi(1-\delta_0)$. Substituting both expressions into (A.14):

$$
\mathbb{E}[U_I] = \frac{\tau'}{2\gamma} \cdot \frac{\gamma^2 \underline{b}^2 + (\tau - \phi\gamma)^2 s^2}{(\tau + \psi\tau' - \phi\gamma)^2} \qquad \text{(A.17)}
$$

Defining the constant $\Omega \equiv \gamma^2 \underline{b}^2 + (\tau - \phi\gamma)^2 s^2$, we obtain the compact expression:

$$
\mathbb{E}[U_I] = \frac{\tau' \, \Omega}{2\gamma \left(\tau + \psi\tau' - \phi\gamma\right)^2} \qquad \text{(A.18)}
$$

Note that Ω does not depend on ψ: all the dependence on the mass of informed investors is isolated in the denominator $(\tau + \psi\tau' - \phi\gamma)^2$, which is increasing in ψ. The expected utility of informed investors is thus unambiguously decreasing in ψ: as more informed investors enter, competition among them compresses profits.

A.5 Proof of Proposition 1

Given the definition of ψ-equilibrium in Definition 2, we need to verify two aspects: (i) the expected utility of informed investors is decreasing in ψ after ψ_s; and (ii) when the discontinuity of the expected utility of informed investors at ψ_s is a *downward* jump.

Let $p_0 \equiv 1 - \delta_0 - s$ denote the expected payoff under the bad signal in the safe zone. Using the equilibrium price (19) for the negative signal and after ψ_s, the expected utility of an informed investor is given by:

$$\mathbb{E}_{\lambda,U}[U_I] = \frac{\tau'}{4\gamma(\tau+\psi\tau'-\phi\gamma)^2}\big(\gamma(B_1-(1-\delta_0)\phi)+(\tau-\phi\gamma)s\big)^2 + \frac{\tau'_\lambda}{4\gamma(\tau_\lambda+\psi\tau'_\lambda-\phi\gamma)^2}\big(\gamma B_1-(1-\lambda)\left[s\tau_\lambda+\phi\gamma p_0\right]\big)^2. \quad \text{(A.19)}$$

Both numerators in (A.19) are independent of ψ, while both denominators are increasing in ψ. Hence $\mathbb{E}_{\lambda,U}[U_I]$ is strictly decreasing in ψ for $\psi > \psi_s$, which proves (i).

It remains to show that the jump at ψ_s is downward. Since sunspot equilibria can arise only after the bad signal, the good-signal contribution to expected utility is the same on both sides of ψ_s. We can therefore compare only the bad-signal term.

By definition of ψ_s, the safe-zone bad-signal price satisfies $q_1(-s;\psi_s) = q^*$. The bad-signal contribution to expected utility just below the threshold is thus:

$$\frac{\tau'}{2\gamma}\big(p_0-q^*\big)^2 = \frac{\tau'}{2\gamma}\big(q^*-p_0\big)^2. \quad \text{(A.20)}$$

Just above the threshold, the crisis-zone bad-signal excess return is:

$$(1-\lambda)p_0 - q_{1,\lambda}(-s;\psi_s) = \frac{\gamma B_1-(1-\lambda)\left[s\tau_\lambda+\phi\gamma p_0\right]}{\tau_\lambda+\psi_s\tau'_\lambda-\phi\gamma}. \quad \text{(A.21)}$$

Therefore the bad-signal contribution to expected utility just above the threshold is:

$$\frac{\tau'_\lambda}{2\gamma}\left(\frac{\gamma B_1-(1-\lambda)\left[s\tau_\lambda+\phi\gamma p_0\right]}{\tau_\lambda+\psi_s\tau'_\lambda-\phi\gamma}\right)^2. \quad \text{(A.22)}$$

Under condition (23), and using $\tau'_\lambda < \tau'$ together with $\tau_\lambda+\psi_s\tau'_\lambda-\phi\gamma > \tau_\lambda-\phi\gamma$:

$$\frac{\tau'_\lambda}{2\gamma}\left(\frac{\gamma B_1-(1-\lambda)\left[s\tau_\lambda+\phi\gamma p_0\right]}{\tau_\lambda+\psi_s\tau'_\lambda-\phi\gamma}\right)^2 < \frac{\tau'}{2\gamma}\left(\frac{\left|\gamma B_1-(1-\lambda)\left[s\tau_\lambda+\phi\gamma p_0\right]\right|}{\tau_\lambda-\phi\gamma}\right)^2 < \frac{\tau'}{2\gamma}\big(q^*-p_0\big)^2. \quad \text{(A.23)}$$

Hence the bad-signal contribution to expected utility is smaller above ψ_s than below it. Since the good-signal contribution is unchanged, the total expected utility jumps downward at ψ_s. Combined with monotonicity on each side of the threshold, this proves that the information-acquisition equilibrium is unique. □

A.6 Proof of Proposition 2

Setting $\mathbb{E}[U_I] = \bar{U}$ as the entry condition for information acquisition, we have:

$$\frac{\tau' \Omega}{2\gamma \left(\tau + \psi\tau' - \phi\gamma\right)^2} = \bar{U} \implies \left(\tau + \psi\tau' - \phi\gamma\right)^2 = \frac{\tau' \Omega}{2\gamma\bar{U}} \tag{A.24}$$

Taking the positive square root (since $\tau + \psi\tau' - \phi\gamma > 0$ by the stability condition $\tau > \phi\gamma$):

$$\tau + \psi\tau' - \phi\gamma = \sqrt{\frac{\tau' \Omega}{2\gamma\bar{U}}} \tag{A.25}$$

Solving for ψ:

$$\psi^* = \frac{1}{\tau'}\left(\sqrt{\frac{\tau' \Omega}{2\gamma\bar{U}}} - (\tau - \phi\gamma)\right) \tag{A.26}$$

which is positive whenever:

$$\bar{U} < \frac{\tau' \Omega}{2\gamma(\tau - \phi\gamma)^2} \tag{A.27}$$

i.e., whenever the reservation utility is low enough that it is profitable for at least some investors to enter. When this condition fails, no investor enters and $\psi^* = 0$. □

A.7 Proof of Proposition 3

If the equilibrium ψ^* is below the threshold ψ_s characterized in Definition 1, then $q_1(s;\psi^*) \geq q_1(-s;\psi^*) \geq q^*$ and a single equilibrium is guaranteed at $t = 2$. We thus only need to verify that:

$$\frac{1}{\tau'}\left(\sqrt{\frac{\tau' \Omega}{2\gamma\bar{U}}} - (\tau - \phi\gamma)\right) \leq \psi_s \tag{A.28}$$

since $\mathbb{E}[U_I](\psi)$ is monotone. This is simply equivalent to (replacing Ω):

$$\bar{U} \geq \frac{\tau'(\gamma^2\underline{b}^2 + (\tau - \phi\gamma)^2 s^2)}{2\gamma\left(\tau + \tau'\psi_s - \phi\gamma\right)^2} \tag{A.29}$$

□

A.8 Proof of Proposition 4

Rearrange equation (A.26):

$$\left(\tau'\psi^* + (\tau - \phi\gamma)\right)^2 = \frac{\tau'}{2\gamma\bar{U}}\left(\gamma^2(B_1 - x_1 - \phi(1-\delta_0))^2 + (\tau - \phi\gamma)^2 s^2\right) \tag{A.30}$$

Taking derivatives:

$$2\tau' d\psi^* \left(\tau'\psi^* + (\tau - \phi\gamma)\right) = -\frac{\tau'}{\bar{U}}\gamma dx_1 (B_1 - x_1 - \phi(1-\delta_0)) \tag{A.31}$$

so that:

$$\frac{d\psi^*}{dx_1} = -\frac{\gamma}{2\bar{U}}\frac{B_1 - x_1 - \phi(1-\delta_0)}{\tau + \tau'\psi^* - \phi\gamma} \tag{A.32}$$

Plugging $x_1 = 0$, and noticing that:

$$\gamma\frac{B_1 - \phi(1-\delta_0)}{\tau + \tau'\psi^* - \phi\gamma} = 1 - \delta_0 - \bar{q} \tag{A.33}$$

yields the end result:

$$\frac{d\psi^*}{dx_1} = -\frac{1 - \delta_0 - \bar{q}}{2\bar{U}} \tag{A.34}$$

□

A.9 Proof of Proposition 5

The risk-premium is defined by:

$$1 - \delta_0 - \bar{q} = \gamma\frac{B_1 - x_1 - \phi(1-\delta_0)}{\tau + \tau'\psi^* - \phi\gamma} \tag{A.35}$$

The total derivative is then (only x_1 and ψ^* can vary):

$$d(1 - \delta_0 - \bar{q}) = \gamma\frac{-dx_1(\tau + \tau'\psi^* - \phi\gamma) - \tau' d\psi^*(B_1 - x_1 - \phi(1-\delta_0))}{(\tau + \tau'\psi^* - \phi\gamma)^2} \tag{A.36}$$

Using the result from Proposition 4 we can write this as:

$$d(1 - \delta_0 - \bar{q}) = -\frac{dx_1}{\tau + \tau'\psi^* - \phi\gamma}\left(\gamma + \tau'\frac{d\psi^*}{dx_1}\gamma\frac{B_1 - x_1 - \phi(1-\delta_0)}{\tau + \tau'\psi^* - \phi\gamma}\right) \tag{A.37}$$

$$\implies d(1 - \delta_0 - \bar{q}) = -\frac{dx_1}{\tau + \tau'\psi^* - \phi\gamma}\left(\gamma - \tau'\frac{(1 - \delta_0 - \bar{q})^2}{2\bar{U}}\right) \tag{A.38}$$

evaluated at the baseline $x_1 = 0$. We can now show that the balance sheet effect always dominates. By contradiction, the information effect dominates if and only if:

$$\tau' \frac{(1 - \delta_0 - \bar{q})^2}{2\bar{U}} > \gamma \tag{A.39}$$

We show that this condition is never satisfied in equilibrium. Using the equilibrium expressions derived in Section 2.5:

$$1 - \delta_0 - \bar{q} = \frac{\gamma \underline{b}}{D}, \qquad \bar{U} = \frac{\tau' \Omega}{2\gamma D^2} \tag{A.40}$$

where $D \equiv \tau + \psi^* \tau' - \phi\gamma$ and $\Omega \equiv \gamma^2 \underline{b}^2 + (\tau - \phi\gamma)^2 s^2$. Substituting into the left-hand side of (A.39):

$$\begin{aligned} \tau' \frac{(1 - \delta_0 - \bar{q})^2}{2\bar{U}} &= \tau' \cdot \frac{\gamma^2 \underline{b}^2 / D^2}{2 \cdot \tau' \Omega / (2\gamma D^2)} \\ &= \frac{\gamma^3 \underline{b}^2}{\Omega} \end{aligned} \tag{A.41}$$

Note that the dependence on D, and hence on ψ^* and $\bar{U}$, cancels out. The condition (A.39) thus reduces to:

$$\frac{\gamma^3 \underline{b}^2}{\Omega} > \gamma \quad \iff \quad \gamma^2 \underline{b}^2 > \Omega = \gamma^2 \underline{b}^2 + (\tau - \phi\gamma)^2 s^2 \tag{A.42}$$

which requires $(\tau - \phi\gamma)^2 s^2 < 0$, hence the contradiction. □

A.10 Proof of Proposition 6

Consider again the expected utility of a prospective informed investor in the safe zone with asset purchases, from (A.18):

$$\mathbb{E}[U_I] = \tau' \frac{\gamma^2 (\underline{b} - x_1)^2 + (\tau - \phi\gamma)^2 s^2}{2\gamma \left(\tau + \psi\tau' - \phi\gamma\right)^2} \tag{A.43}$$

As a consequence, the expected utility (i) attains a minimum at $x_1 = \underline{b}$, and (ii) is strictly decreasing in x_1 in $[0, \underline{b}]$. At the point $\underline{b}$, the expected utility becomes:

$$\mathbb{E}[U_I] = \frac{\tau'}{2\gamma} \cdot \frac{(\tau - \phi\gamma)^2 s^2}{(\tau + \psi\tau' - \phi\gamma)^2} \tag{A.44}$$

At the same time, the new threshold $\psi_s(x_1)$ after that level of purchases is given by (see Equation 29):

$$\psi_s(\underline{b}) = \psi_s + \frac{\underline{b}\gamma}{\tau' \left(q^* - (1 - \delta_0 - s) \right)} \tag{A.45}$$

Now, given the jump is assumed to be downward, if $\bar{U}$ is above the expected utility evaluated at this new threshold, the equilibrium is guaranteed to be safe:

$$\bar{U} \geq \frac{\tau'}{2\gamma} \cdot \frac{(\tau - \phi\gamma)^2 s^2}{(\tau + \psi_s \tau' + \frac{\underline{b}\gamma}{(q^* - (1 - \delta_0 - s))} - \phi\gamma)^2} \tag{A.46}$$

□

B Empirical Analysis

B.1 Relative Price Informativeness from Default Probabilities

This part uses the methodology developed by Dávila and Parlatore (2023). This measure, however, is not directly applicable to the sovereign bond market, as it relies on regressions of current prices on *future cash flows*. In the case of Italy, no default happened in the sample, so cash-flows are constant, and hence no variation can be explained by movements in market prices. To adapt this methodology to this case, I instead propose to explain the variation in the *expected probability of default* of the country by market prices, rather than cash-flows. This also has the advantage of being close to the theoretical framework developed in the paper, where information acquisition is about the fundamental component of sovereign bond risk. I gather the expected probability of default of Italian sovereign bonds provided by LSEG, as detailed in the main text.

Dávila and Parlatore (2023) propose a bounded (between 0 and 1) and unit-free measure of informativeness, and show how to identify it. I use their results, using estimated probabilities of default instead of earnings. Dávila and Parlatore (2023) show that the relative price informativeness can be estimated by running the following two regressions:

$$\Delta y_t = \bar{\beta} + \beta_0 \Delta d_t + \beta_1 \Delta d_{t+6} + \varepsilon_t \tag{B.1}$$

$$\Delta y_t = \zeta\beta + \zeta_0 \Delta d_t + \varepsilon_t^{\zeta} \tag{B.2}$$

Denote respectively by $R^2_{\Delta d,\Delta d'}$ and $R^2_{\Delta d}$ the R-squared of these regressions. The relative price informativeness is then given by:

$$\tau^R_\pi = \frac{R^2_{\Delta d,\Delta d'} - R^2_{\Delta d}}{1 - R^2_{\Delta d}} \tag{B.3}$$

I look at 6-month changes in expected default probabilities (Δd) and average bond yields for 3 month, 3 year, and 5 year maturity (Δy). The forecasting is done at a 6-month horizon (Δd_{t+6}). I estimate τ^R_π on a rolling 12-month window, for each of the five horizons available for the estimated default probabilities, and take the average of the informativeness measures across horizons.

B.2 Informativeness from Auction Data[32]

Marginal R^2: The informativeness of primary market auctions is measured by computing the reduction in conditional variance of secondary market yields that arises from observing auction outcomes, beyond what is already captured by recent secondary market data. Specifically, on each auction day t, we estimate two regressions:

$$S_t = \alpha + \beta_1 S_{t-1} + \beta_2 S_{t-2} + \beta_3 S_{t-3} + \varepsilon_t, \tag{B.4}$$

$$S_t = \alpha + \beta_1 S_{t-1} + \beta_2 S_{t-2} + \beta_3 S_{t-3} + \gamma P_t + \varepsilon_t \tag{B.5}$$

yielding respectively two R-squared coefficients: $R^2(S_{t-1})$ and $R^2(S_{t-1}, P_t)$. The marginal R^2 is then defined as:

$$\Delta R^2 = \frac{R^2(S_{t-1}, P_t) - R^2(S_{t-1})}{1 - R^2(S_{t-1})}, \tag{B.6}$$

which captures the share of residual variance (unexplained by the recent path of secondary yields) that is accounted for by the auction result.

Surprise Elasticity: I estimate the elasticity of secondary market yield surprises to primary market yield surprises in two steps. In the first step, I project both the primary yield P_t and the secondary yield S_t on auction day t onto three lags of pre-auction secondary market yields:

$$P_t = \alpha^P + \beta^P_1 S_{t-1} + \beta^P_2 S_{t-2} + \beta^P_3 S_{t-3} + \varepsilon^P_t, \tag{B.7}$$

$$S_t = \alpha^S + \beta^S_1 S_{t-1} + \beta^S_2 S_{t-2} + \beta^S_3 S_{t-3} + \varepsilon^S_t. \tag{B.8}$$

[32] This part follows exactly Cole et al. (2025).

The fitted values $\hat{y}_t^m$ for $m \in \{P, S\}$ represent the expected yields at the start of the auction day. In the second step, we define the unexpected change in yields as the log deviation of realized from expected gross yields: $\Delta \log y_t^m \equiv \log(1 + y_t^m) - \log(1 + \hat{y}_t^m)$. I then regress the secondary market surprise on the primary market surprise:

$$\Delta \log y_t^S = \alpha + \beta \, \Delta \log y_t^P + \eta_t. \tag{B.9}$$

The coefficient β measures the elasticity of the surprise innovation in secondary market yields to the surprise innovation in primary market yields. To increase statistical power, I pool 6-month and 12-month auctions by stacking each auction observation matched to its own-maturity secondary market yield and lags.