Information Spillovers and Sovereign Debt: Theory Meets the Eurozone Crisis*

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Abstract

We develop a theory of information spillovers in sovereign bond markets in which investors can learn about default risk before trading in primary and secondary markets. If primary markets are structured as multi-unit discriminatory-price auctions, an endogenous winner's curse leads to strategic complementarities in information acquisition. Shocks to default risk in one country may trigger crisis episodes with widespread information acquisition, sharp increases in the level and volatility of yields in risky countries, low and stable yields in safe countries, market segmentation, and arbitrage profits between primary and secondary markets. These predictions are consistent with the dynamics of auction informativeness during the Eurozone Sovereign Debt Crisis, which we measure using the reaction of secondary market yields to primary market yields.

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1 Introduction

Governments typically finance large parts of their budgets by selling bonds in sequences of auctions. The most commonly-used protocol in these auctions is the discriminatory-price protocol in which accepted bids are executed at the bid price.[1] This leads to information rents for investors who know more about the fundamental value of bonds than others.[2] Information is particularly valuable during periods of heightened uncertainty in which default risk can vary substantially from auction to auction, such as when there are concerns about a country's solvency or policy stance. In such circumstances, some investors may start acquiring information before bidding for bonds, chasing away other investors who do not become informed and instead move more of their wealth to other countries. As a result of this interaction between information acquisition and cross-country flows, fundamental shocks in one country may affect yields and portfolio choices in other countries even when there are no fundamental linkages between them. We develop a model that shows these interactions are surprisingly rich and, in particular, can account for many key features of the 2010 Eurozone sovereign debt crisis.

Our model features two countries and a continuum of risk averse investors. In each country, the government faces an exogenous revenue requirement that can be satisfied by selling government bonds in a discriminatory-price auction. After the auction, investors can trade these bonds in a competitive secondary market. Bonds are risky because governments stochastically default. Investors are initially uninformed about the prevailing default risk in either country, but can learn it at a cost. Auctions are multi-unit and sealed bid; hence investors must bid before observing others' demands. Information is valuable because it allows investors to tailor their bids to the fundamental value of bonds.

We show that the behavior of yields and portfolio choices is tightly linked to the presence of informed investors. When no investor acquires information, yields are low and stable and investors are well-diversified across countries. When some

[1] Brenner, Galai, and Sade (2009) collected data of sovereign bond primary markets in 48 countries. They show that 42 of these countries used auctions, with 24 using discriminatory-price auctions, 9 using uniform-price auctions and 9 using both (for different securities). This is consistent with earlier results by Bartolini and Cottarelli (2001).

[2] Milton Friedman famously argued that the U.S. should switch from largely relying on discriminating-price auctions to uniform-price auctions for this reason (Hearings before the Joint Economic Committee, 86th Congress, 1st Session, Washington, D.C., October 30, 1959, 3023-3026).

investors are informed about a country, uninformed investors reduce their participation at auction to avoid the winner's curse and move their wealth towards another country. Hence markets are fragmented and yields are high and volatile.

With endogenous information acquisition, this environment becomes sensitive to changes in fundamentals. For an individual investors, information is valuable when the level and variance of default risk is high, when the country needs to raise substantial funds, and when the investor's is highly exposed to the country. This means that a shock to default risk or funding needs in one country may trigger information acquisition in that country. The resulting capital flows then induce some investors to hold a more concentrated position in a second country, which leads to information acquisition in that country if its average default risk is high enough. When such an adverse *information spillover* occurs, it raises yields and yield volatility in the second country even without any shocks to its fundamentals. If the second country is instead believed to be relatively safe, it serves as a *safe haven with common ignorance* where yields are low and uninformed investors can invest without fear of adverse selection. In this case, the second country may not see an increase in its borrowing costs even as the common pool of investors grows more worried about the first country. That is, spillovers are determined by the global distribution of default risk.

Our informational effects can be large relative to the underlying shocks. Under the discriminatory auction protocol, information is a *strategic complement* in that it is more valuable when some other investors are also informed. This creates the possibility of multiple equilibria, one without information and the other with a large share of informed investors. This allows for the possibility of discontinuous changes in the mapping from fundamentals to yields and portfolio flows.

The information environment also determines the relationship between primary and secondary markets. When investors do not acquire information, auction results do not convey new information and bond yields are similar across both markets. When some investors do acquire information, they exploit their information to "buy low" at the auction and "sell high" in the secondary market. Such trades are possible because uninformed investors face the winner's curse at auction, and are willing to pay a premium to trade under symmetric information in the secondary market. A striking implication of this fact is that the private value of information is higher when investors can trade in secondary markets. This is because secondary markets allow informed investors to buy more "underpriced" bonds at auction without having to hold the resulting risk exposure to maturity. Bidder risk-aversion, which is one key aspect of our theory, is critical for this result. Without it, investors would fully exploit their information advantage irrespective of secondary market trading opportunities.

The informational link between primary and secondary generates two important testable predictions of our theory. First, if some investors are better informed about default risk than others, such information is revealed at the auction and subsequently impounded into secondary market yields. Second, yields in the secondary market should be lower than in the primary market, thereby allowing informed investors to earn information rents. Coupled with our previous results on endogenous information, our theory suggests that these effects occur in response to shocks to fundamental risk or debt levels, domestic and/or foreign.

We confront our theory with data from the Eurozone sovereign debt crisis. This episode is commonly rationalized by a "wake-up call" narrative: problems in some countries led investors to pay closer attention to other countries as well. We provide an explicit account of the origins of such "information spillovers," and offer a strategy to measure their presence: more information acquisition should make auction prices more informative, and this can be detected by comparing primary and secondary market yields. In line with these predictions, we show that a fundamental increase in default risk and information acquisition in one country (Portugal, in our application) was accompanied by information acquisition in Italy, but not in Germany or France, which were widely believed to be relatively safe.

Our model also generates other implications that allow us to distinguish information spillovers from other potential sources of contagion. First, when there is more information acquisition in one country, the resulting winner's curse widens the spread between primary and secondary prices. Second, in contrast to many other models in which an increase in risk would justify more diversification, uninformed investors (such as non-resident investors) invest less in countries where information is more asymmetric. These implications are consistent with the information changes we documented: they occurred in Portugal and Italy during the Eurozone sovereign debt crisis, but not for Germany and France.

Related Literature. Previous work in the sovereign debt literature has highlighted cross-country spillovers. The most common view relies on real linkages, such as trade or finance, or on correlated shocks, that may transmit negative shocks from one country to the next. However, it is often difficult to empirically identify linkages that are powerful enough to induce the observed degree of spillovers. This led to a new set of explanations that rely on self-fulfilling debt crises either through feedback effects as in Calvo (1988) and Lorenzoni and Werning (2013) or rollover problems, as in Cole and Kehoe (2000), Aguiar et al. (2015), and Bocola and Dovis (2015). We explore a different form of spillovers that stems not from country fundamentals (supply side) but rather from portfolio choices of a common pool of investors (demand side).

Previous work has also explored demand side spillovers based on changes in risk aversion (Lizarazo (2013) and Arellano, Bai, and Lizarazo (2017)), wealth (Kyle and Xiong (2001) or Goldstein and Pauzner (2004)), borrowing constraints (Yuan (2005)), short-selling constraints (Calvo and Mendoza (1999)), or exogenous private information in Walrasian markets (Kodres and Pritsker (2002)). Broner, Gelos, and Reinhart (2004) provide empirical evidence of the importance of portfolio effects for spillovers. This work is based on a common pool of investors in secondary markets. Our innovation is introducing a rich dual market structure that is explicit about the auction protocol used in primary markets and its implications for information acquisition and information-based contagion. Closer to our insight, Van Nieuwerburgh and Veldkamp (2009) use a model of information acquisition to study home bias and segmentation in financial markets. They consider competitive secondary markets and find that information acquisition is a strategic substitute. In our model, the auction protocol generates a strategic complementarity that leads to equilibrium multiplicity and contagion of information regimes.

Other work has studied the interaction of primary and secondary markets, but found that secondary markets increase primary market prices, either through incentives to signal private information (Bukchandani and Huang (1989)), or by providing commitment against default on foreign creditors (Broner, Martin, and Ventura (2010)). We find that secondary markets may contribute to lower prices at auction through endogenous information acquisition. We also exploit the dual market structure to empirically measure changes in information acquisition during the Eurozone crisis, and to confront the model's testable implications with this data.

Our work provides theoretical underpinnings for the "wake-up call" literature. This idea was first suggested by Goldstein (1998) to explain contagion from Thailand (a relatively small and closed economy) to other Asian countries that shared the same economic weaknesses but were ignored by investors until the Thai "wake-up call" in

1997. This form of contagion, consistent with rational inattention, has found empirical support in Giordano, Pericolli, and Tommasino (2013), Bahaj (2020) and Moretti (2021) for the Eurozone crisis and in Mondria and Quintana-Domeque (2013) for the Asian crisis. These papers use a narrative approach based on news events to isolate changes in sovereign risk that are orthogonal to the economy's fundamentals, and do not find evidence of fundamental linkages that can explain the co-movement of sovereign yields across periphery countries. Ahnert and Bertsch (2022) use a global games model to rationalize the wake-up call hypothesis for currency crises or bank runs, in which investors move sequentially in secondary markets and become informed about the countries' fundamental linkages. There is no portfolio choice or prices in their model, so their main focus is on run contagion. Our focus is on price spillovers in primary markets.

In relation to the auction literature, our model can be used to study information acquisition because we circumvent some of the standard challenges that arise when solving for equilibrium prices in multi-unit auction models.[3] This is because of three key characteristics: (i) the good being auctioned is perfectly divisible, (ii) the number of risk averse bidders is large, and (iii) there is uncertainty about the quality of the good. Given these characteristics, the price-quantity strategic aspects of standard auction theory become less relevant and a price-taking analysis emerges as a good approximation.[4]

In this context, studying risk-averse investors is important for the interpretation of the shading factor in bids (as argued by Wilson (1979)) and it is critical for thinking about the reaction of bond prices to shocks during periods with high volatility. Previous literature on auctions with risk averse bidders primarily focuses on risk aversion with respect to winning the auction rather than *ex post* risk in the objects for sale. An important exception is Esö and White (2004) who consider an auction with a single risky good with independent ex-ante signals and ex-post risk to bidders' valuations. They find that risk aversion reduces bids and that prices fall by more than the "fair" risk premium. Our work consider a multi-unit auction with ex-post risky objects

[3]The main challenge is characterizing equilibria when bidders have a two-dimensional strategic problem involving both bid quantities and bid prices. See Wilson (1979), Engelbrecht-Wiggans and Kahn (1998), Perry and Reny (1999), Kagel and Levin (2001) and McAdams (2006).

[4]Recent auction literature shows that price-taking arises as the number of bidders get large. A recent example is Fudenberg, Mobius, and Szeidl (2007), who show that the equilibria of large double auctions with correlated private values are essentially fully revealing and approximate price-taking behavior when the number of risk neutral bidders goes to infinity. Another is Reny and Perry (2006) who show a similar result when bidders have affiliated values and prices are on a fine grid.

where there is (correlated) asymmetric information about default risk and marginal valuations depend on quantities purchased.

More recent work tackles these challenges from an empirical perspective. Hortaçsu and McAdams (2010) develop a model based on Wilson (1979)'s model of a multi-unit discriminatory price auction with a finite set of potential risk-neutral bidders with symmetric and independent private values. Instead of computing the market clearing price analytically, they use a re-sampling technique to construct a non-parametric estimator of bidder valuations and apply it to data from Turkish treasury auctions.[5]

The model in this paper complements Cole, Neuhann, and Ordoñez (2022a), who study a single-country model with a fixed information environment and use rich bid-level data to provide evidence for asymmetric information about default risk in Mexican sovereign bond auctions.[6] In this paper, we allow for endogenous information acquisition and use a multi-country model with cross-auction linkages due to a common pool of investors. Combining these elements with both primary and secondary markets allows us to capture changes in information regimes, and their implications, for several countries with distinct experiences during the Eurozone crisis.

The next section describes our model of primary and secondary sovereign debt markets in two countries with a common pool of investors. Section 3 characterizes the equilibrium in three steps: with exogenous information (with a focus on bidding behavior and pricing), with endogenous information (with a focus on information spillovers) and finally with secondary markets (with a focus on their effects on pricing and spillovers). Section 4 confront the model with the experiences of Portugal, Italy, Germany and France during the Eurozone crisis. Section 5 concludes.

2 Model

We study a economy with a single good (the numéraire), a measure one of ex-ante identical risk-averse investors with fixed per-capita wealth W, and two countries indexed by $j \in \{1, 2\}$. There are two dates, $t = 1, 2$. Investors have preferences over

[5] Kastl (2011) extended Wilson (1979)'s model, which is based on continuous and differentiable functions, to more realistic discrete-step functions, showing that in such case only upper and lower bounds on private valuations can be identified, which he does by exploiting the previously discussed resampling method on Czech bills auctions.

[6] Cole, Neuhann, and Ordoñez (2022b) uses additional data from Mexico to show that asymmetric information may support bond prices in particularly bad times.

consumption at date 2 that are represented by a strictly concave utility function u that is twice continuously differentiable, satisfies the Inada condition, and has weakly decreasing absolute risk aversion. These conditions are satisfied by CRRA preferences.

At date 1, country j's government needs to raise fixed revenue $D_j \geq 0$ by selling sovereign bonds to investors at an auction (the primary market). Immediately after the auction, investors can trade bonds in a competitive secondary market. At date 2, payoffs are realized and consumption takes place. Investors' outside option is a risk-free asset whose net return is normalized to zero. There is no borrowing and no short-selling: investors cannot submit negative bids at auction, and can sell no more than the bonds acquired at auction when trading in the secondary market.

Bonds are risky zero-coupon bonds. They promise a unit payoff at date 2, but pay zero if the government defaults. Default by country j is denoted by by $\delta_j = 1$ and repayment by $\delta_j = 0$. The default probability in each country is determined by an exogenous stochastic process that is independent across countries and depends on two variables. The first is the country's *risk regime*, which we denote by ρ_j. The second is a *state of the world* $\theta_j \in \{\theta^1, \theta^2, \dots \theta^K\}$ for $K \geq 2$. Hence we write the default probability given regime and state as $\kappa_j(\theta_j, \rho_j)$. The probability of state θ_j^k in regime ρ_j is $f_j(\theta_j^k, \rho_j) > 0$. Conditional on the regime, the expected probability of default is

$$\bar{\kappa}_j(\rho_j) = \sum_{k=1}^{K} f_j(\theta_j^k, \rho_j)\kappa_j(\theta^k, \rho_j).$$

Within regime, default risk is ordered by the state of the world,

$$\kappa_j(\theta^k, \rho_j) > \kappa_j(\theta^{k+1}, \rho_j) \qquad \text{for all } \rho_j \text{ and } 1 \leq k \leq K-1$$

Information environment. All investors know the risk regime in both countries, but are initially uninformed about the state of the world in either country. Investors can learn θ_j in one or both countries by paying a utility cost. We summarize this decision by $a_j \in \{0, 1\}$, where $a_j = 1$ means that the investor learned θ_j. The cost of information acquisition is a function $C(a_1, a_2)$ that is increasing in both arguments.

Since investors are ex-ante identical, we say that an information acquisition strategy $\vec{a} = \{a_1, a_2\}$ defines the investor's *type* going forward. Consequently, there are four possible types (informed in one country, in both, or in neither), and we use generic superscript i to index them. Their masses, which are determined in equilibrium, are denoted by $n^i \in [0,1]$, with $\sum_i n^i = 1$.

Primary market structure. Governments sell bonds using discriminatory multi-unit auctions. Investors can submit multiple bids consisting of a non-negative quantity and price. Bids are a commitment to buy the bid quantity at the bid price, should the government decide to execute the bid. We assume that bids in country j can be made contingent on the realized state in that country, should the investor be informed, but not on the realized state in country $-j$. However, they can be contingent on the information acquisition *strategy* in $-j$. This assumption simplifies matters without affecting the basic mechanisms.[7]

The government treats bids independently and executes them in descending order of prices until it generates the required revenue D_j. The quantity of bonds sold is determined in equilibrium.The *marginal price* $P_j(\theta_j, \rho_j)$ is the lowest price accepted by government j in state θ_j and regime ρ_j. Since bonds pay at least zero and at most one, the range of marginal prices is $[0,1]$.

A *bidding strategy* maps any price in $[0,1]$ into a weakly positive bid quantity. Since investors have rational expectations with respect to the set of possible marginal prices, it is without loss of generality to consider only bidding strategies that assign zero bids to any price that is not marginal in at least one state of the world.[8] Given this restriction, it is convenient to define bidding strategies as a function of the underlying states of the world as well. That is, if $B'_j(P)$ maps prices into bid quantities, we can define another function $B_j(\theta_j, \rho_j) \equiv B'(P_j(\theta_j, \rho_j))$ that maps (θ_j, ρ_j) into a quantity at the associated marginal price $P_j(\theta_j, \rho_j)$. Thus, investors must ultimately decide *how many bonds to bid for at the marginal prices associated with all possible states of the world*.

Of course, even if uninformed investors have rational expectations over the set of marginal prices, they do not know the realized state at the time of bidding. This creates uncertainty about which bids ultimately will be executed. To capture this concern, we define *executed bid sets* $\mathcal{E}^i_j(\theta_j, \rho_j)$ which summarize all bids by an investor

[7]Carlos Garriga interpreted this assumption as a financial intermediary with separate divisions specialized in each country that only periodically re-balances portfolios and exchanges information.

[8]Excess demand at the marginal price is rationed pro-rata, but rationing does not occur in equilibrium. An investor can avoid rationing by offering an infinitesimally higher price. Moreover, given that marginal prices are distinct, for any equilibrium with rationing there is an equivalent equilibrium in which bidders scale down their bids by the rationing factor

that are executed in country j given (θ_j, ρ_j). Since there is a unique marginal price in each state, we define these sets directly in terms of the underlying states. Hence:

$$\mathcal{E}_j^i(\theta_j, \rho_j) = \begin{cases} \{\theta_j\} & \text{if } i \text{ is informed in } j \\ \{\theta_j' : P_j(\theta_j', \rho_j) \geq P_j(\theta_j, \rho_j)\} & \text{if } i \text{ is uninformed in } j. \end{cases}$$

The realized quantity of country-j bonds acquired by investor i given (θ_j, ρ_j) is

$$\mathcal{B}_j^i(\theta_j, \rho_j) = \begin{cases} B_j^i(\theta_j, \rho_j) & \text{if } i \text{ is informed in } j \\ \sum_{(\theta_j', \rho_j) \in \mathcal{E}_j^i(\theta_j, \rho_j)} B_j^i(\theta_j', \rho_j) & \text{if } i \text{ is uninformed in } j. \end{cases}$$

and realized expenditures on bonds in country j are

$$X_j^i(\theta_j, \rho_j) = \begin{cases} P_j(\theta_j, \rho_j) B_j^i(\theta_j, \rho_j) & \text{if } i \text{ is informed in } j \\ \sum_{(\theta', \rho_j) \in \mathcal{E}_j^i(\theta_j, \rho_j)} P_j(\theta', \rho_j) B_j^i(\theta', \rho_j) & \text{if } i \text{ is uninformed in } j. \end{cases}$$

Holdings of the risk-free asset after the auction closes are given by

$$w^i(\theta_1, \rho_1, \theta_2, \rho_2) = W - \sum_j X_j^i(\theta_j, \rho_j),$$

and the market-clearing condition that ensures the revenue target is met is

$$\sum_i n^i X_j^i(\theta_j, \rho_j) = D_j. \tag{1}$$

Secondary market structure. The secondary market opens once the primary market closes. All auction results are assumed to be public knowledge prior to the secondary market. Hence the secondary market operates under symmetric information.

We use hats to denote secondary market counterparts of primary market variables. Quantities are $\widehat{B}_j^i(\theta_j, \rho_j)$, prices are $\widehat{P}_j(\theta_j, \rho_j)$, and expenditures are $\widehat{X}_j^i(\theta_j, \rho_j) = \widehat{P}_j(\theta_j, \rho_j)\widehat{B}_j^i(\theta_j, \rho_j)$. Investors can sell no more than the total quantity of bonds acquired at auction, $\widehat{B}_j^i(\theta_j, \rho_j) \geq -\mathcal{B}_j^i(\theta_j, \rho_j)$. Since no new bonds are issued, the secondary market clearing condition is

$$\sum_i n^i \widehat{B}_j^i(\theta_j, \rho_j) = 0. \tag{2}$$

The final quantity of country j bonds held by investor i given (θ_j, ρ_j) is

$$\widehat{\mathcal{B}}^i_j(\theta_j, \rho_j) = \mathcal{B}^i_j(\theta_j, \rho_j) + \widehat{B}^i_j(\theta_j, \rho_j).$$

Final holdings of the risk-free asset are given by

$$\widehat{w}^i(\theta_1, \rho_1, \theta_2, \rho_2) = w^i(\theta_1, \rho_1, \theta_2, \rho_2) - \sum_j \widehat{X}^i_j(\theta_j, \rho_j)$$

Decision Problems and Equilibrium Concept. Let $\Theta_j = \{\theta_j, \rho_j\}$, $\vec{\Theta} = \{\Theta_1, \Theta_2\}$, and $\vec{\delta} = \{\delta_1, \delta_2\}$. Further, let $\iota(\vec{a})$ be the type induced by an information acquistion strategy $\vec{a} = \{a_1, a_2\}$. Type $i's$ bidding strategy is a tuple of primary and secondary market quantities at each marginal price associated with some state of the world,

$$\vec{B}^i \equiv \left\{ \left\{ B^i_j(\Theta_j), \widehat{B}^i_j(\Theta_j) \right\}_{\Theta_j} \right\}_{j \in \{1,2\}}.$$

The consumption process induced by the bidding strategy is

$$c^i(\vec{\Theta}, \vec{\delta}, \vec{B}^i) = \widehat{w}^i(\vec{\Theta}) + (1 - \delta_1)\widehat{\mathcal{B}}^i_1(\Theta_1) + (1 - \delta_2)\widehat{\mathcal{B}}^i_2(\Theta_2) \quad \text{for all } \vec{\Theta} \text{ and } \vec{\delta}.$$

Optimal bidding strategies solve the following portfolio problem, where $\mathbb{E}^i$ denotes the expectation operator given the information set of type i.

Definition 1 (Portfolio choice problem)**.** *Type i's portfolio choice problem is*

$$\begin{aligned} V^i = &\max_{\vec{B}^i} \quad \mathbb{E}^i\Big[u(c^i(\vec{\Theta}, \vec{\delta}, \vec{B}^i))\Big] \qquad (3)\\ \textit{s.t.} \quad & B^i_j(\Theta_j) \geq 0 \textit{ and } \widehat{B}^i_j(\Theta_j) \geq -\mathcal{B}^i_j(\Theta_j) \quad \textit{for all } j \textit{ and } \Theta_j \\ & w^i(\vec{\Theta}) \geq 0 \textit{ and } \widehat{w}^i(\vec{\Theta}) \geq 0 \textit{ for all } \vec{\Theta}. \end{aligned}$$

Given an optimal bidding strategy, information acquisition is determined by the following problem, where $\iota(\vec{a})$ is the type induced by information acquisition strategy $\vec{a}$.

Definition 2 (Information acquisition problem)**.** *The information acquisition problem is*

$$\max_{\vec{a}} V^{\iota(\vec{a})} - C(\vec{a}). \qquad (4)$$

We can then define our equilibrium concept.

Definition 3 (Equilibrium). *For any risk regimes $\{\rho_1, \rho_2\}$, an equilibrium consists of pricing functions $P_j : \{\theta_j\} \to [0, 1]$ and $\widehat{P}_j : \{\theta_j\} \to [0, 1]$ for each j, an information acquisition strategy $\vec{a}$ for each investor, and bidding strategies $\vec{B}^{\iota(\vec{a})}$ for each investor type such that:*

(i) $\vec{B}^{\iota(\vec{a})}$ *solves type $\iota(\vec{a})$'s portfolio choice problem* (3) *for all $\vec{a}$ chosen by some investor,*

(ii) any $\{\vec{a}\}$ chosen by at least one investor solves the information acquisition problem (4) *given equilibrium bidding strategies, and*

(iii) market clearing conditions (1) *and* (2) *hold given the masses of investor types as determined by equilibrium information acquisition strategies.*

3 Auction Equilibrium

We first study the auction equilibrium without secondary markets. The equilibrium definition is Definition 3, augmented with the requirement that all secondary market quantities are zero. We turn to the effects of secondary markets in Section 3.3.

The theoretical mechanisms are most transparent if the state of the world is binary, so that news is either good or bad relative to the unconditional expectation. Hence, in this section we restrict attention to $\theta_j \in \{b, g\}$. Since the risk regime is public information, we also suppress reference to ρ_j to simplify notation.

3.1 Auction Equilibrium with Exogenous Information

We begin by characterizing bids and prices taking as given investors' information acquisition decisions. The first step is to characterize optimal bids, given some information acquisition strategies. Formulating a bidding strategy requires forming expectations about the states of the world in which a given bid will be accepted. Hence we define *acceptance sets* $\mathcal{A}^i_j(\theta_j)$ which collect all states of the world in which a bid in country j at some marginal price $P_j(\theta_j)$ is accepted. For uninformed investors, a particular bid is accepted in all states with lower marginal prices; for informed investors a bid is accepted only in the state associated with the realized marginal price. Hence

$$\mathcal{A}^i_j(\theta_j) = \begin{cases} \{\theta_j\} & \text{if } i \text{ is informed in } j \\ \{\theta'_j : P_j(\theta'_j) \le P_j(\theta_j)\} & \text{if } i \text{ is uninformed in } j. \end{cases}$$

The difference in informed and uninformed acceptance sets captures the winner's curse, which is that uninformed bids at high prices are also accepted when the fundamental value of the bond is low. Notice also that acceptance sets are the complement of executed bid sets, which capture all the states with higher marginal price.

Optimal bidding strategies trade off the expected marginal utility loss from default against the expected marginal benefit of the yield earned after repayment, averaged across the states of the world in which the bid is accepted. We can summarize this trade-off by defining i's expected marginal utility for bids in country j given state θ_j and default realization δ_j by

$$m^i_j(\theta_j, \delta_j) = \mathbb{E}^i\left[u'(c^i(\vec{\theta}, \vec{\delta}, \vec{B}^i))\middle|\theta_j, \delta_j\right],$$

where the expectation is taken over states of the world and default or repayment in country $-j$. Taking ratios over default and repayment in j yields the relevant *marginal rate of substitution* (MRS) for evaluating bids at marginal price $P_j(\theta_j)$, which is

$$M^i_j(\theta_j) = \frac{\sum_{\theta'_j \in \mathcal{A}^i_j(\theta_j)} f_j(\theta'_j)\kappa_j(\theta'_j)m^i_j(\theta'_j, 1)}{\sum_{\theta'_j \in \mathcal{A}^i_j(\theta_j)} f_j(\theta'_j)\left(1 - \kappa_j(\theta'_j)\right) m^i_j(\theta'_j, 0)}.$$

If investors are willing to bid at a particular marginal price, the optimal quantity is such that marginal rate of substitution is equal to the bond yield $y_j(\theta_j) \equiv \frac{1-P_j(\theta_j)}{P_j(\theta_j)}$. That is, for a marginal investor, optimal bidding is determined by the condition

$$y_j(\theta_j) = M^i_j(\theta_j), \tag{5}$$

The next proposition characterizes basic properties of prices and portfolios. Intuitively, the multi-unit discriminatory auction leads to a variant of the canonical risk-return trade-off, where the key modification introduced by the auction protocol is that bids at all possible prices (rather than just the marginal price) jointly determine state-contingent marginal rates of substitution.

Proposition 1 (Marginal Investor and Prices)**.** *Fixing information acquisition decisions, the following statements characterize equilibrium prices and bidding strategies:*

(i) If there are no informed investors in j then there exists a single marginal price $\bar{P}_j$ that is the same in all states θ_j, and uninformed investors are marginal in every state. That is,

$$\frac{1-\bar{P}_j}{\bar{P}_j} = M_j^i(g) = M_j^i(b) \qquad \textit{for all } i.$$

(ii) If there are informed investors in country j, then the marginal price is strictly higher in the good state than in the bad state, $P_j(g) > P_j(b)$. While informed investors are marginal in every state, uninformed investors may not submit any bids at the high price. That is, uninformed investor optimality conditions satisfy

$$M_j^i(b) = \frac{1-P_j(b)}{P_j(b)} \qquad \textit{and} \qquad M_j^i(g) \geq \frac{1-P_j(g)}{P_j(g)} \qquad \textit{for all } i \textit{ such that } a_j^i = 0,$$

where the inequality is strict if and only if the short-sale constraint binds for $B_j^U(g)$.

(iii) For informed investors, $M_j^i(\theta_j)$ is separable across states: $M_j^i(\theta_j)$ depends only on bids submitted at $P_j(\theta_j)$. For uninformed investors, $M_j^i(\theta_j)$ is not separable across states: $M_j^i(b)$ is strictly increasing in $B_j^i(g)$, because bids at the high marginal price are also accepted if the state is bad.

(iv) Let there be n_1 informed investors in Country 1, and hold fixed all bids in Country 2.

In the good state, all bids are executed at the marginal price $P_1(g)$, the marginal price is strictly increasing in n_1, and it converges to the uninformed price $\bar{P}_1$ as n_1 goes to zero.

In the bad state, marginal price $P_1(b)$ converges to a price below the uninformed price as n_1 goes to zero, $\lim_{n_1 \to 0} P_1(b) < \bar{P}_1$. Since uninformed bids at the high price are also executed in the bad state, the average price in the bad state is $P_1^{avg}(b) = \omega_1 P_1(g) + (1 - \omega_1 P_1(b)$, where ω_1 is the share of bids executed at $P_1(g)$. The average price converges to $\bar{P}_1$ as n_1 goes to zero, and to $P_1(b)$ as n_1 goes to 1.

Figure 1 shows prices in Country 1 using a numerical example, holding Country 2 bids fixed at the level that would obtain in an equilibrium where there are no informed investors. The horizontal line shows the uninformed equilibrium price $\bar{P}_1$.

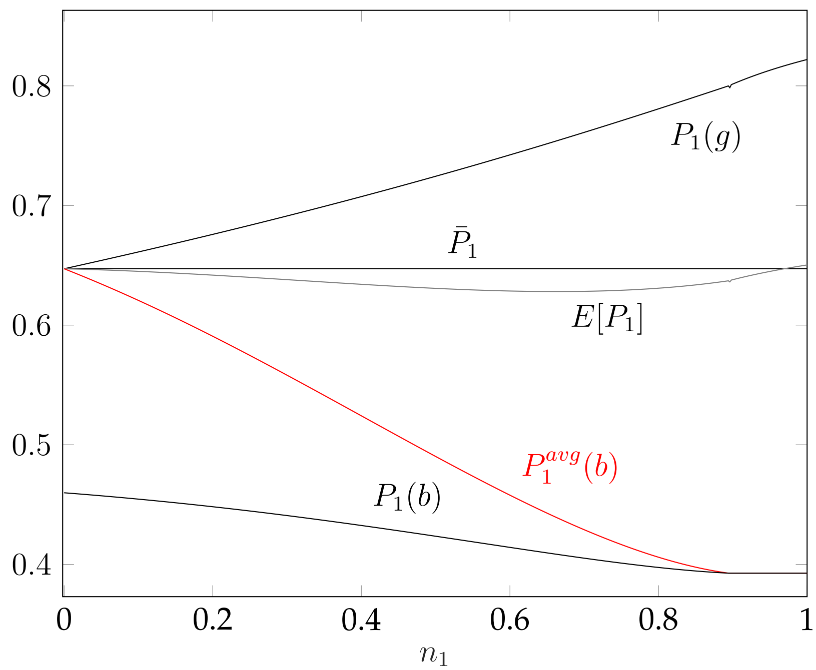


Figure 1: Prices in Country 1 as a function of n_1 given a fixed bond portfolio in Country 2. Countries are ex-ante symmetric. Wealth is $W = 800$ and outstanding debt is $D_j = 300$. Default probabilities are $\kappa_j(g) = 0.1$, $\kappa_j(b) = 0.35$, and $f_j(g) = 0.6$. Hence $\bar{\kappa}_j = 0.2$. Utility is $U(\cdot) = \log(\cdot)$.

The high marginal price $P_1(g)$ is increasing in n_1, the low marginal price $P_1(b)$ is decreasing in n_1. The average price in the bad state, $P_1^{avg}(b)$, is close to $P_1(g)$ when the share of informed investors is small, but converges to $P_1(b)$ as n_1 increases.

In the limit without informed investors, prices are determined as follows. As $n_1 \to 0$, the government can raise the required revenue only if uninformed investors buy enough debt in both states. In the good state, all bids are executed at the marginal price and so expenditures can converge to D_j only if the price converges to the uninformed price. But since all high-priced bids are also accepted in the bad state, bids at the low marginal price must converge to zero. Given that bids at the low price must be strictly positive for $n_1 > 0$ by Part (ii) of Proposition 1, this requires that the limit of $P_1(b)$ is strictly below the uninformed price. This turns out to be important for equilibrium information acquisition choices because it implies that informed investors may get better "deals" if some other investors are also informed.

We next analyze the allocation of funds across countries. We find that information leads to segmentation, whereby informed investors specialize in the country where they are informed, and uninformed investors move to country with fewer informed investors. For simplicity, we assume that a fraction n_1 of investors is informed in Country 1, while no investor is informed in Country 2.

Since this channel depends on informational differences, we study a second-order approximation of the optimal portfolio problem that eliminates prudence-driven spillovers. Specifically, we consider constant relative risk aversion (CRRA) preferences with risk aversion coefficient γ, and approximate around zero bond holdings. Since we assume no investor is informed in Country 2, we simplify notation by using I to index investors with information in Country 1, and U to index investors without information. We denote portfolio shares scaled by the coefficient of risk aversion by

$$\omega_j^i(\theta_j) \equiv \frac{\gamma P_j(\theta_j) B_j^i(\theta_j)}{W}.$$

Given that investors are ex-ante symmetric, we define *market segmentation* as the difference in equilibrium portfolio weights between informed and uninformed investors across countries.

Proposition 2 (Information and Segmentation)**.** *Assume that the unconditional default probability is not too high, $\bar{\kappa}_1 < \frac{1}{2}$. Then portfolios satisfy the following conditions:*

(i) If all investors are symmetrically informed in both countries, there is no segmentation: all investors choose the same portfolio weights in every country and state of the world.

(ii) If some investors are informed in Country 1, then portfolios are segmented: optimal portfolio weights satisfy $\omega_1^U(g) < \omega_1^I(g)$ and $\omega_2^U > \omega_2^I$, where I denotes informed and U denotes uninformed investors. Segmentation is increasing in $P_1(g)$, $\frac{\partial(\omega_2^U - \omega_2^I)}{\partial P_1(g)} < 0$.

3.2 Auction Equilibrium with Endogenous Information

The previous section studied equilibrium prices given exogenous information choices. We now study optimal information acquisition decisions. We first show that there are strategic complementarities in information acquisition within a country. This has the implication that there may be large changes in the share of informed investors as soon as some investors decide to become informed.

To focus on within-country effects, we assume that all investors are uninformed in Country 2, and we study the choice to become informed in Country 1. The value of becoming informed in Country 1 then is the additional expected utility earned by informed investors,

$$\Delta V(n_1) = V^I(n_1) - V^U(n_1).$$

and $K \equiv C(1,0)$ is the marginal cost of acquiring information in Country 1.

When some investors are informed, $\Delta V(n_1)$ is the *equilibrium* utility difference between informed and uninformed investors. When no investor is informed, $\Delta V(0)$ denotes the *counterfactual* expected utility gain achieved by a single deviating investor when all other investors remain uninformed. An equilibrium without information acquisition exists if $\Delta V(0) \leq K$, an equilibrium with $n_1^* \in (0,1)$ informed investors is such that $\Delta V(n_1^*) = K$, and an equilibrium with $n_1 = 1$ obtains if $\Delta V(1) \geq K$.

The following result demonstrates that information acquisition is a strategic complement for n_1 sufficiently small, in the sense that the value of information for an individual investor increases as other investors become informed.

Proposition 3 (Complementarity and Multiplicity)**.** *There exists a threshold share of informed investors $\bar{n}_1 > 0$ such that the value of information is strictly higher if $n_1 \in (0, \bar{n}_1]$ than if $n_1 = 0$. The informed and uninformed regime co-exist if and only if $K \in [\Delta V(0), \max_{n_1} \Delta V(n_1)]$. The maximal share of informed investors is decreasing in K.*

In a discriminatory-price auction, the ability to exploit information depends on prevailing marginal prices. Proposition 1 shows that the presence of informed investors drives down the bad-state marginal price below the uninformed price. Hence informed investors have *greater* opportunities to exploit their information advantage when there are other informed investors.[9] This price dispersion also exposes uninformed investors to the winner's curse, which further raises the utility difference between informed and uninformed investors. Substantively, the main upshot of this result is that shocks to the value of information (driven for example by shocks to default risk) can lead to a large share of investors simultaneously becoming informed.

Next, we study the fundamental determinants of the value of information. We focus in particular on the role of default risk and overall portfolio exposures. To do so, it is convenient to analyze the *marginal* value of information $mv_j(\epsilon)$ for an investor

[9] In Cole, Neuhann, and Ordoñez (2022a) we augment the one-country auction model with a demand shock similar to Grossman and Stiglitz (1980), and show this smooths the discontinuity in the value of information at $n = 0$ while preserving the strategic complementarity in information acquisition as well as the scope for equilibrium multiplicity.

that is uninformed in Country j. We define this as the marginal increase in utility achieved by allowing the investor to replace some quantity ϵ of her non-contingent bids in country j with bids at the appropriate state-contingent marginal price, holding consumption after repayment fixed. This captures the value of information as allowing for state-contingent bids, holding fixed expenditures. If we evaluate the marginal value near $\epsilon = 0$, we can measure investor i's *exposure* to country j given the original bidding strategy as her *expenditures* $X_j^i(b)$ on country j bonds in state b.

Proposition 4. *(Investor exposure, risk, and the value of information) The marginal value of information for uninformed investor i in country j in a neighborhood around $\epsilon = 0$ is*

$$mv_j^i(0) = f_j(b)\kappa_j(b)\Delta_j \mathbf{E}_{-j} u' \left(W - X_j^i(b) + (1 - \delta_{-j}) B_{-j}^i(\theta_{-j}) \right) > 0.$$

where $\Delta_j \equiv P_j(g) - P_j(b)\frac{1-P_j(g)}{1-P_j(b)} > 0$ measures how much cheaper it is to buy a dollar of consumption after repayment by paying $P(b)$ rather than $P(g)$. For any risk averse utility function, the marginal value is strictly increasing in default probability $\kappa_j(b)$ and in the investor's exposure to country j, i.e.

$$\frac{\partial mv_j^i(\epsilon)}{\partial X_j^i(b)}|_{\epsilon=0} = -f_j(b)\kappa_j(b)\Delta_j \mathbb{E}_{-j} u'' \left(W - X_j^i(b) + (1 - \delta_{-j}) B_{-j}^i(\theta_{-j}) \right) > 0.$$

Information is thus most valuable when the country is risky and when the investor has high exposure to the country when uninformed. The reason is that information allows the investor to obtain the same exposure to the country at lower cost, thereby allowing for more investment in the risk-free asset. This is particularly valuable when the investor's portfolio is risky to begin with. For our application to the Eurozone, an important upshot is that fundamental shocks to risk, such as a change in the risk regime, can trigger information acquisition, with implications for prices, price volatility, and portfolio segmentation, which then feed back into information acquisition incentives in other countries – our source of spillovers.

3.3 Effects of Secondary Markets

Many sovereign bonds can be readily traded in secondary markets. We now study how secondary markets affect auction prices and the value of information. Since auction prices and allocations are disclosed at the end of the auction, secondary markets take place under symmetric information, and the only motive for trade is reallocating risk exposure acquired at auction. Since investors are ex-ante identical, they choose different portfolios at auction only to the extent that they have different information.

This suggests an equilibrium whereby informed investors exploit their information advantage at auction in order to sell in the secondary market, while uninformed investors buy in the secondary market in order to avoid the winner's curse at auction. Our key result is that such an equilibrium obtains if only if there are not too many informed investors. The upper bound on the share of informed investor is

$$\widehat{n}_j = \frac{D_j}{W - D_{-j}},$$

which is the share of informed investors in country j beyond which informed investors are able to buy the entire stock of debt outright.

Proposition 5. *Let $n_j > 0$. Then the equilibrium with secondary markets satisfies:*

(i) If and only if $n_j < \widehat{n}_j$, informed investors earn strict arbitrage profits in the good state by buying at $P_j(g)$ at auction and selling some of their bonds at $\widehat{P}_j(g) > P_j(g)$ in the secondary market. The arbitrage persists in the limit with no informed investors, $\lim_{n_1 \to 0}(P_j(g) - \widehat{P}_j(g)) < 0$.

(ii) There are no arbitrage profits in the low state, $P_j(b) = \widehat{P}_j(b)$ for any n_j. This is because there is no winner's curse when bidding at low prices.

(iii) Any equilibrium with endogenous information acquisition must offer a strict arbitrage in the good state, $n_1 < \widehat{n}_1$. Moreover, in the limit as $n_1 \to 0$, the value of information is strictly higher with secondary markets than without. Hence there are information costs for which an informed equilibrium exists only if there are secondary markets.

The option to re-trade raises the value of information because informed investors can buy under-priced bonds at auction without having to hold the associated risk to maturity. Uninformed investors respond by buying fewer bonds at auction and more in the secondary market, where they do not face the winner's curse. This leads to a revenue loss for the government because fewer investors participate in the auction. Two features of our model are critical for this result, and differentiate us from the literature: bidders are risk averse, which imposes a cost to holding risk exposures, and auction protocol is multi-unit, which allows bidders to adjust the intensive margin.

4 Auction Informativeness and European Debt Crisis

Our theoretical analysis demonstrates that shocks to domestic or foreign default risk can trigger information acquisition in primary markets, and that this leads to (i) a tighter link between prevailing default risk and auction prices, and thus more informative auction prices and higher price volatility, (ii) arbitrage opportunities between primary and secondary markets, and (iii) portfolio differences between informed and uninformed investors.

We now evaluate these channels in the context of the 2010 European sovereign debt crisis. This crisis is a useful laboratory for several reasons. Many of the largest European countries use discriminatory-price auctions to sell short-term bonds in primary markets, and despite being members of the same economic union, they are quite heterogeneous in the fundamentals that determine their risk of default. Additionally, European capital markets were well-integrated at the onset of the crisis, which allows for the possibility of information spillovers.

We focus in particular on the experience of four large European countries, all of whom use discriminatory auctions to sell short-term bonds: Portugal, Italy, Germany and France. To facilitate cross-country comparisons, we report all data in yields y_j rather than prices, where $y_j = \frac{1-P_j}{P_j}$, as defined in equation (5). Figure 2 shows that, in the period 2010-2012 that represented the bulk of the crisis, the level and volatility of one-year sovereign bond real yields increased sharply in Portugal and, with some delay, in Italy, but remained low and stable in Germany and France. Despite these differences, sovereign bond yields were similarly low and stable in all four countries both before and after the crisis. While this pattern has previously caught the attention of academics and policymakers, we argue that changes in the way information was processed in primary markets may have contributed to these dynamics.

We proceed in four steps. First, we provide a thorough description of how the European Sovereign Debt Crisis unfolded in these four countries. The prevailing narrative among policymakers and academics is that investors differentially paid attention to default risk in certain countries at various points in time. Second, we provide new evidence that the information content of bond auctions changed during this period in ways consistent with such a narrative: it was low in all countries prior to the crisis, but increased in Portugal and Italy during the crisis. Third, we simulate an extended version of our model that captures the main elements of the crisis, includ-

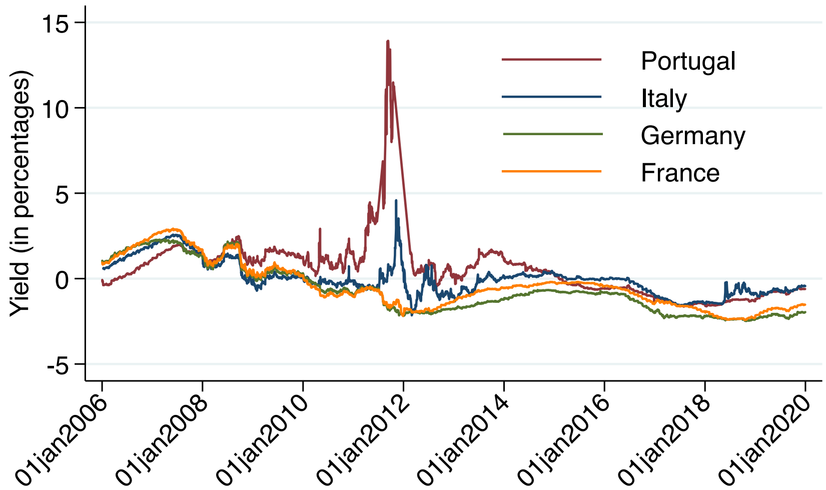


Figure 2: Real annualized secondary market yields (one-year bonds).

ing our documented changes in auction informativeness. We show that the model rationalizes the joint evolution of sovereign bond yields and informativeness over the crisis, and generates additional testable predictions: an increase in cross-market spreads (primary vs. secondary market yields) and a decline in non-resident holdings of sovereign bonds during the crisis, but only in Portugal and Italy. Fourth, we show empirically that these predictions indeed hold during the crisis.

4.1 A Narrative Account of the Eurozone Crisis

The start of European Sovereign Debt Crisis can be dated to early 2010, shortly after some European countries reported surprisingly high deficit-to-GDP ratios in the aftermath of the Global Financial Crisis of 2008, with Greece representing the most dramatic case. Lane (2012) summarizes the timeline of events. In early 2010, Greece was the first country to experience a divergence of sovereign bond yields from the rest of the Eurozone, requiring official assistance in May 2010. This experience was mirrored in late 2010 by Ireland and Portugal, with Ireland requiring a bailout in November 2010 and Portugal in May 2011. Spain and Italy experienced their own increase in bond yields a year later. Strikingly, the yields of ”core” countries such as Germany and France remained low and stable throughout this period. Lane also highlights the extent to which markets became fragmented during this episode, with the share of “periphery” bonds held by foreign investors declining precipitously.

Portugal was among the hardest-hit countries. Its sovereign bond rating was downgraded by Moody's in the summer of 2010, and it obtained a bailout of 78 billion euros from the ECB and the IMF almost a year later. The experience of Italy was rather different. In contrast to Greece, Ireland, Portugal and Spain, Italy was able to keep its 2009 budget deficit in check. It had entered the crisis period with high debt-to-GDP levels, however, second only to Greece among European countries. This raised concerns about the sustainability of Italian debt and, although Italian bonds were not downgraded based on Italy's fundamentals, there was an increase in oversight by credit rating agencies. It was only in September of 2011 that Italian bonds were downgraded by Standard and Poor's, a month after the ECB announced the possibility of buying Italian bonds to lower its borrowing costs.

In contrast to the "periphery" countries described thus far, the "core" countries followed a very different path: German and French bond fundamentals were never in doubt by investors or credit rating agencies. Indeed, during the crisis their borrowing costs remained low and stable while most other countries' borrowing costs increased. This divergence between the core and the periphery was all the more striking because both group of countries faced almost identical interest rates for a number of years preceding the crisis. In part, this may have been because investors expected the Eurozone, and its key institutions such as the ECB, to deploy transfers and other cross-subsidies in order to maintain the stability of its members and the monetary union.[10] Against this background, the crisis was interpreted as calling into question both the commitment and ability of the Eurozone to support its fellow members.[11]

Mario Draghi's London speech on July 26, 2012 is widely credited with creating the conditions for ending the Eurozone crisis. In that speech, the ECB president gave an account of the euro-zone economy, trying to convince international investors that the region's economy was not as bad as yields suggested, and then made a powerful and credible statement: *"Within our mandate, the ECB is ready to do whatever it takes to*

[10] The Maastricht treaty which established the European Monetary Union in 1992 allowed for fiscal independence within limits on the size of public debt and deficits, and included an explicit "no-bailout" clause. However countries like Greece and Italy were allowed to join despite being in violation of the limits. Hence bond markets seem to have anticipated that the no-bailout clause would not, in the end be enforced, and there was almost complete convergence in sovereign yields within the EU despite countries having very different public finances.

[11] At the height of the crisis, the Economist's Intelligence Unit stated: "For much of 2010, political energies across the region were consumed with preventing contagion to other countries and restoring faith in the long-term sustainability of the monetary union. As things stand, it is far from clear that European policy-makers have succeeded." See Unit and Britain (2011).

preserve the euro. And believe me, it will be enough." The effectiveness of this announcement strongly suggests that a critical source of uncertainty during the crisis was the ability and willingness of the ECB to intervene.[12]

In sum, Portugal was a country with fundamental solvency problems that were quickly recognized by credit rating agencies, Germany and France did not have fundamental problems, and Italy was an intermediate case: it did not suffer from clear fundamental problems at the onset of the crisis, but its high overall debt levels raised suspicions and induced investors to pay closer attention to its economic and political prospects. The New York Times reported *"As Greece teeters on the brink of a default, the game has changed: Investors are taking aim at any country suffering from a combination of high debt, slow growth and political dysfunction and Italy has it all, in spades."*[13]

This narrative - upon revelation of weak fundamentals in Portugal, investors paid closer attention to Italy but not to Germany or France - is sometimes referred to as the "wake-up call" hypothesis. Several papers document empirical patterns in line with this hypothesis. For example, yields decoupled from standard measures of fundamental risk in Italy and Portugal, and/or become more sensitive to news about other countries.[14] However, these papers do not describe a particular mechanism by which information acquisition was encouraged and then impounded into prices.

We argue that the auction protocol used by European countries encourages information acquisition by generating rents for informed investors, and that such information is exploited at auction and then revealed in secondary markets. Narrative evidence suggests that the information at hand may have been related to the strength of the Eurozone, the stance of the ECB on interventions, the credibility of "no bailout" clauses, and the the willingness of affected countries to accept the terms of potential bailouts. The combination of these two arguments leads to the conclusion that auction design can dramatically shape the behavior of yields and impose externalities on other countries during crises. Moreover, the winner's curse provides a stark mechanism that induces investors to stop diversifying across countries precisely when risk

[12] Moghadam (2014) states that: "Perhaps markets understood that the economic and financial integration of the euro area made it 'too-big-to-fail', so that the "no bailout" clause was not credible. At the height of the crisis in 2011, when there were real doubts about whether or not the euro area would survive, the dispersion of cross-country bond yields reemerged. But with this existential threat, the authorities acted to keep the currency union intact—the assessment that the euro area was 'too-big-to-fail' was right.' "

[13] "Debt Contagion Threatens Italy" New York Times, July 11, 2011.

[14] See for instance Giordano, Pericolli, and Tommasino (2013), D'Agostino and Ehrmann (2014), Ehrmann and Fratzscher (2017), Bahaj (2020), and Moretti (2021).

is high and diversification would be particularly valuable. In the next section, we provide evidence of changes in the information regime in "periphery" countries, but not in "core" countries, and show that the behavior of cross-market spreads and market segmentation are consistent with these changes, as implied by our model.

4.2 Measuring the Information Content of Sovereign Bond Auctions

We now use two complementary approaches that exploit the relation between primary and secondary market yields during auction days to measure the information content of bonds auctions during the Eurozone crisis.

First, we construct a measure of auction informativeness by computing the reduction in conditional variance of secondary market yields that arise from observing primary market outcomes in addition to secondary market data, during auction days. Specifically, we compute the share of unexplained variance of auction-day secondary market yields that can be accounted for using auction results in addition to pre-auction secondary market yields. This statistic is called *marginal* R^2 and it is formally given by

$$\Delta R^2 = \frac{R^2_{(S_{t-1},P_t)} - R^2_{(S_{t-1})}}{1 - R^2_{(S_{t-1})}},$$

where $R^2_{(S_{t-1})}$ is the R^2 of a regression of secondary yields reported at market close on auction days on three lags of pre-auction secondary market yields, and $R^2_{(S_{t-1},P_t)}$ is the R^2 of the same regression but including primary market yields observed at auction as an additional regressor. As formally shown in Appendix B, marginal R^2 thus is a measure of the information contained in primary markets that is impounded into secondary markets. It is also easy to interpret: $\Delta R^2 = 0.5$, for instance, implies that primary markets contain enough information to explain 50% of the variance unaccounted for by lagged secondary market yields.

More than its absolute value, we are interested in the *change* of marginal R^2 during the crisis. Hence, we separately compute the marginal R^2 for Portugal, Italy, Germany and France in three sub-periods: pre crisis, crisis and post crisis.[15] For this exercise, we take the break point between pre-crisis and crisis to be January 2010,

[15]Portugal, Italy and Germany conducted auctions roughly every month and France roughly every week. Since France reports the average yield at auction, but not the marginal yield, we use the quantity-weighted average yields for all countries, but results are very similar using marginal yields in the three countries for which we have such information.

when the crisis was already evident. We date its end to August 2012.[16] We focus on one-year bonds, but Appendix C shows similar results using half-year and quarter-year bonds in .[17] We describe data sources and institutional details in Appendix D.

Table 1 shows that marginal R^2 increased substantially during the crisis for Portugal and Italy, but not for Germany and France. For instance, the share of the variance of one-year secondary market yields that can be accounted for using auction information increased to 19% from 3% in Portugal and then receded to 0.5%. In the case of Italy, the increase was to 76% from 24%, before receding to 44% after the crisis. Germany and France, in contrast, did not experience any significant change on informativeness during this period, and the information content of French bond auctions declined drastically during and after the crisis.

Marginal R^2: One-year Sovereign Bond				
Country	Portugal	Italy	Germany	France
Pre-crisis ΔR^2	0.026	0.244	0.131	0.380
Observations	*45*	*46*	*10*	*122*
Crisis ΔR^2	0.190	0.761	0.104	0.157
Observations	*25*	*31*	*29*	*118*
Post-crisis ΔR^2	0.005	0.439	0.086	0.044
Observations	*69*	*89*	*41*	*365*

Table 1: Fraction of unexplained secondary yield variance explained by primary yields.

While these results suggest that the information content of auctions did increase during the crisis in the periphery, marginal R^2 cannot be used to assess the sign of the relation between primary and secondary market yields. Since our theory suggests that this sign should be positive, we now measure it using a two-step procedure. First, we predict auction yields and post-auction secondary market yields using a regression on lagged secondary market yields from the three days prior to an auction

[16]It is challenging to define the start an end of a slowly evolving crisis. We use January 2010 as a start because it corresponds to the period surrounded by Greek's prime minister George Papandreou revealing that Greece's budget deficit will exceed 12 percent of GDP and credit-rating agencies downgrading Greece's sovereign debt to junk status, triggering concerns in all Europe. We use August 2012 as the end because it corresponds to the period right after ECB President Mario Draghi vow on July 26, 2012 to "do whatever it takes to preserve the euro," pre-announcing an open-ended program to buy the government bonds of struggling Eurozone states on the secondary market.

[17]For half-year bonds Germany's primary markets also saw some increase in the marginal R^2. Even though data on quarter-year bonds is only available for Portugal and France, results are also consistent with the findings in this section.

day. The fitted values of these regressions $\widehat{y}^m_{i,t}$ are the *expected* primary and secondary market yields at the start of an auction day, where $m \in \{Prim, Sec\}$.

Second, we define the *unexpected change* in yields as the difference between realized and expected yields, $\Delta \log y^m_{i,t} \equiv \log(y^m_{i,t}) - \log(\widehat{y}^m_{i,t})$, and regress the *unexpected* change in country $i's$ secondary market yield at the end of auction day t on the *unexpected* change of primary market yields of the same country on the same day. The associated regression coefficient is the *elasticity of the surprise innovation in secondary market yields to the surprise innovation in primary market yields*. According to our theory, secondary market yields should react positively and more strongly to primary market innovations when auction outcomes are more informative (e.g. because there are more informed investors).

Table 2 shows precisely this pattern. The primary market surprise is significantly more informative during the crisis in the periphery, but not in the core. This can be seen in the statistically significant positive increase in the elasticity for Portugal (an increase of 0.188) and Italy (an increase of 0.491), but not for Germany and France. In contrast, the elasticity difference between pre- and post-crisis is not statistically significant for any of the four countries.

Dependent variable: $\Delta \log y^{\text{Sec}}_{i,t}$: One-year Sovereign Bond				
Country	Portugal	Italy	Germany	France
$\Delta \log y^{\text{Prim}}_{i,t} \times \mathbb{I}$(pre-crisis)	0.015	0.206**	-0.001	0.337***
	(0.086)	(0.102)	(0.056)	(0.030)
$\Delta \log y^{\text{Prim}}_{i,t} \times \mathbb{I}$(crisis)	0.202***	0.697***	-0.056	0.308***
	(0.051)	(0.053)	(0.064)	(0.062)
Difference w/pre-crisis	*0.188**	*0.491****	*-0.055*	*-0.028*
	(0.100)	*(0.115)*	*(0.085)*	*(0.069)*
$\Delta \log y^{\text{Prim}}_{i,t} \times \mathbb{I}$(post-crisis)	-0.006	0.419***	0.103**	0.225***
	(0.060)	(0.111)	(0.048)	(0.070)
Difference w/pre-crisis	*-0.020*	*0.214*	*0.104*	*-0.111*
	(0.105)	*(0.151)*	*(0.074)*	*(0.076)*
Observations	139	166	80	605
R^2	0.11	0.55	0.20	0.22

Table 2: Elasticity of secondary yields to primary yields.

4.3 The Eurozone Crisis Through the Lens of the Model

We have shown that auction informativeness increased during the Eurozone crisis in the periphery, but not in the core. We now use our theoretical framework to assess the implications of these patterns for the dynamics of yields and market segmentation.

To capture the main elements of the Eurozone crisis, we use a repeated version of our model extended along two dimensions. First, since the "wake-up call" narrative suggests that investors were worried about a "disaster" situation in which the ECB would not bailout countries in distress at the height of the crisis, we consider a three-state process for default risk within each regime, i.e. $\theta \in \{d, b, g\}$. State d captures the (ultimately unrealized) "disaster" in which Portugal does not obtain a bailout.

Second, we allow for ex-ante heterogeneity among investors and trading frictions in the secondary market. With respect to heterogeneity, we capture home bias in information, as in Van Nieuwerburgh and Veldkamp (2009), by assuming that investors have a particular "home" country in which they can acquire information relatively cheaply. With respect to frictions, we assume that investors may not always find buyers or sellers in secondary markets, which hampers perfect diversification ex-post. For simplicity, we assume a fixed probability $\psi < 1$ that a given investor can access the secondary market. Frictional secondary markets are indeed a concern in practice, as shown by Passadore and Xu (2020) and Chaumont (2021).

As emphasized by Lane (2012), the Eurozone crisis unfolded in three main phases that differed in public perceptions of default risk. Hence we assume that countries transition through three phases that correspond to three *publicly known* regimes, with increasing risk levels: *tranquil* (t), *alarming* (a), and *crisis* (c), so $\rho_j \in \{t, a, c\}$. We then ask whether investors choose to become informed about the state of the world θ_j *given* a change in the public regime. Table 3 shows the default probabilities for each risk regime and state that we use for our numerical illustration.

	Tranquil regime	Alarming regime	Crisis regime
$\kappa(g)$	0.1%	1.5%	3%
$\kappa(b)$	0.5%	3%	7%
$\kappa(d)$	1.5%	6%	15%

Table 3: Default Risk Across Public Regimes and Quality Shocks. In all regimes, the probability of the good state is $f(g) = 0.6$ and the probability of a disaster is $f(d) = 0.1$.

Lane (2012) also shows that Portugal was central to the dynamics of the Eurozone crisis. We capture the deterioration of its fiscal situation by assuming that Country 1 (representing Portugal) transitions from the tranquil regime (prior to 2010), to alarming (late 2010), to crisis (most of 2011). Since our evidence indicates that Portuguese bond auctions became more informative at the height of the crisis, we choose information costs such that the transition to the crisis regime triggers information acquisition by domestic investors in Country 1. We then evaluate information spillovers and the dynamics of bond yields and portfolios in two scenarios. In Scenario A, Country 2 transitions to the alarming regime (and therefore represents Italy). In Scenario B, Country 2 remains tranquil throughout (and therefore represents Germany or France). These regimes and transitions are summarized in Table 4. We hold the cost of information fixed across both scenarios. This allows us to isolate the role of information spillovers and country heterogeneity in driving bond yields and portfolio choices.

	Phase 1	Phase 2	Phase 3
Country 1	Tranquil	Alarming	Crisis
Country 2 in Scenario A	Tranquil	Tranquil	Alarming
Country 2 in Scenario B	Tranquil	Tranquil	Tranquil

Table 4: Regime changes in Scenario A and Scenario B. In Scenario A, Country 1 represents Portugal and Country 2 represents Italy. In Scenario B, Country 1 represents the periphery and Country 2 represents the Core.

Figure 3 shows simulation results for Scenario A, where Country 2 transitions to the alarming regime in Phase 2 and then remains there. In this scenario, Country 2 represents Italy which, given its indebtedness, experienced concerns about solvency at the height of the crisis. Because the value of information is increasing in the level and dispersion of default risk conditional on a public regime, the transition to the alarming regime in Country 2 alone is not enough to trigger information acquisition. But if a crisis in Country 1 has triggered information acquisition there, then Country 2 also becomes informed. This is the essence of informational spillovers: Italy would not have become informed in the absence of Portugal becoming informed.

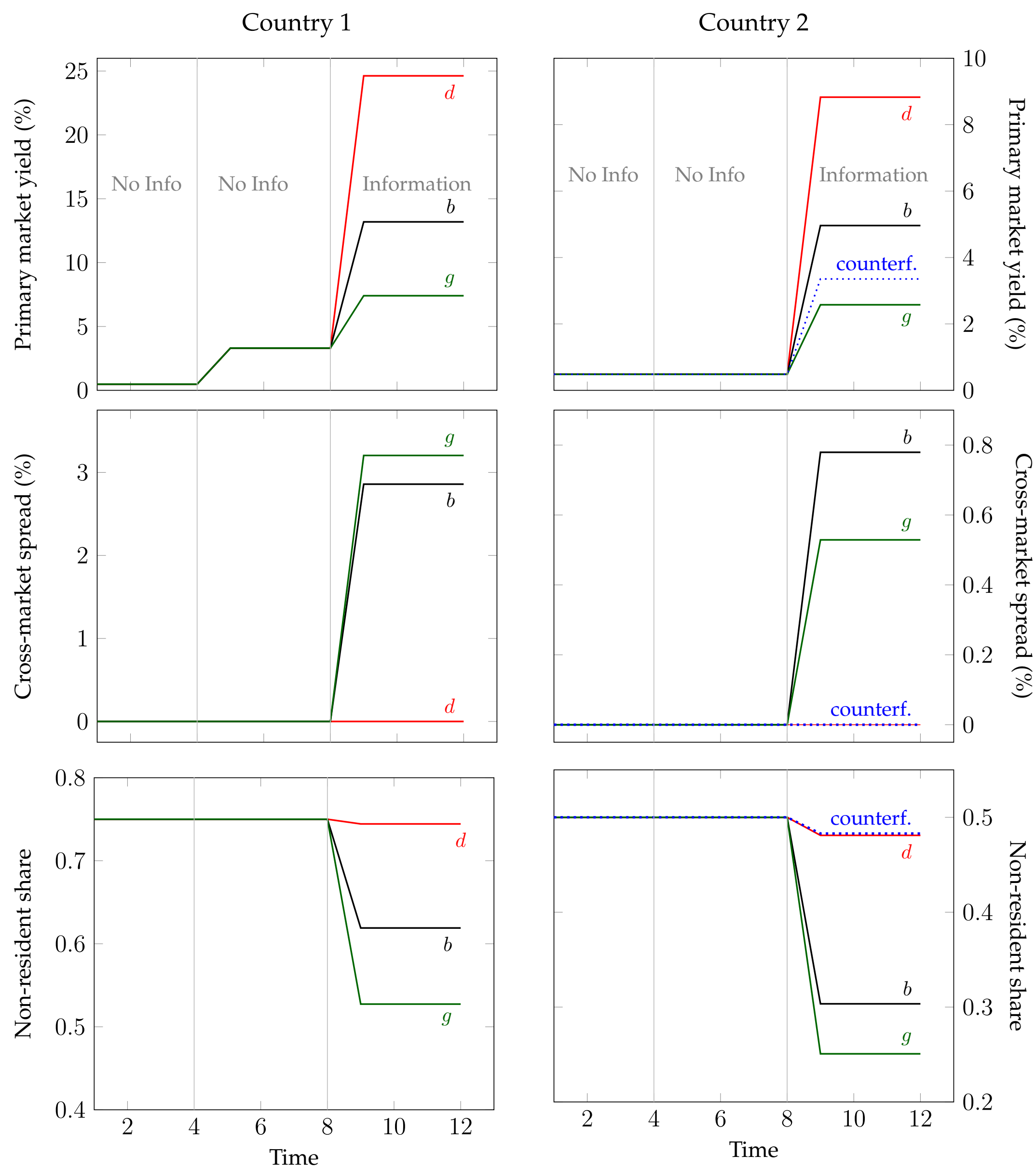
As in the data, the informational spillover leads to a spike in average yields and yield *volatility*: average yields are high because default risk has increased and the winner's curse leads to poor risk sharing, and volatility is high because yields more closely reflect the realized states. Indeed, because primary market prices now reflect the underlying state, the information content of auctions increases. The advent of the winner's curse further induces market segmentation: because foreign investors can no longer bid in Portugal or Italy without fear of adverse selection, they limit their auction participation in those countries. This fragmentation is simultaneously reflected in high average yields and a large primary-secondary market spread.

These effects of informational spillovers to Country 2 are shown in the right column of Figure 3. Equilibrium outcomes are shown in solid lines; the counterfactual where Country 2 investors do not acquire information is shown in in dashed lines. Absent the information spillover from Country 1, in Country 2 average yields and volatility would have been lower, the primary-secondary market spread would have been zero, and the non-resident share would have remained stable.

Figure 4 shows an analogous simulation for Scenario B, where Country 2 does not experience an increase in default risk (and can therefore be taken to represent France and Germany.) Equilibrium outcomes are shown in solid lines. Country 1 behaves very similar to before. Given the *same* cost of domestic information acquisition as in Scenario A, there is no information spillover: while the transition to the crisis regime induces information acquisition in Country 1, tranquil fundamentals in Country 2 are sufficient to discourage information acquisition in the "core". We find sharply different predictions for yields, informativeness and portfolio choices. Since the core remains uninformed, the level and volatility of yields are low. Since auction prices do not convey information about default risk, they do not predict subsequent secondary market prices, and there is no cross-market spread. In fact, yields fall slightly because the lack of winner's curse means Country 2 can serve as a refuge for uninformed investors. Accordingly, Country 2's non-resident share is approximately flat in Phase 3.

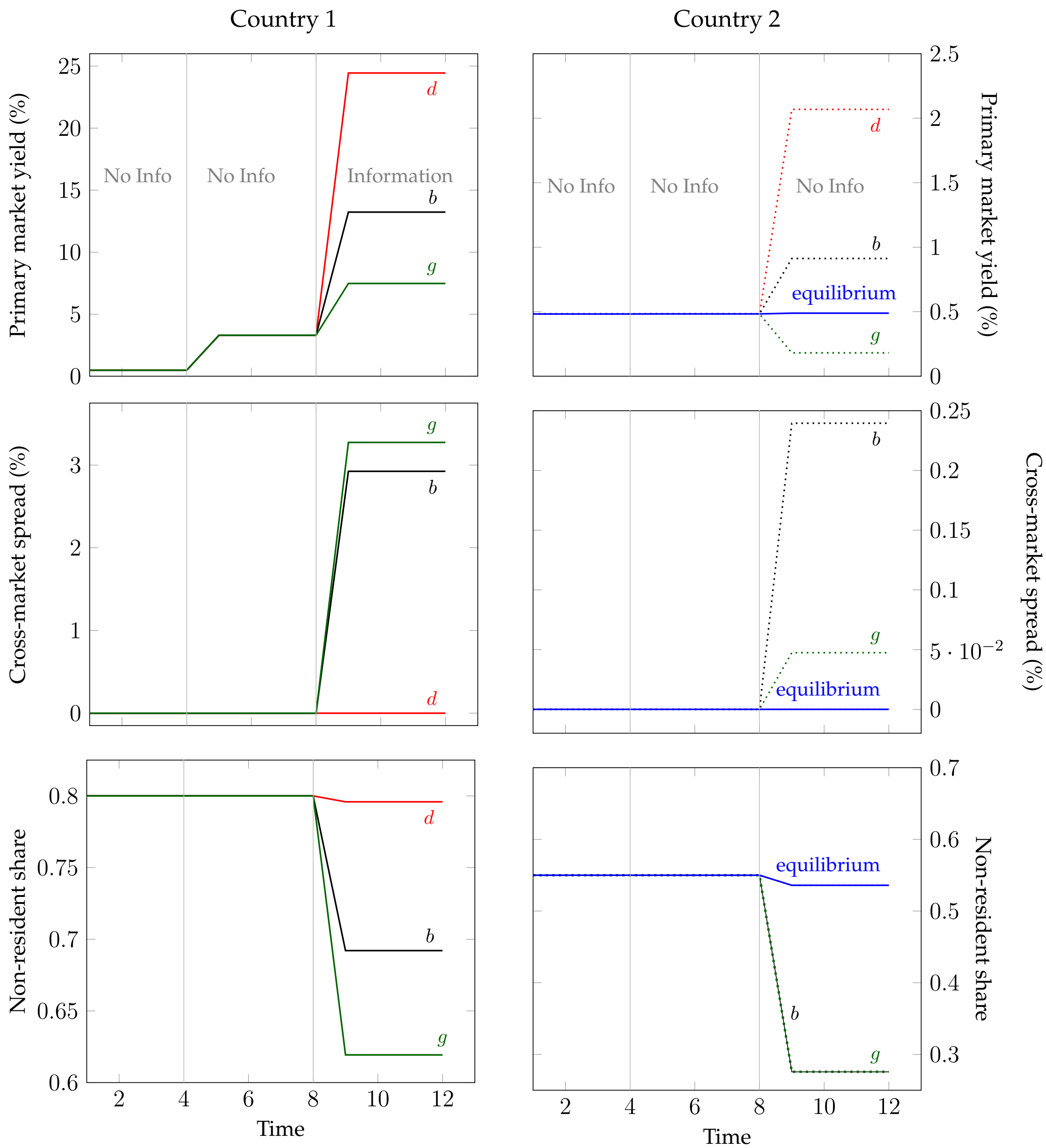
The dashed lines in the right column of Figure 4 shows counterfactual outcomes *with* information acquisition by domestic investors in Country 2. These reveal that the behavior of yields, portfolios, and auction informativeness is strongly affected by the lack of informational spillovers: had there been information acquisition in Country 2, yield volatility and cross-market spreads would have risen and the non-resident share would have fallen sharply.

Figure 3: Spillovers from Country 1 when Country 2 is Risky.



Notes: Simulation results for Scenario A. Country 1 transitions from tranquil to alarming to crisis. Country 2 transitions from tranquil to alarming in Phase 3. Parameters: Debt levels $D_1 = D_2 = 300$, investor wealth $W = 1200$, probability of secondary market access $\psi = 0.5$, risk aversion $\gamma = 1$. There are three groups of investors: residents of Country 1, residents of Country 2, and foreign investors. Their respective masses are $N_1 = 0.25$, $N_2 = 0.5$, and $N_f = 0.25$. The cost of acquiring information at home is set to $K = 0.024$, the cost of acquiring information abroad is $K^* >> K$ (e.g., $K^* = 1$). Under these parameters, all domestic investors acquire information at home in Phase 3 only, and and no investor acquires information in a foreign country at any stage. Population masses are chosen such that non-resident shares are approximately similar to the data in the pre-crisis period.

Figure 4: Spillovers from Country 1 when Country 2 is Stable.



Notes: Simulation results for Scenario B. Country 1 transitions from tranquil to alarming to crisis. Country 2 remains in the tranquil regime throughout. Parameters: Debt levels $D_1 = D_2 = 300$, investor wealth $W = 1200$, probability of secondary market access $\psi = 0.5$, risk aversion $\gamma = 1$.
There are three groups of investors: residents of Country 1, residents of Country 2, and foreign investors. Their respective masses are $N_1 = 0.2$, $N_2 = 0.45$, and $N_f = 0.35$. The cost of acquiring information at home is set to $K = 0.024$, the cost of acquiring information abroad is $K^* >> K$ (e.g., $K^* = 1$). Under these parameters, all Country 1 investors acquire information in Country 1 in Phase 3 only, and foreign and Country 2 investors do not acquire information in any country at any time. Population masses are chosen such that non-resident shares are approximately similar to the data in the pre-crisis period.

4.4 Further Evidence of Model Implications

Our simulations imply two main additional implications: First, increased information in primary markets raises the spread between primary and secondary market yields during the crisis in Portugal and Italy, but not in Germany and France. Further, after the crisis, the spread declines to pre-crisis levels for all countries. This is confirmed in Figure 5. During the crisis, there was first a sizable increase in cross-market spreads in Portugal in 2010, followed by an increase in Italy in 2011.

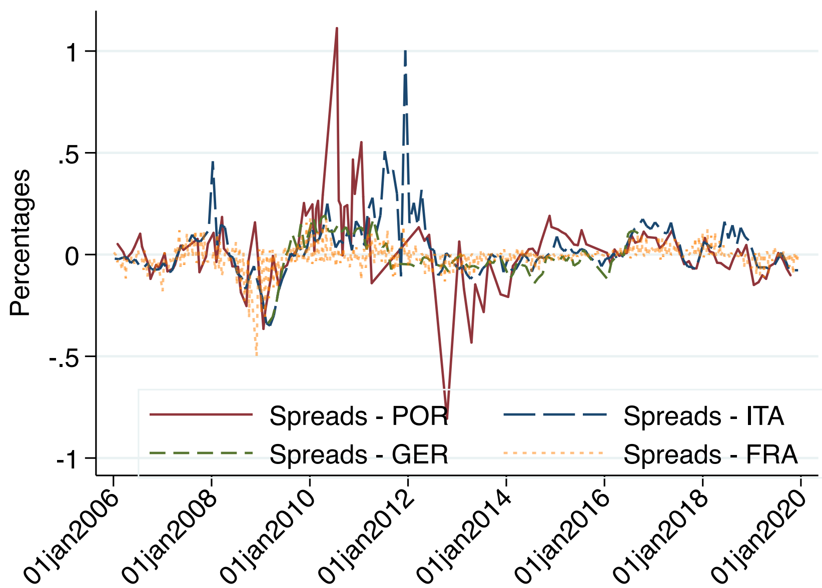


Figure 5: Cross-market spreads.

Second, increased information acquisition in Portugal and Italy induces uninformed investors to move their funds out of those countries. Assuming that the cost of information is relatively larger for foreign investors, the model predicts a decline in the share of bonds held by non-resident investors in Portugal and Italy, while the opposite would happen for Germany and France, where auctions did not attract more information. Further, we expect such segmentation to start when information acquisition intensifies both for Portugal and Italy and an increase in non-resident shares for France and Germany during the crisis. This effect should be particularly pronounced for France after the crisis, as we have seen that auction informativeness fell in France post crisis. Figure 6 shows that these patterns are present in the data.[18]

[18]Non-resident shares is reported in the Bruegel database of sovereign bond holdings developed in

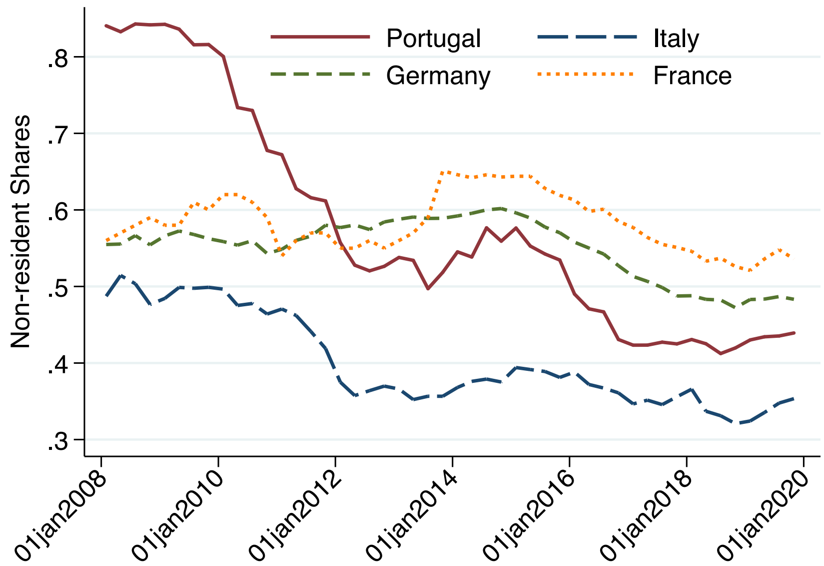


Figure 6: Segmentation (Non-resident shares of government debt).

5 Conclusion

This paper constructs a model of portfolio choice with information acquisition by an international pool of risk-averse investors who can buy sovereign debt issued by different countries in primary markets, and later trade in secondary markets. There are three novelties in our approach. First, we allows for endogenous asymmetric information about fundamental default risk. Second, we focus on primary markets and the role of commonly-used discriminatory price protocols in determining the equilibrium degree of information asymmetry and its impact on bond yields and spillovers. Third, we explore the implications of secondary markets for these variables, as well as their interaction with primary markets and asymmetric information.

The discriminatory-price auction protocol generates information rents that can induce sudden switches in the degree of asymmetric information in response to fundamental shocks. We show that this leads to a theory of yield movements that also speaks to evidence of retrenchment in capital flows during sovereign bond crises. We also show that the multi-unit auction with risk-averse investors gives rise to rich interactions with secondary markets. Specifically, the ability to offload default risk boosts the value of information at auction and induces an arbitrage spread between

Silvia Merler and Jean Pisani-Ferry (2012), "Who's afraid of sovereign bonds", Bruegel Policy Contribution 2012—02, February 2012.

primary and secondary markets. The relation between primary and secondary market prices can therefore inform us about changes in information regimes, and the model's unique predictions for the cross-market spread can be evaluated with data.

We apply our model and these insights to the recent Eurozone sovereign debt crisis and show that indeed there is evidence of information spillovers from Portugal to Italy, but not to Germany and France. Based on this evidence, we find that the model can rationalize several key facts from that episode, including yield contagion among the periphery, falling yields in the core, a decline in the foreign ownership of periphery bonds but an increase in foreign ownership of core bonds, and a wider primary-secondary yield spread in the periphery but not in the core.

Overall, our paper highlights choice of auction protocol in sovereign bond markets has implications that go well beyond the cost of borrowing for a government. Because the auction protocol determines information rents, it affects the extent of asymmetric information about a country's fundamentals, capital flows, yield volatility and ultimately information spillovers to other unrelated countries in ways reminiscent of a wake-up call narrative.

Data Availability Statement The data and code underlying this research are available on Zenodo at https://doi.org/....

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A Appendix: Proofs

A.1 Proof of Proposition 1

The stated conditions for optimal bids are the first-order conditions from the decision problem. Given the convexity of constraints and the strict concavity of the objective function, first-order conditions are necessary and sufficient for optimality. By investors' risk aversion, $P_j(\theta_j) < 1 - \kappa_j(\theta_j)$ whenever there are informed investors in country j, and $P_j(g) = P_j(b) < 1 - \bar{\kappa}_j$ if there is no informed investors. Hence bonds offer a strictly positive risk premium.

Statement (i): If no investor is informed, no bid can be contingent on the state. Since it is never optimal to bid at prices above the marginal price, the marginal price in each state must be the same. When there is no asymmetric information, all investors face the same gamble with positive excess returns. Since default risk is uncorrelated across countries, the first-order condition holds with equality.

Statement (ii): Assume for a contradiction that $P_j(g) = P_j(b)$. Since all uninformed bids are accepted in every state and informed bids are accepted contingent on the state, market-clearing then implies that informed investors must bid the same in both states. This is inconsistent with bid optimality given $\kappa_j(g) < \kappa_j(b)$.

It is trivial that informed investors must bid in every state, and that, due to the winner's curse, the short-sale constraint may bind for uninformed investors in the good state. It remains to be shown that uninformed investors' short-sale constraint never binds in the bad state (that is, uninformed investors always bid at the low price). Suppose first that the uninformed do not bid at the high price. Then $m_j^i(b,1) = m_j^i(b,0)$ if $B_j^i(b) = 0$ for some uninformed type i, which implies that it is strictly optimal to bid a positive amount because the bond offers a strictly positive risk premium. Next, assume that the uninformed do bid at the high price. For a contradiction, let $B_j^i(b) = 0$. Then $m_j^i(g,\delta_j) = m_j^i(b,\delta_j)$ since bids at the high price are accepted in all states. The first-order condition for bids at the high price is

$$- \bar{\kappa}_j m_j^i(g,1) + (1-\bar{\kappa}_j) m_j^i(g,0) y_j(g) = 0. \tag{6}$$

By the first-order condition for bids at the low price, it is strictly optimal for an uninformed investor to bid at $P_j(b)$ if and only if

$$-\kappa_j(b) m_j^i(g,1) + (1-\kappa_j(b)) m_j^i(g,0) y_j(b) > 0.$$

Combining these conditions shows that bidding at $P_j(b)$ is strictly optimal if

$$\frac{1-\kappa_j(b)}{\kappa_j(b)} y_j(b) > \frac{1-\bar{\kappa}_j}{\bar{\kappa}_j} y_j(g).$$

From the first-order conditions of some informed type i we have

$$\frac{m_j^i(g,1)}{m_j^i(g,0)} = \frac{(1-\kappa_j(g))}{\kappa_j(g)} y_j(g) \qquad \text{and} \qquad \frac{m_j^i(b,1)}{m_j^i(b,0)} = \frac{(1-\kappa_j(b)}{\kappa_j(b))} y_j(b).$$

If the uninformed do not bid at the low price, the auction can clear only if informed expenditures are the same in both states. This implies $m_j^i(g,1) = m_j^i(b,1)$, i.e. marginal utility after default is invariant in the state. Since $\kappa_j(b) > \kappa_j(g)$, the convexity of marginal utility implies that $m^i(b,0) < m^i(g,0)$. Hence

$$\frac{m_j^i(b,1)}{m_j^i(b,0)} > \frac{m_j^i(g,1)}{m_j^i(g,0)} \Rightarrow \frac{(1-\kappa_j(b))}{\kappa_j(b))} y_j(b) > \frac{(1-\kappa_j(g))}{\kappa_j(g)} y_j(g) > \frac{(1-\bar{\kappa}_j)}{\bar{\kappa}_j} y_j(g).$$

Statement (iii): Follows from the definition of acceptance sets. For an uninformed investor, bids at $P_j(g)$ are accepted even if the realized marginal price is $P_j(b)$. Under convex marginal utility, we then have that $M_j^i(b)$ is strictly increasing in $B_j^i(g)$ for an uninformed investor, but independent of $B_j^i(b)$ for an informed investor.

Statement (iv): Let B_2 denote investors' bids in Country 2 given marginal price P_2, both of which are assumed to be fixed. We will show that informed investors spend strictly more than uninformed investors in the good state and weakly less in the bad state. This implies that an increase in n_1 leads to a strict increase in $P_1(g)$.

Assume first that uninformed investors submit bids in all states, so that all first-order conditions for optimal bids hold with equality. We show that $P_1(b)B_1^I(b) < P_1(g)B_1^U(g) + P_1(b)B_1^U(b)$. For a contradiction, suppose not. Then for any $\widetilde{W} \in \{W - P_2B_2, W + (1 - P_2B_2\}$, marginal utility after default satisfies

$$P_1(b)\kappa_1(b)u'(\widetilde{W} - P_1(b)B_1^I(b)) \geq P_1(b)\kappa_1(b)u'(\widetilde{W} - P_1(g)B_1^I(g) - P_1(b)B_1^U(b)).$$

First-order conditions for bids at $P_1(b)$ then imply that, for any $\widetilde{W} \in \{W - P_2B_2, W + (1 - P_2B_2\}$, marginal utility after repayment satisfies

$$u'\Big(\widetilde{W} + (1-P_1(b))B_1^I(b)\Big) \geq u'\Big(\widetilde{W} + (1-P_1(g))B_1^U(g) + (1-P_1(b))B_1^U(b)\Big).$$

By the concavity of $u(\cdot)$, we have

$$B_1^I(b) - \Big(B_1^U(g) + B_1^U(b)\Big) \leq P_1(b)B_1^I(b) - \Big(P_1(g)B_1^U(g) + P_1(b)B_1^U(b)\Big).$$

We have assumed for a contradiction that $P_1(b)B_1^I(b) \geq P_1(g)B_1^U(g) + P_1(b)B_1^U(b)$. Moreover, $P_1(b) < 1$ by investors' risk aversion. Hence the right-hand side of the preceding inequality satisfies

$$P_1(b)B_1^I(b) - \Big(P_1(g)B_1^U(g) + P_1(b)B_1^U(b)\Big) < B_1^I(b) - \Big(\frac{P_1(g)}{P_1(b)}B_1^U(g) + B_1^U(b)\Big).$$

Since $P_1(g) \geq P_1(b)$, the contradiction obtains.

Next, we show that informed investors spend more than uninformed investors in the good state, $P_1(g)B_1^I(g) > P_1(g)B_1^U(g)$. For any fixed repayment or default decision in Country 2 and associated risk-free holdings $\widetilde{W} \in \{W - P_2B_2, W + (1 - P_2B_2\}$, uninformed investors' first-order condition for bids at $P_1(g)$ can be written as

$$\begin{aligned}
&f_1(b)\Big[P_1(g)\kappa_1(b)u'(\widetilde{W} - P_1(g)B_1^U(g) - P_1(b)B_1^U(b))\dots\\
&-(1-P_1(g))(1-\kappa_1(b))u'(\widetilde{W} + (1-P_1(g))B_1^U(g) + (1-P_1(b))B_1^U(b))\Big]\\
=&f_1(g)\left[(1-P_1(g))(1-\kappa_1(g))u'(\widetilde{W}(1-P_1(g))B_1^U(g)) - P_1(g)\kappa_1(g)u'(\widetilde{W} - P_1(g)B_1^U(g))\right].
\end{aligned}$$

Since $P_1(g) \geq P_1(b)$, the first-order condition for bids at $P_1(b)$ implies that the left-hand side is positive. This implies

$$\frac{(1-\kappa_1(g))u'(\widetilde{W} + (1-P_1(g))\,B_1^U(g))}{\kappa_1(g)u'(\widetilde{W} - P_1(g)B_1^U(g))} > \frac{P_1(g)}{(1-P_1(g))}.$$

Comparing with informed investors' FOC for bids at $P_1(g)$ implies the result.

Lastly, assume that the short-sale constraint binds for uninformed bids at $P_1(g)$. Then uninformed investors' decision problem for bids at $P_1(b)$ is identical to that of informed investors (else the only difference is that the uninformed know bids at $P_1(g)$ are also going to be accepted). Hence they choose the same bidding strategy at $P_1(b)$.

We now turn to the marginal price in the bad state. We show that $P_1(b) < \bar{P}_1$ for all $n_1 > 0$. Suppose for a contradiction that $P_1(b) \geq \bar{P}_1$. By definition, $\bar{P}_1$ is the price at which uninformed investors are willing to spend D_1 on bonds given that the acquired bonds default with probability $\bar{\kappa}_1$. Recall also that $P_1(g) \geq P_1(b)$. Hence if $P_1(b) \geq \bar{P}_1$, first-order conditions for bid optimality imply that $X_1^U(b) = P_1(g)B_1^U(g) + P_1(b)B_1^U(b) < D_1$. The first statement of this proposition showed that $X_1^U(g) \leq X_1^U(g)$. Hence $n_1X_1^I(b) + (1-n_1)X_1^U(b) < D_1$, a contradiction with the market-clearing condition.

Now consider the limit as $n_1 \to 0$. By Proposition 1, uninformed investors must always bid at the low price (that, is their first-order condition must hold with equality.) To clear the market in the good state as the share of informed investors shrinks to zero, it must be that $\lim_{n1\to 0} P_1(g)B_1^U(g) = D_1$. Since uninformed bids at the high price are also accepted in the bad state, we must have that $\lim_{n1\to 0} P_1(g)B_1^U(g) = 0$. Since the price must be bounded away from zero, this implies $\lim_{n1\to 0} B_1^U(g) = 0$ and so $m_j^i(g,\delta_j) = m_j^i(b,\delta_j)$ in the limit. First-order optimality for bids at the high price requires

$$\bar{\kappa}_j m_j^i(g,1) + (1-\bar{\kappa}_j)m_j^i(g,0)y_j(g) = 0,$$

while the analogue condition for bids at the low price is

$$\kappa_j(b)m_j^i(g,1) + (1-\kappa_j(b))m_j^i(g,0)y_j(b) = 0,$$

Since $\kappa_j(b) > \bar{\kappa}_j$, these conditions jointly hold only if $y_j(b) > y_j(g)$. **Q.E.D.**

A.2 Proof of Proposition 2

Statement (i). Since investors are ex-ante identical, they are also ex-post identical if they make the same information choices. Hence the optimal portfolio choice problem is identical for all investors, they choose the same portfolio weights in all countries and all states of the world.

Statement (ii). Now consider the case with asymmetric information. We solve a second-order approximation to the optimal portfolio choice problem. Let $n_1 \in (0,1)$. There are 8 possible states: for each $\theta_j \in \{g, b\}$, each country may default (d) or repay (r). Since there is no information in Country 2, we can proceed as if there were only one state with default probability $\bar{\kappa}_2$. Simplify notation by writing state-contingent consumption as $\{c_{rr}^i(\theta), c_{rd}^i(\theta), c_{dr}^i(\theta), c_{dd}^i(\theta)\}$. Then i's objective function can be written as

$$\begin{aligned} V^i =& f_1(g)\left\{ \begin{array}{c} \kappa_1(g)\Big[\bar{\kappa}_2 u(c_{dd}^i(g)) + (1-\bar{\kappa}_2)u(c_{dr}^i(g))\Big] \\ +(1-\kappa_1(g))\Big[\bar{\kappa}_2 u(c_{rd}^i(g)) + (1-\bar{\kappa}_2)u(c_{rr}^i(g))\Big] \end{array} \right\} \\ &+ f_1(b)\left\{ \begin{array}{c} \kappa_1(b)\Big[\bar{\kappa}_2 u(c_{dd}^i(b)) + (1-\bar{\kappa}_2)u(c_{dr}^i(b))\Big] \\ +(1-\kappa_1(b))\Big[\bar{\kappa}_2 u(c_{rd}^i(b)) + (1-\bar{\kappa}_2)u(c_{rr}^i(b))\Big] \end{array} \right\} \end{aligned}$$

We compute a second-order Taylor approximation of the objective function around $B_j^i(\theta_j) = 0$ for all i, all j, and all θ_j. For informed investors, the associated first-order conditions with respect to $B_1^i(g)$, $B_1^i(b)$ and B_2^i are, respectively,

$$\begin{aligned} 0 =& f_1(g)(1-\kappa_1(g)-P_1(g))u'(W) \\ &+ f_1(g)\Big[\kappa_1(g)(-P_1(g))^2 + (1-\kappa_1(g))(1-P_1(g))^2\Big]u''(W)B_1^I(g) \\ &+ f_1(g)(1-\kappa_1(g)-P_1(g))(1-\bar{\kappa}_2-P_2)u''(W)B_2^I \end{aligned} \tag{7}$$

$$\begin{aligned} 0 =& f_1(b)(1-\kappa_1(b)-P_1(b))u'(W) \\ &+ f_1(b)\Big[\kappa_1(b)(-P_1(b))^2 + (1-\kappa_1(b))(1-P_1(b))^2\Big]u''(W)B_1^I(b) \\ &+ f_1(b)(1-\kappa_1(b)-P_1(b))(1-\bar{\kappa}_2-P_2)u''(W)B_2^I \end{aligned} \tag{8}$$

$$
\begin{aligned}
0 =&(1-\bar{\kappa}_2-P_2)u'(W)\\
&+\left[\bar{\kappa}_2(-P_2)^2+(1-\bar{\kappa}_2)(1-P_2)^2\right]u''(W)B_2^I\\
&+f_1(g)(1-\bar{\kappa}_2-P_2)(1-\kappa_1(g)-P_1(g))u''(W)B_1^I(g)\\
&+f_1(b)(1-\bar{\kappa}_2-P_2)(1-\kappa_1(b)-P_1(b))u''(W)B_1^I(b)
\end{aligned} \tag{9}
$$

Define informed expected rates of return by $\tilde{r}_1^I(g)=\frac{1-\kappa_1(g)-P_1(g)}{P_1(g)}$, $\tilde{r}_1^I(b)=\frac{1-\kappa_1(b)-P_1(b)}{P_1(b)}$ and $\tilde{r}_2^I=\frac{1-\bar{\kappa}_2-P_2}{P_2}$ and let $\sigma_1^I(g)$, $\sigma_1^I(b)$, and σ_2^I denote the associated standard deviations. The first term of the RHS of (7) can be rewritten in terms of returns as

$$f_1(g)(1-\kappa_1(g)-P_1(g))u'(W)=f_1(g)\tilde{r}_1(g)P_1(g)u'(W)$$

and the second term as

$$f_1(g)\left[\kappa_1(g)(-P_1(g))^2+(1-\kappa_1(g))(1-P_1(g))^2\right]u''(W)B_1^I(g)=f_1(g)\mathbb{E}\left[\left(r_1^I(g)\right)^2\right]P_1(g)^2u''(W)B_1^I(g)$$

All other terms in equations (7)-(9) can be analogously rewritten. Let $u(c)=\frac{c^{1-\gamma}-1}{1-\gamma}$, and define the state-contingent portfolio weights $\omega_1^I(g)=\frac{P_1(g)B_1^I(g)}{W}$, $\omega_1^I(b)=\frac{P_1(b)B_1^I(b)}{W}$, and $\omega_2^I=\frac{P_2B_2^I}{W}$. Since $Var(x)=\mathbb{E}[x^2]-(\mathbb{E}[x])^2$, the system of equations is

$$\tilde{r}_1^I(g)=\gamma\omega_1^I(g)\left(\left(\sigma_1^I(g)\right)^2+\left(\tilde{r}_1^I(g)\right)^2\right)+\gamma\omega_2^I\left(\tilde{r}_1^I(g)\tilde{r}_2^I\right) \tag{10}$$

$$\tilde{r}_1^I(b)=\gamma\omega_1^I(b)\left(\left(\sigma_1^I(b)\right)^2+\left(\tilde{r}_1^I(b)\right)^2\right)+\gamma\omega_2^I\left(\tilde{r}_1^I(b)\tilde{r}_2^I\right) \tag{11}$$

$$\tilde{r}_2^I=\gamma\omega_2^I\left(\left(\sigma_2^I\right)^2+\left(\tilde{r}_2^I\right)^2\right)+f_1(g)\gamma\omega_1^I(g)\tilde{r}_1^I(g)\tilde{r}_2^I+f_1(b)\gamma\omega_1^I(b)\tilde{r}_1^I(b)\tilde{r}_2^I \tag{12}$$

Optimality conditions for uninformed investors are analogous, modulo adjusting expected returns and standard deviations to take into account that bids $P_1(g)$ are also accepted in the bad state. To facilitate comparisons of optimal portfolios, going forward we denote expected returns for a given information set simply by R_g, R_b and R_2. Let σ_g, σ_b, and σ_2 denote the associated standard deviations, and S_g, S_b and S_2 the Sharpe ratios. Optimal portfolios then satisfy the following system of equations, with the only differences across types accounted for by differences in expected returns and volatility:

$$\omega_g=\left(\frac{R_g}{\sigma_g^2+R_g^2}\right)(1-\omega_2R_2)$$

$$\omega_b=\left(\frac{R_b}{\sigma_b^2+R_b^2}\right)(1-\omega_2R_2)$$

$$\omega_2=\left(\frac{R_2}{\sigma_2^2+R_2^2}\right)(1-f_1(g)\omega_gR_g-f_1(b)\omega_bR_b)$$

Multiplying by $R_i(1/\sigma_i^2)$, dividing by $(1/\sigma_i^2)$ and defining $s = \frac{S^2}{1+S^2}$, which is strictly increasing in S, we can rewrite these expressions as

$$R_g\omega_g = s_g\left(1 - R_2\omega_2\right)$$

$$R_b\omega_b = s_b\left(1 - R_2\omega_2\right)$$

$$R_2\omega_2 = s_2\left(1 - f_1(g)R_g\omega_g - f_1(b)R_b\omega_b\right)$$

Then plug in the first two equations into the third to give:

$$R_2\omega_2 = s_2\Bigg(1 - f_1(g)s_g\left(1 - R_2\omega_2\right) - f_1(b)s_b\left(1 - R_2\omega_2\right)\Bigg)$$

It follows that

$$\omega_2 = \frac{1}{R_2}\left(\frac{1 - f_1(g)s_g - f_1(b)s_b}{\frac{1}{s_2} - f_1(g)s_g - f_1(b)s_b}\right)$$
$$\omega_g = \frac{s_g}{R_g}\left(\frac{\frac{1}{s_2} - 1}{\frac{1}{s_2} - f_1(g)s_g - f_1(b)s_b}\right)$$
$$\omega_b = \frac{s_b}{R_b}\left(\frac{\frac{1}{s_2} - 1}{\frac{1}{s_2} - f_1(g)s_g - f_1(b)s_b}\right)$$

We now show that when $\bar{\kappa}_1 < \frac{1}{2}$, informed investors obtain a higher Sharpe ratio when bidding at the high marginal price in Country 1, $S_1^I(g) > S^U$, and that the difference in Sharpe ratios is strictly decreasing in $P_1(g)$, i.e. $\frac{\partial S_1^I(g) - S_1^U(g)}{\partial P_1(g)} < 0$. Observe that the return of a Country-1 bond bought at the high price (in state g) in case of default is -1 (with expected probability $\kappa_1^i(g)$) and in case of repayment $\frac{1-P_1(g)}{P_1(g)}$ (with expected probability $1 - \kappa_1^i(g)$). This implies that the expected return of such bond is $\widehat{R}_1^i(g) = \frac{1-\kappa_1^i(g)-P_1(g)}{P_1(g)}$ and the standard deviation is $\widehat{\sigma}_1^i = \frac{\sqrt{\kappa_1^i(g)(1-\kappa_1^i(g))}}{P_1(g)}$. Since $\kappa_1^I(g) = \kappa_1(g)$ and $\kappa_1^U(g) = \bar{\kappa}_1$, the difference in Sharpe ratios can be written as

$$S_1^I(g) - S_1^U(g) = \frac{1-\kappa_1(g)}{\sqrt{\kappa_1(g)(1-\kappa_1(g))}} - \frac{1-\bar{\kappa}_1}{\sqrt{\bar{\kappa}_1(1-\bar{\kappa}_1)}} - P_1(g)\left(\frac{1}{\sqrt{\kappa_1(g)(1-\kappa_1(g))}} - \frac{1}{\sqrt{\bar{\kappa}_1(1-\bar{\kappa}_1)}}\right)$$

If $\bar{\kappa}_1 < \frac{1}{2}$, then $S_1^I(g) - S_1^U(g) > 0$ and strictly decreasing in $P_1(g)$.

Since $\frac{\partial\omega_g}{\partial S_g} > 0$, it follows that $\omega_1^I(g) > \omega_1^U(g)$. Since $\frac{\partial\omega_2}{\partial S_g} < 0$, we also have $\omega_2^I < \omega_2^U$ and $\frac{\partial(\omega_2^U - \omega_2^I)}{\partial P_1(g)} < 0$. **Q.E.D.**

A.3 Proof of Proposition 3

In the uninformed equilibrium, prices are invariant in the state, $P_1(g) = P_1(b) = \bar{P}_1$. Let $\bar{B}_1 = D_1/\bar{P}_1$ denote the equilibrium bids of uninformed investors in the uninformed equilibrium. Proposition 1 shows that the informed equilibrium satisfies $\lim_{n_1 \to 0} P_1(g) = \bar{P}_1$, $\lim_{n_1 \to 0} P_1(b) < \bar{P}_1$, $\lim_{n_1 \to 0} B_1^U(g) = \bar{B}_1$ and $\lim_{n_1 \to 0} B_1^U(b) = 0$. In words, in the limit as $n_1 \to 0$, uninformed investors purchase bonds only at $P_1(g)$ and obtain the same utility as in the uninformed equilibrium. Hence we must show that informed investors do strictly better in the limit of the informed equilibrium as $n_1 \to 0$. By the fact that $\lim_{n_1 \to 0} P_1(g) = \bar{P}_1$, informed investors face the same decision problem (and obtain the same utility advantage over uninformed investors) in the good state. In the bad state, informed investors face a strictly lower marginal price in the limit of the informed equilibrium than in the uninformed equilibrium. Hence they are strictly better in the informed equilibrium if and only if the short-sale constraint does not bind at $P_1^0(b) \equiv \lim_{n_1 \to 0} P_1(b)$. We now show that this constraint does not bind. Recall that $P_1^0(b)$ is such that uninformed investors are willing to purchase a vanishingly small number of bonds in a neighborhood around $n_1 = 0$. This requires $P_1(b) < 1 - \kappa_1(b)$. Since informed investors can make state-contingent bids and hold only uncorrelated risks in Country 2, it is strictly optimal to purchase bonds at $P_1^0(b)$.

The previous arguments have shown that $\Delta\bar{V} < \lim_{n_1 \to 0} \Delta V(n_1)$, and we can find a cost of information such that it is strictly sub-optimal to acquire information if no other investor does so, but strictly optimal to acquire information if some other investors do so as well. Since K is the cost of acquiring information, it is trivial that the share of informed investors in any equilibrium with endogenous information acquisition is weakly increasing in K. **Q.E.D.**

A.4 Proof of Proposition 4

We assume that some investors are informed in a given country (say Country 2), and compute the marginal value of information for an informed investor. Denote the original bidding strategy of the investor by $\{B_2^0(g), B_2^0(b)\}$.

To capture a marginal increase in the benefits of information, consider the following marginal increase in the state-contingency of bids. In every state let the investor take some number ϵ of his bids at the price associated with the unrealized state and replace them with $\widetilde{B}_2(\theta_j)$ bids at the state-contingent price $P_2(\theta_2)$, where $\widetilde{B}_2(\theta_j)$ is chosen such that the investor's consumption after repayment remains unchanged. That is, the investor can increase the state-contingency of ϵ bids, and does so in a manner that raises payoffs when marginal utility is high (i.e. when the country defaults.)

Given that only bids at the high price are accepted in the good state, the adjustment leaves consumption unchanged conditional on $\theta_2 = g$. In the bad state, consumption is unchanged conditional on repayment by construction. This requires

$$\begin{aligned} &W - P_2(g)(B_2^0(g) - \epsilon) - P_2(b)(B_2^0(b) + \widetilde{B}_2(b)) + (B^0(g) - \epsilon) + B(b) \\ =&W - P(g)B^0(g) - P(b)B_2^0(b) + B^0(g) + B_2^0(b). \end{aligned}$$

Letting $X_2^0(b)$ denote expenditures at the original bidding strategy and $\widetilde{X}_2(b)$ expenditures after the adjustment, we have

$$\widetilde{X}_2(b) = X_2^0(b) - \epsilon\Delta_2$$

where $\Delta_2 \equiv P_2(g) - P_2(b)\frac{1-P_2(g)}{1-P_2(b)} > 0$. This implies that the adjustment leads to lower expenditures because it is cheaper to buy at $P_2(b)$ than at $P_2(g)$. Next, consider the effect on expected utility. By construction, utility *only* changes due to the adjustment if Country 2 is in the bad state, and *only* if the Country defaults. Hence the change in utility depends only on marginal utility in this state of the world. Differentiating utility with respect to ϵ around $\epsilon = 0$ then gives the change in utility $mv_2(0)$ as

$$mv_2(0) = f_2(b)\kappa_2(b)\Delta_2\mathbf{E}_1 u'\left(W - X_2(b) + (1 - \delta_1)B_1(\theta_1\right) > 0.$$

where we take expectations over default and the state of the world in Country 1. That the marginal value is increasing in the exposure and the default probability $\kappa_j(b)$ then follows directly.

A.5 Proof of Proposition 5

Statement (i): By auction market-clearing, $P_j(g) <\leq \widehat{P}_j(g)$ because all investors would prefer to trade in the secondary market if $P_j(g) > \widehat{P}_j(g)$.

If $P_1(g) < \widehat{P}_1(g)$, it is strictly optimal for informed investors to spend all wealth not invested in Country 2 at the auction in Country 1 if $\theta_1 = g$ and to sell bonds in the secondary market. We now use this observation to construct an equilibrium where this leads to no arbitrage if and only if $n_1 \geq \widehat{n}_1$. Let $\widehat{P}_j(g)$, $\widehat{B}_j^I(g)$ denote the equilibrium good-state price and informed bids in the equilibrium in which all investors are informed and there are no secondary markets. In this equilibrium, informed investors spend $\widehat{P}_2\widehat{B}_2^I$ in Country 2. By auction-clearing, $\widehat{P}_2\widehat{B}_2^I = D_2$. By the budget constraint, informed investors have $W - D_2$ in capital to invest in Country 1. For informed investors to buy the entire supply of bonds in Country 1 at price $\widehat{P}_1(g)$ in the good state, we require that $n_1(W - D_2) \geq \widehat{P}_1(g)\widehat{B}_1^I(g) = D_1$, where the last equality follows from auction clearing. This holds iff $n_1 \geq \widehat{n}_1$.

By market-clearing in Country 2, there does not exist an equilibrium with no arbitrage in the good state if $n_1 < \widehat{n}_1$. We now argue that there does exist an equilibrium with arbitrage. Given the winner's curse at auction, uninformed investors prefer to buy in the secondary market rather than bid at $P_1(g)$ if $\widehat{P}_1(g) - P_1(g)$ is sufficiently small. Moreover, $\widehat{P}_j(g) - P_j(g)$ is decreasing in the number of uninformed bids submitted at auction relative to the quantity of bonds bought by uninformed investors in the secondary market. Hence there exists an equilibrium with $P_j(g) < \widehat{P}_j(g)$ in which the arbitrage spread is such that uninformed investors are either indifferent to buying in either market or strictly prefer to buy in the secondary market.

Lastly, we show that the arbitrage persists in the limit as the share of informed investors shrinks to zero. In the limit $n_1 \to 0$, almost all investors are ex-ante identical. This implies that there exist essentially zero gains from trade ex-post. By market-clearing, it then follows trivially that auction prices must converge to the limiting prices of the equilibrium without secondary markets. Now consider the limit of secondary market prices. Suppose for a contradiction that $\lim_{n_1 \to 0} \widehat{P}_1(g) = \lim_{n_1 \to 0} P_1(g)$. Since $\lim_{n_1 \to 0} P_1(b) < \lim_{n_1 \to 0} P_1(g)$, for n_1 sufficiently small it is strictly optimal for any uninformed investor to submit zero bids at $P_1(g)$ and purchase bonds only in the secondary market. Since $n_1 W < D_1$ for n_1 sufficiently small, we have a contradiction with market clearing.

Statement (ii): If $P_j(b) > \widehat{P}_j(b)$, it is strictly optimal to submit zero bids at auction, so the auction cannot clear. Now suppose that $P_j(b) < \widehat{P}_j(b)$ and recall that uninformed bids at $P_j(b)$ are accepted if and only if $\theta_j = b$. Then it is strictly optimal for all investors to buy bonds at the auction and sell in the secondary market. Hence the secondary market cannot clear.

Statement (iii): By the first statement, there is no arbitrage if $n_1 \geq \widehat{n}_1$. But absent arbitrage, the value of information is zero because the uninformed can avoid the winner's curse without paying higher prices in the secondary market.

Next, we show that the value of information is strictly higher in the limit without informed investors. We define $P_j^A(\theta_j)$ to be the "auction-only" equilibrium price that would obtain if investors could not access secondary markets. Recall from above that $\lim_{n_1 \to 0} \widehat{P}_j(\theta_j) = \lim_{n_1 \to 0} P_j^A(\theta_j)$ and $\lim_{n_1 \to 0} \widehat{P}_1(g) > \lim_{n_1 \to 0} P_1(g)$That is, the auction prices with secondary markets converge to the auction-only prices as $n_1 \to 0$. By the Inada condition, in the auction-only equilibrium it is strictly optimal to hold a strictly positive final position in the risk-free asset, say $\widetilde{W}$. When there are secondary markets, the following is a feasible portfolio that generates strictly higher utility than the optimal auction-only portfolio: (1) buy the same portfolio at auction, (2) in addition spend $\widetilde{W}$ on bonds in state g in Country 1, and (3) sell the additional bonds purchased with $\widetilde{W}$ in the secondary market at a strict profit. This portfolio has higher average returns and lower volatility than the original portfolio, and so it is strictly preferred. Since uninformed investors obtain the same utility as in the auction-only equilibrium in the limit $n_1 \to 0$, the result follows. **Q.E.D.**

B Marginal R^2 and Auction Information Content.

Here we show how the marginal R^2 provides evidence of the information content in primary prices that are reflected in secondary prices. We adapt a strategy described in (Dávila and Parlatore 2022) that is designed to measure the information about a firm's fundamentals contained in asset prices.

Denote the primary market yield in period t as P_t and the secondary market yield in period t as S_t. Assume primary market yields are modeled as

$$P_t = \alpha_0 + \alpha_S S_{t-1} + \rho u_t$$

where S_{t-1} are lagged secondary prices that contained all information about fundamentals (in our case the default probability, θ) available before the auction and u_t is the learnable fundamental innovation, with $Var[u_t] = \tau_u^{-1}$. Here ρ captures the information regime, this is the sensitivity of the auction price to learnable innovations in those fundamentals. This is a reduced form representation (entering simply as a scalar in a linear approximation) of the gap between price schedules in the good and bad states, which depends on the fraction of informed investors participating in the auction, n, such that ρ is positive and increasing in n.

Assume secondary market yields are modeled as

$$S_t = \phi_0 + \phi_S S_{t-1} + \phi_P P_t + \phi_e e_t$$

where S_t occur after the observation of P_t (in the empirical strategy we measure secondary yields in auction days at closing, usually 4pm, while auction results are disclosed right after auctions, usually noon) and $e_t = \bar{e} + \epsilon_t$, with $Var[\epsilon_t] = \tau_e^{-1}$. These errors capture innovations that matter for prices in secondary markets beyond fundamentals, such as liquidity needs and other noise trading.

Measure of information content: This should capture the extent to which u_t is incorporated into S_t through P_t. Denote π the unbiased signal about u that can be obtained conditional on observing both primary prices and lags of secondary prices, this is $\pi_t = E[u_t|S_{t-1}, P_t]$. Then

$$\pi_t \equiv \frac{S_t - (\phi_0 + \phi_P \alpha_0 + \phi_e \bar{e} + [\phi_s + \phi_P \alpha_S] S_{t-1})}{\rho \phi_P}$$

Hence, by definition $\mu_t = \pi_t - \frac{\phi_e}{\rho \phi_P} \epsilon_t$, or

$$\pi_t = \mu_t + \frac{\phi_e}{\rho \phi_P} \epsilon_t.$$

The precision of the signal about u_t contained in S_t is then

$$\tau_\pi \equiv Var^{-1}[\pi_t | S_{t-1}, P_t] = \left(\frac{\rho\phi_P}{\phi_e}\right)^2 \tau_e$$

We can then define the (relative) information content about fundamental innovations in secondary prices coming from primary markets as

$$IC = \frac{\tau_\pi}{\tau_\pi + \tau_u} = \left[\left(\frac{\phi_e}{\rho\phi_P}\right)^2 \frac{\tau_u}{\tau_e}\right]^{-1}$$

Notice that *information content* increases when secondary prices react more to primary prices (ϕ_P), when the variance of liquidity needs decline (an increase in τ_e) or the variance of fundamentals increase (a reduction in τ_u). Our identification relies on fixing these and assigning the increase to an increase in ρ, the mapping from fundamentals to primary prices coming form changes in the fraction of informed investors in auctions, n.

Marginal R^2 as a measure of information content: We now show that

$$IC = \Delta R^2 \equiv \frac{R^2_{(S_{t-1},P_t)} - R^2_{(S_{t-1})}}{1 - R^2_{(S_{t-1})}}$$

where $R^2_{(S_{t-1},P_t)}$ is the R^2 of the regression

$$S_t = \beta_0 + \beta_1 S_{t-1} + \beta_2 P_t + \varepsilon_t$$

and $R^2_{(S_{t-1})}$ is the R^2 of the following simplified version

$$S_t = \widetilde{\beta}_0 + \widetilde{\beta}_1 S_{t-1} + \widetilde{\varepsilon}_t$$

Proof. The proof follows (Dávila and Parlatore 2022).

By definition

$$R^2_{(S_{t-1},P_t)} = 1 - \frac{Var[\varepsilon_t]}{Var[S_t]} \qquad \text{and} \qquad R^2_{(S_{t-1})} = 1 - \frac{Var[\widetilde{\varepsilon}_t]}{Var[S_t]}$$

The structural counterparts of the long equation are

$$S_t = \underbrace{\phi_0 + \phi_e \bar{e}}_{\beta_0} + \underbrace{\phi_S}_{\beta_1} S_{t-1} + \underbrace{\phi_P}_{\beta_2} P_t + \underbrace{\phi_e \epsilon_t}_{\varepsilon_t},$$

while the structural counterparts of the short equation are

$$S_t = \underbrace{\phi_0 + \phi_P \alpha_0 + \phi_e \bar{e}}_{\widetilde{\beta}_0} + \underbrace{\phi_S + \phi_P \alpha_S}_{\widetilde{\beta}_1} S_{t-1} + \underbrace{\phi_P \rho u_t + \phi_e \epsilon_t}_{\widetilde{\varepsilon}_t}.$$

Using this last expression

$$Var[S_t] = Var[\widetilde{\beta}_1 S_{t-1}] + \underbrace{Var[\widetilde{\varepsilon}_t]}_{(\phi_P \rho)^2 Var[u_t] + \phi_e^2 Var[\epsilon_t]}$$

Rewriting it

$$1 = \underbrace{\frac{1 - Var[\widetilde{\varepsilon}_t]}{Var[S_t]}}_{R^2_{(S_{t-1})}} + \underbrace{\frac{Var[\varepsilon_t]}{Var[S_t]}}_{1 - R^2_{(S_{t-1}, P_t)}} \left[\underbrace{\frac{(\phi_P \rho)^2 Var[u_t]}{\phi_e^2 Var[\epsilon_t]}}_{\tau_\pi / \tau_u} + 1 \right]$$

Then,

$$\frac{\tau_\pi}{\tau_u} = \frac{R^2_{(S_{t-1}, P_t)} - R^2_{(S_{t-1})}}{1 - R^2_{(S_{t-1}, P_t)}}$$

and

$$IC = \frac{\tau_\pi}{\tau_\pi + \tau_u} = \frac{1}{1 + \frac{\tau_u}{\tau_\pi}} = \frac{R^2_{(S_{t-1}, P_t)} - R^2_{(S_{t-1})}}{1 - R^2_{(S_{t-1})}}$$

$\square$

C Results with Shorter Maturities

In the main text, we showed results for one-year bonds. We now replicate these results for half-year bonds and quarter-year bonds. Since we have information about the later only for Portugal and France, we relegate their discussion at the end.

C.1 Half-year Bonds

In Figure 7 we show average yields for half-year bonds. While Portuguese yields departed from the others in 2009, Italian yields departed (moving in opposite direction) from those in Germany and France when Portugal lost access to markets in April 2011. While this pattern is very clear for the one-year maturity, it is also present in the half-year maturity, albeit with much higher volatility.

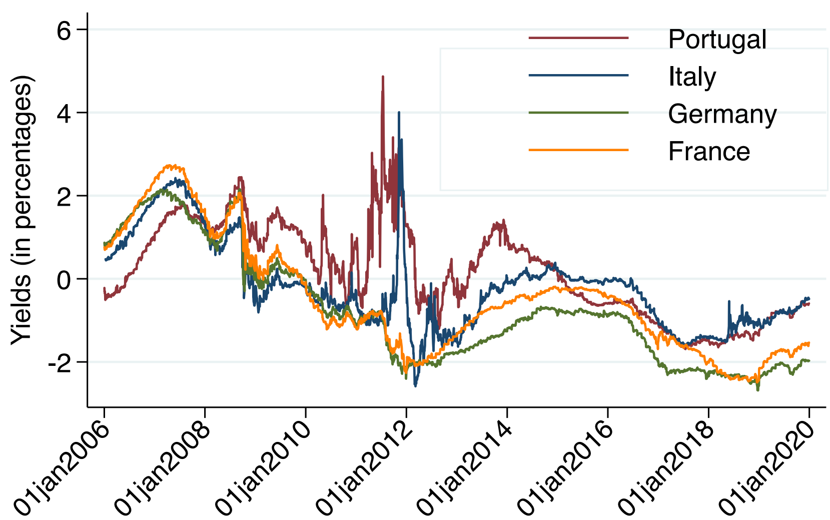

Figure 7: Real Annualized Secondary Market Yields (half-year bonds).

Tables 5 and 6 are the counterparts of Tables 1 and 2 for half-year bonds. The main result that during the crisis primary markets were particularly informative, specially for the periphery, remains. There are, however, some interesting differences that are consistent to our theory given the shorter maturity. First, it seems that in general primary markets are more informative for these shorter-term bonds than for one-year bonds. Second, Germany's information also increased during the crisis, which is suggestive that investors may not have been worried about the longer term prospects of Germany, but perhaps more concerned about shorter-term exposures and contagion possibilities from periphery countries. Finally, primary markets in Italy not only became more informative during the crisis but also remained as such after the crisis.

Marginal R^2: Half-year Sovereign Bond				
Country	Portugal	Italy	Germany	France
Pre-crisis ΔR^2	0.009	0.111	0.151	0.482
Observations	*19*	*48*	*47*	*115*
Crisis ΔR^2	0.395	0.518	0.659	0.180
Observations	*24*	*30*	*31*	*128*
Post-crisis ΔR^2	0.013	0.610	0.096	0.218
Observations	*35*	*90*	*68*	*371*

Table 5: Fraction of unexplained secondary yield variance explained by primary yields.

Dependent variable: $\Delta \log y_{i,t}^{\text{Sec}}$: Half-year Sovereign Bond				
Country	Portugal	Italy	Germany	France
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(pre-crisis)	-0.018	0.054	0.077***	0.605***
	(0.102)	(0.069)	(0.025)	(0.036)
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(crisis)	0.267***	0.811***	0.477***	0.375***
	(0.037)	(0.096)	(0.069)	(0.085)
Difference w/pre-crisis	*0.285****	*0.757****	*0.400****	*-0.230***
	(0.109)	*(0.118)*	*(0.073)*	*(0.092)*
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(post-crisis)	0.008	0.383***	0.096**	0.382***
	(0.095)	(0.048)	(0.046)	(0.084)
Difference w/pre-crisis	*0.026*	*0.329****	*0.019*	*-0.223***
	(0.140)	*(0.084)*	*(0.052)*	*(0.092)*
Observations	78	168	146	614
R^2	0.43	0.47	0.34	0.35

Table 6: Elasticity of secondary prices to primary prices.

C.2 Quarter-year Bonds

Unfortunately there is not enough three-month bonds data to replicate our results for Italy and Germany. Still we do for a periphery country (Portugal) and a core country (France). Consistent with the previous results from longer-term bonds, only Portugal experienced a sizable increase in marginal R^2 and a significant increase in the elasticity of secondary yields with respect to primary yields. These results are in Tables 7 and 8 respectively.

Marginal R^2: Quarter-year Sovereign Bond		
Country	Portugal	France
Pre-crisis ΔR^2	0.168	0.136
Observations	*17*	*198*
Crisis ΔR^2	0.507	0.015
Observations	*24*	*130*
Post-crisis ΔR^2	0.023	0.219
Observations	*41*	*374*

Table 7: Fraction of unexplained secondary yield variance explained by primary yields.

Dependent variable: $\Delta \log y_{i,t}^{\text{Sec}}$: Quarter-year Sovereign Bond		
Country	Portugal	France
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(pre-crisis)	0.063	0.233***
	(0.096)	(0.030)
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(crisis)	0.440***	0.092*
	(0.069)	(0.053)
Difference w/pre-crisis	*0.377****	*-0.141***
	(0.118)	*(0.061)*
$\Delta \log y_{i,t}^{\text{Prim}} \times \mathbb{I}$(post-crisis)	-0.006	0.340***
	(0.085)	(0.049)
Difference w/pre-crisis	*-0.070*	*0.107**
	(0.128)	*(0.057)*
Observations	82	702
R^2	0.45	0.14

Table 8: Elasticity of secondary prices to primary prices.

D Details on Institutions and Data

D.1 Primary Markets

Here we present the details and sources of the primary markets data we use in our analysis. We also discuss the institutional details of primary markets in the four countries that we focus on. We first provide a brief description of the variables that we have collected and used:

- Auction Date: Date on which the auction is held.
- Maturity Date: Date on which the face value of the bond is paid to the investor.

- Effective Maturity: This variable highlights the distinction between new bond issuance (a new brand instrument is auctioned) and re-openings (a bond previously issued is auctioned). For example, a 9-month bond could be "re-opened" 6 month later. This implies the new issued bond will mature in 3 months, and both bonds will mature the same day. The effective maturity for the new issued bond will equal 3 months.

- Segment Maturity: In the previous example, this refers to the date of the original issuance. This implies that the segment maturity will equal 9 months for the re-opened 3 month bond. The Segment maturity and the Effective Maturity will be same only for issuances of brand new bonds.

- Issuance Amount: Measured in euros. Total value of bonds auctioned.

- Bid Amount: Measured in euros. Total value of bids by market participants in the auction. This variable potentially could be larger than the Issuance Amount, in which case the auctioneer follows a rationing rule to allocate the auctioned resources.

- Allotted Amount: Measured in euros. Total value of the bonds effectively sold after the bid process is concluded. Normally if the Bid Amount is larger than the Issuance Amount, the Allotted amount will equal the Issuance Amount. Otherwise it will equal the Bid Amount.

- Weighted Average Yield: Weighted average of the yields of allotted bids.

- Maximum Average Yield: The yield associated with the lowest accepted price .

- Minimum Average Yield: The yield associated with the highest accepted price.

In the paper we focus on discount Treasury Bills for (in alphabetical order) France, Germany, Italy and Portugal. Their specific instrument names are:

1. **France:** Bons du Trésor à Taux fixe et à Intérêts Précomptés (BTFs).

2. **Germany:** Unverzinsliche Schatzanweisungen (Bubills).

3. **Italy:** Buoni Ordinari del Tesoro (BOTs).

4. **Portugal:** Bilhetes do Tesouro (BTs)

Table 9 lists all variables and their availability for each particular instrument.

Table 9: Primary Market Variables Availability by Country

Variable List - Auction				
Variables / Country	**France** (BTFs)	**Germany** (Bubills)	**Italy** (BOTs)	**Portugal** (BTs)
Data Availability	1999-2021	2005-2020	2000-2021	2006-2021
Auction Date	✓	✓	✓	✓
Maturity Date	✓	✓	✓	✓
Effective Maturity	✓	✓	✓	✓
Segment Maturity	✓	✓	✓	✓
Issuance Amount (€)	✓	✓	✓	*Incomplete*
Bidded Amount (€)	✗	✓	✓	✗
Alloted Amount (€)	✓	✓	✓	✓
Weighted Average Yield	✓	✓	✓	✓
Maximum Yield	✗	✓	✓	✓
Minimum Yield	✗	✗	✓	✓
Competitive Bids (€)	✓	✓	✗	✓
Non-Competitive Bids (€)	✗	✓	✗	✗
Competitive Allotment (€)	✓	✗	✗	✓
Non-Competitive Allotment (€)	✓	✗	✗	✓

Now we provide specific details about the auction protocol in each country. We provide the main source of information below, which we complement with more general details about participants in European auctions from the "European Primary Dealers Handbook", published by the Association for Financial Markets in Europe's (AFME): https://www.afme.eu.

D.1.1 France

Data for France was taken from the French Treasury Agency (AFT - L'Agence France Trésor). The auctions historical results can be found in: https://www.aft.gouv.fr/en/btf-principaux-chiffres.

Description of the Primary Market: The composition of the French government debt has three categories of standardized government securities: OATs, BTANs and BTFs. Obligations Assimilables du Trésor (OATs, or fungible Treasury bonds) are the government's medium and long-term debt instruments with maturities from two to fifty years. Bons du Trésor à Taux fixe et à Intérêts Précomptés (BTFs or negotiable fixed-rate discount Treasury bills) are the government's cash management instrument. Finally, the Bons du Trésor à Intérêts Annuels (BTANs or negotiable fixed-rate medium-term Treasury notes paying an annual interest) represent medium-term government debt. Importantly, the auction type for all these instruments is a multi-price auction. In this paper we focus on BTFs, which are issued at auctions held every

Monday, according to a quarterly schedule published in advance. Every week, BTFs with maturity of 3 months are issued, which are supplemented with BTFs of maturity of 6 months and/or 1 year. Unscheduled BTFs with maturities from 4 to 7 weeks may be issued as needed for cash management purposes.

Participants Primary Dealers (SVT - Spécialistes en Valeurs du Trésor), are subject to certain obligations, which include participating in auctions, placing treasury securities and maintaining a liquid secondary market. Primary Dealers are selected by the Minister of the Economy and Finance, for a period of three years. Primary dealers represent a diversity of institutions active on the French government debt market: major retail banks, specialised institutions and French and foreign institutions.

Each SVT shall bid at all auctions and be significant buyers, with average purchases over the previous 12 months of 2% of the volumes sold through competitive bidding at each type of auction; or 2% of the volumes sold through competitive bidding at three of the four types of auction and an arithmetic mean of at least 3% for the four types of auction combined. SVTs may submit non-competitive bids (NCBs) after each auction, and all SVTs participate in the placement of syndicated issues.

The French government evaluates annually each of the SVTs. The ranking of the SVTs considers three assessment factors with the following weights: 40% for participation in the primary market, 30% for operations on the secondary market and 30% for a qualitative assessment of the SVT relationship with the AFT.

Bidding Details BTFs auctions are held each Monday at 2.50p.m CET. An additional auction of short-term BTF may be held for cash management purposes in exceptional circumstances, announced to the market at least one day in advance

Bids from participants may be sent to the Banque de France. The Banque de France delivers the bids to AFT withholding the names of the bidders. AFT then determines the amount to be allocated on each security and reserves the right to scale down bids to the lowest accepted price (OATs) or rate (BTFs) on a pro-rata basis. The maximum amount proposed for each rate of the bidding scale for each participant in BTF auctions is set at €1 billion. This is done in order to ensure the smooth execution of auctions and to avoid excessive concentration of the securities among several investors upon issuance.

D.1.2 Germany

Data for Germany was taken from the Federal Republic of Germany's Finance Agency (Bundesrepublik Deutschland Finanzagentur GmbH), which is the central service provider for the Federal Republic of Germany's borrowing and debt management. They provide historical about auction results,[19] and information about the operation

[19] https://www.deutsche-finanzagentur.de/en/institutional-investors/primary-market/auction-results/

and institutional details of auctions.[20]. We have complemented some of the information with data from the Bundensbank.[21]

Description of the Primary Market: Federal bonds (Bunds), five-year Federal notes (Bobls), Federal Treasury notes (Schätze) and Treasury discount paper (Bubills) are issued through a tender procedure. They differ in their maturity, and interest, among other details. Importantly, the German government issues and taps securities for *all their long-and short-term borrowing via multi-price auctions.* For easy of comparison with other countries, in this paper we focus on short-term treasury discount paper, Bubills. These bonds (normally) have maturities of 6 and 12 months. The auctions for Bubills take place on Mondays with value date on the following Wednesday.

Participants: Only members of the Bund Issues Auction Group (Bietergruppe Bundesemissionen) may participate in the auctions directly. Membership is approved by the German Finance Agency on behalf of the German Government. The Auction Group is comprised of credit institutions, securities trading banks and securities trading firms. At the end of each year, the German Finance Agency publishes a ranking list of bidders' maturity-weighted shares in the allotted issue amounts. Members are expected to have a certain minimum placing power, i.e. at least 0.05% of the total maturity-weighted amounts allotted in the auctions in a calendar year [22]. Those member institutions that fail to reach the required minimum share of the total amount allotted are excluded from the Auction Group.

Bidding Details: Bids for Federal bonds, five-year Federal notes and Federal Treasury notes and Treasury discount paper must be for a par value of no less than €1 million or an integral multiple thereof and should state the price, as a percentage of the par value, at which the bidders are prepared to purchase. It is possible to make non-competitive bids and to submit several bids at different prices. In accordance to the multiple-price auction, bids which are above the lowest price accepted by the Federal Government will be allotted in full. Bids which are below the lowest accepted price will not be considered. Non-competitive bids are allotted at the weighted average price of the competitive bids accepted. Bidders are informed of the allotment immediately.

Bund Bidding System (BBS): The Deutsche Bundesbank provides the BBS (Bund Bidding System) as an electronic primary market platform. The allotted amounts are published in the Bund Bidding System (BBS) for the members of the Bund Issues Auction Group *on the day of the auction immediately after the allotment decision has been made*. The securities allotted are settled on the value date specified in the invitation to bid.

[20] https://www.deutsche-finanzagentur.de/en/institutional-investors/primary-market/auction-results/

[21] https://www.bundesbank.de/resource/blob/706804/599ea32756aa5d2d8c9493b8a028e886/mL/2007-07-public-sector-debt-data.pdf

[22] 6-month Bubills are weighted with a factor of 0.5, while 12-month Bubills are weighted with a factor of 1. Schätze, Bobls, ten-year Bunds and 30-year Bunds are weighted with the factors 4, 8, 15 and 25 respectively.

D.1.3 Italy

Data for Italy was taken from the Ministry of the Economy and Finance (Ministero dell'Economia e delle Finanze). The Ministry provides historical information about auction results,[23] and information about the operation and institutional details of auctions.[24] [25]

Description of the Primary Market: The Ministry of the Economy and Finance sets out the issue of five categories of Government bonds available for both private and institutional investors on the domestic market: Treasury Bills (BOTs); Zero Coupon Bonds (CTZs); Treasury Certificates (CCTeus); Treasury Bonds (BTPs); Treasury Bonds Indexed to Eurozone Inflation (BTP€is); Treasury Bonds Indexed to Italian Inflation (BTPItalia). They differ in their maturity, interest, and importantly in the auction type.

The Italian Treasury makes use of two kinds of auction protocols for these instruments:

1. Multi-price auction on a yield basis are used for BOTs, with standard maturities of 3, 6, and 12 months.

2. Single-price auction, where the auction price and the quantity issued are determined discretionally by the Treasury within a pre-announced interval of amounts in issuance, are used for all medium-long terms bonds (zero-coupon, nominal fixed and floating rate, and inflation indexed bonds).

Participants Only Primary Dealers can participate in auctions. They also have exclusive access to reserved reopenings of Government bond auctions and exclusive participation in syndicated and US dollar issuances. These Dealers are called "Specialists" and must reside in the European Union, be a bank or an investment company, and operate on regulated markets and/or on wholesale multilateral trading systems whose registered office is in the EU. According to the Italian regulation, Primary Dealers should participate in the Government securities auctions with continuity and efficiency, and contribute to the efficiency of the secondary market. A necessary condition to maintain the qualification of a Specialist is the allocation at auction, on an annual basis, of a primary market quota equal to, at least, 3% of the total annual issuance through auctions by the Treasury [26]. Another index called the

[23] http://www.dt.mef.gov.it/en/debito_pubblico/emissioni_titoli_di_stato_interni/risultati_aste/

[24] http://www.dt.mef.gov.it//export/sites/sitodt/modules/documenti_en/debito_pubblico/specialisti_titoli_di_stato/Specialists_evaluation_criteria_-_year_2019.pdf

[25] http://www.dt.mef.gov.it/en/debito_pubblico/titoli_di_stato/quali_sono_titoli/bot/

[26] Values of 0.5, 1, and 2 are assigned to BOTs for 3, 6, and 12 months, respectively. Greater coefficients are obtained from longer maturity instruments like the BTPs of 20, 30, and 50 years which give scores of 13, 15, and 20, respectively.

"Continuity of participation in auctions" parameter is an indicator that penalize those Specialists that more frequently did not achieve the minimum level of participation.

Bidding Details Authorized dealers can place up to five bids, using the National Interbank Network. until 11a.m of the auction day. Presently, the settlement date for all Government bonds is two business days following the auction date (T+2). For BOTs this usually coincides with the maturity of corresponding bonds, so as to facilitate reinvestment. In Italy, unlike in many other countries, dealers place their bids in yields, not prices. Their yields must differ by at least one thousandth of one percent, and must be of at least €1.5 million and at most the entire quantity offered by the Treasury at the auction. The minimum denomination for investors is €1,000. If bids at the final awarded yield cannot be completely satisfied, they are divided proportionally, rounding off when needed.[27]

D.1.4 Portugal

Data for Portugal was taken from the Portuguese Treasury and Debt Management Agency (IGCP - Agência de Gestão da Tesouraria e da Dívida Pública). The Agency provides historical information about auctions results,[28] and information about the operation and institutional details of auctions.[29]

Description of the Primary Market: The IGCP issues various kind of debt instruments: Fixed rate Bonds (OT), Treasury Bills (BT), Floating Rate Bonds (OTRV), Saving Certificates (CA) and Treasury Certificates (CT), among others. The Obrigações do Tesouro (OT) are the main instrument used by the Republic of Portugal to satisfy its borrowing requirements. OTs are medium- and long-term book-entry securities issued by syndication, auction or by tap. These instruments are released every quarter, and auctioned through single/uniform auction protocols. In this paper we focus on Treasury Bill (BT) instruments, which are short-term securities with a face value of one euro and are issued with maturities of 3, 6, and 12 months. Importantly, *the IGCP uses the multi-price auction method for BTs.*

Participants: Participation in BT auctions is confined to institutions that have been granted the status of Treasury Bill Specialist (EBT)[30]. These Primary Dealers are entitled to exclusive access to the facilities created by the IGCP to support the market, such as the BT repo window of last resort, among others. Treasury Bill Specialists are bound to actively participate in BT auctions, by bidding regularly under normal market conditions and by subscribing to a share no lower than 2% of the amount

[27] To avoid that the weighted average yield is negatively influenced by bids made at yields that are not in line with the market, a minimum acceptable (or safeguard) yield is calculated.

[28] https://www.igcp.pt/en/1-4-399/auctions/bt-auctions/

[29] https://www.igcp.pt/fotos/editor2/2015/Legislacao/Instrucao_BT_1_2015_UK.pdf

[30] Notice that for Portugal, the list of the Primary Dealers for the Bond Market (OT) might differ from that of the Primary Dealers / Specialists in the Treasury Bills market (EBT).

placed in the competitive phase of auctions. They should also participate actively in the secondary market of Treasury Bills (BT), by maintaining a share of no less than 2% of the turnover of this market segment. Primary Dealers are ranked based on the EBT Performance Appraisal Index, which is constructed considering their participation in both primary and secondary markets.

Bidding Details: BT auctions can be held on the 1st or (usually) 3rd Wednesday of each month. The specific details for each auction are announced directly to the Treasury Bill Specialists (EBT) and to the market, up to three days before the auction date. Settlement takes place two working days after the auction date (T+2). BT auctions are supported by an electronic system: the Bloomberg Auction System (BAS) and follow a multi-price auction model.

In the competitive phase, each participant may submit a maximum of five bids per line, in multiples of €1 million, the total of which cannot exceed the indicative amount of the auction, divided by the number of lines. Should the total amount of bids exceed the amount that the IGCP decided to place in the auction, the bids with a rate equal to the cut-off rate are allotted on a pro-rata basis (according to €1,000 lots). The IGCP may decide to place an amount up to one-third higher than that announced. The auction results are announced up to 15 minutes after that time, usually in the three-minute period following the deadline. The non-competitive phase amounts to a maximum of 40% of the amount allocated at the competitive auction. The competitive phase of auctions will end at 10.30a.m (11.30a.m CET) and the period for the submission of bids for the non-competitive phase will end at 10.30p.m (11.30p.m CET) of the following business day.

D.2 Secondary Markets

The yields for the Treasury Bills of the four countries, traded daily on secondary markets, were obtained from Bloomberg. Table 10 shows the availability of the data by country and by instrument, and the corresponding Bloomberg tickers. As clear from the table, and for availability reasons, we will focus on 6-month and 12-month T-bills.

Table 10: Secondary Market Variables Availability by Country

Variable List - Auction				
Country/ Instrument	**France** (BTF)	**Germany** (BUBILL)	**Italy** (BOT)	**Portugal** (BT)
3-month T-bill				
Ticker	GTFRF3M Govt	✗	✗	GTPTE3M Govt
Period	2002-2021	✗	✗	2004-2021
6-month T-bill				
Ticker	GTFRF6M Govt	GTDEM6M Govt	GTITL6M Govt	GTPTE6M Govt
Period	2002-2021	2002-2021	2006-2021	2004-2021
12-month T-bill				
Ticker	GTFRF1Y Govt	GTDEM12M Govt	GTITL1Y Govt	GTPTE1Y Govt
Period	2002-2021	1997-2021	2006-2021	2002-2021

In what follows we discuss the requirements for participation of Primary Dealers in secondary markets in each of the four countries we consider.

D.2.1 France

Each Primary Dealer participates in transactions on the secondary markets for French Treasury securities and ensures a consistent coverage of the entire range of products issued by AFT. A 2% share of the secondary market is considered a reasonable minimum. Primary Dealers are responsible for keeping AFT informed of decisions concerning the multilateral trading systems in which they participate. SVTs may access a repo facility that provides temporary interest-bearing lending of French Treasury securities.

D.2.2 Germany

Nominal and inflation-linked German government securities traded on German exchanges, numerous international electronic trading platforms and on the over-the-counter (OTC) markets. Unlike many other countries, the German Primary Dealers do not have strict market maker obligations, especially in the secondary market.[31] At the end of 2020, Bubills made up €113,5 bn of Federal securities outstanding in the secondary market (incl. inflation-linked securities). This corresponds to a share of about 8% of the volume of all outstanding Federal securities.

[31] In 2005, the German Finance Agency established a reporting system regarding the secondary market activities of the members of the Bund Issues Auction Group in marketable German Federal securities. The members of the Bund Issues Auction Group provide information on prices, trade volumes, and counterparty data to the Finance Agency.

D.2.3 Italy

The Treasury does not directly set specific quoting obligations for Primary Dealers (i.e., Specialists) on the market. According to the current Italian framework, the Treasury must evaluate the Specialists on quote-driven regulated markets, on a relative basis monitoring certain parameters such as the quotation quality index.[32] Other indices used to evaluate Specialists include cash traded volumes parameter, depth contribution indices, repo traded volumes, etc.

D.2.4 Portugal

Primary Dealers commit to continuously quote firm prices for all the securities subject to quoting obligations for a minimum of EUR 5 million amounts both for bid and offer sides at least five hours per day. New BT lines are admitted to trading immediately after being issued for the first time and once the pricing is defined. An EBT has fulfilled its quoting obligation if it has established a compliance ratio of at least 80% for each entire calendar month.[33] If any of these conditions are not met, the EBT is non-compliant on that security. An EBT can achieve additional points on the market making activity if they quote more than the minimum amount required, quote longer than the minimum time required, and comply with the requirements in specially volatile days.

[32]The quotation quality index (QQI) is an indicator based on high frequency snapshots, made on each market day for each Specialist. For each snapshot, the ranking of the Specialist is made with respect to the best ranked Specialist, both for the bid and ask sides for each traded instrument. The index rewards more those dealers that continuously show the best prices both for the bid and the ask sides. Lower QQI values, which indicate an average overall positioning closer to the best prices, denote a better performance. The daily rankings relative to each bond are then aggregated (simple average) by classes of bonds.

[33]For an EBT to be compliant on any given security, it must provide quotes for a minimum of five hours a day in one of the designated platforms, and the bid offer spread of such quote cannot exceed in more than 50% the average of all quotes from all EBTs that quoted that security for at least five hours, on the same day.