# The Linkage between Primary and Secondary Markets for Eurozone Sovereign Debt

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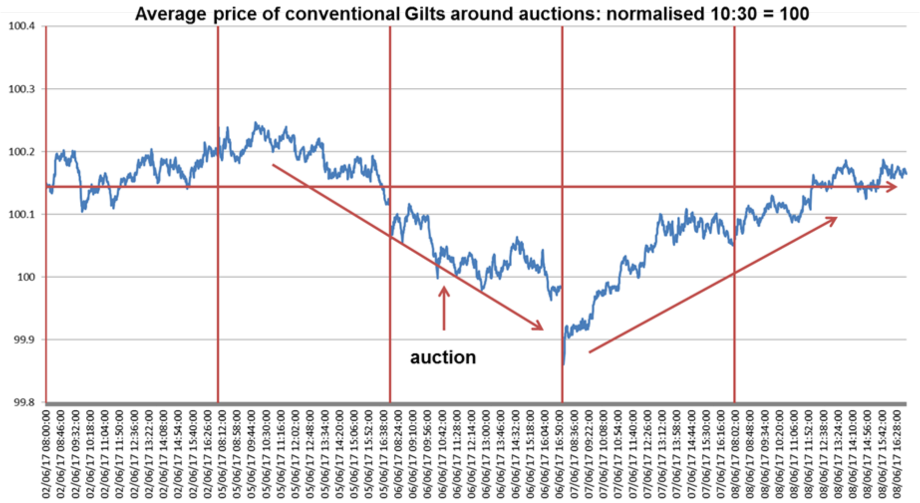
# Motivation

- Sovereign bonds are an important **safe asset class**:
  - As a significant part of many investors' portfolios
  - As a proxy for risk free rates, i.e., the yield curve
  - For managing economic risk, i.e., as a hedging tool
- As a consequence of these economic functions, sovereign bond markets in the Eurozone, as in many countries, are typically **transparent and liquid**.
- Yet, bond yields exhibit **predictable movements** around times of an auction.
- Main **contribution** of this paper: we rationalize the so called **auction cycle** for a set of Eurozone countries and identify its **key drivers**.

## Why is this relevant?

- Auction cycles occur in the secondary market, yet depressed prices on the secondary market affect the auction bidding, thus auction cycles translate to the **increased cost of debt**.
- Price change is a **consequence of supply-demand mismatch**. Thus, can we uncover the underlying mechanism?

# Example: Auction Cycle




Source: UK Debt Management Office

# Background

**Primary and secondary sovereign debt markets are interlinked:**

- Sovereign bond markets across the Eurozone are typically designed around the services of **primary dealers**.
- Primary dealership is a privileged status for market participants with **benefits and obligations**, and this system is adopted to different extents by several countries.
- Primary dealers may participate in **bond auctions** on their own account, for later resale, or directly on behalf of their clients.
- In return, they are required to provide **secondary market liquidity** as market makers.
- Thus, bond auctions can have **broad implications across securities** held by primary dealers (and other investors).

# Literature

- **Fleming and Rosenberg (2008, Fed WP)** show that primary dealers are compensated for their inventory risk (due to their participation in bond auctions) by approporiate asset returns *over time*, i.e., they mostly buy on their own accounts.
- **Lou et al. (2013, RFS)** document auction cycles for US Treasuries and find hidden issuance costs for the sovereign; **Beetsma et al. (2016, JFI)** find similar evidence for the Eurozone; however, their results are not consistent across countries, and bonds with different characterstics.
- While **Duffie (2010), JF** suggests that yields may suddenly decline after an auction due to capital immobility; **Sigaux (2016, ECB WP)** relates price decreases before an auction to the uncertainty about net-supply.
- **Brunnermeier & Pedersen (2008, RFS)** suggest that liquidity cycles may move prices away from fundamentals; **Comerton-Forde et al. (2010, JF)** empirically show that market-maker inventories affect market conditions.

# Motivation revisited

A common motivation for auction cycles is limited **risk bearing capacity**, and **imperfect capital mobility**.

However, the primary dealers also have **inventory** and **funding constraints**:

- Dealers have **existing inventory**, and may:
  - Have to adjust their inventory
  - Engage in costly hedging activities
  - Start rebalancing/hedging *before* an auction, since it may be time consuming
- Dealers are **funding constrained** and:
  - Have to free up inventory to be able to bid in an auction
  - Face funding costs that determine their capability to raise capital
  - Face regulations that affect funding costs

# Contribution

## Research Question

Can the inventory considerations of primary dealers explain auction cycles?

Specifically, we address the following questions:

- Can we find evidence that the auction cycle is **impacted by**:
  - Opportunity costs,
  - Financing costs,
  - Capital constraints,
  - Demand volatility?
- Which mechanism underlies the **supply-demand mismatch** that leads to auction cycles?
- Empirically, how do auction cycles vary across **bonds and countries**?
- What factors **explain differences** in the auction cycles?

# Model

- **Two-period** model $t = 0, 1$ with two bonds $i = 0, 1$, adaptation of the capacitated newsvendor model of Hadley and Whitin (1963)
- At time $t = 0$, a primary dealer is **endowed with an inventory** of $Q_0^e$ bonds, which are indexed by $i = 0$.
- At time $t = 1$, a **new bond** with index $i = 1$ is issued (more specifically: *retapped*) by the government at price $c_1$, while $p_1^{bid} \leq c_1 \leq p_1^{ask}$.
- We assume that the dealer has to consider its overall (regulatory) **capital constraint** $R$ at a **cost-of-capital** of $w_i$.
- The dealer finances all positions at the overall **funding cost** $I$, i.e., the rate for buying/ holding one unit of bond 0,1.
- The **market demand** $D_i$ of bond $i$ is uncertain, i.e., let $f_i, F_i$ denote the density and cumulative distribution function.

# Model

- The dealer has to **allocate the inventory** to $Q_0$ units of the old bonds, and $Q_1$ units of the newly issued bonds.
- At time $t = 1$ the old bond can be bought at $p_0^{ask}$ and sold at $p_0^{bid}$, i.e., outside market-making in **need of immediacy**.
- The underage costs $U_i$ represent the **forgone profit when the vendor has too little inventory** of bond $i$:
  - Old bond: $U_0 = p_0^{ask} - p_0^{bid} - lp_0^{bid}$
  - New bond: $U_1 = p_1^{ask} - c_1 - lc_1$
- The overage costs $E_i$ represent the **costs of holding too much inventory** of bond $i$:
  - Old bond: $E_0 = p_0^{bid} - p_0^{bid} + lp_0^{bid} = lp_0^{bid}$
  - New bond: $E_1 = c_1 - p_1^{bid} + lc_1$
- Economically, the total costs are **compensated by** the bid-ask spread:

  $U_i + E_i = p_i^{ask} - p_i^{bid} = s_i$

# Model

## Problem Definition

The dealer would like to optimize the expected profit, which can be rewritten as:

$$\max_{Q_i, i=1,2} \sum_i (U_i + E_i) \int_0^\infty \min(Q_i, x) f(x) dx - E_i Q_i, \quad (1)$$

$$\text{s.t.} \sum_i w_i Q_i \leq R.$$

- The dealer **maximizes** her market-making profits **minus** the expected cost of a shortage / excess of inventory.
- Our model produces the **optimal inventory allocation** of the old- and newly issued bonds $Q_0, Q_1$.
- Lower $Q_0$ implies a greater likelihood for the liquidation of the old bonds, i.e.. a greater yield increase and **greater amplitude** of the auction cycle.

# Model Solution

## Optimal Allocation

The solution to the optimal allocation problem is given by:

$$Q_i = F_i^{-1}\left(\frac{U_i - \lambda w_i}{E_i + U_i}\right),$$
$$R \geq \sum_i w_i Q_i \tag{2}$$

- If the capital constraint is binding, the Lagrange multiplier $\lambda > 0$ represents the **shadow price** of capital.
- We compare the **optimal level of inventory** for the bonds of the existing inventory, and the newly issued bonds: $\Delta = \frac{U_1 - \lambda w_1}{E_1 + U_1} - \frac{U_0 - \lambda w_0}{E_0 + U_0}$
- If $\Delta \geq 0$, the newly issued bond has a weakly greater optimal level of inventory than the old bonds, i.e., there is a **greater amplitude** of the auction cycle.

# Comparative Statics

## Non-Binding Capital Constraint

If the capital constraint is not binding, the optimal inventory is determined in the following ways:

- $\frac{dQ_i}{dU_i} \geq 0$,
- $\frac{dQ_i}{dE_i} \leq 0$,
- $\frac{dQ_i}{d\sigma_i} \geq 0$, if and only if $U_i \geq E_i$,
- All cross-derivatives are zero.

Typically, the dealer has a **preference to participate in the auction** due to high $U_1$. Thus, there may be a higher optimal level of $Q_1$ that may be amplified by $\sigma_1$.

# Comparative Statics

We generally consider **capital constraints to be binding** for the average market participant. This case, however, is considerably more complex!

## Binding Capital Constraint

If the capital constraint is binding, $f_i = Uniform[\underline{a}_i, \bar{a}_i]$, i.e., the expected demand $\mu_i = (\underline{a}_i + \bar{a}_i)/2$, and the standard deviation $\sigma_i = (\bar{a}_i - \underline{a}_i)/(2\sqrt{3})$ we need to evaluate $\frac{dQ_i}{dU_i}, \frac{dQ_i}{dE_i}, \frac{dQ_i}{d\sigma_i}$ based on:

$$Q_i = \mu_i + \sigma_i\sqrt{3}\frac{U_i - E_i}{E_i + U_i} + \frac{\frac{w_i}{E_i+U_i}\sigma_i}{\frac{w_i^2}{E_i+U_i}\sigma_i + \frac{w_{1-i}^2}{E_{1-i}+U_{1-i}}\sigma_{1-i}} \times \\ \times \left(R - w_i\mu_i - w_{1-i}\mu_{1-i} - w_i\sigma_i\sqrt{3}\frac{U_i - E_i}{E_i + U_i} - w_{1-i}\sigma_{1-i}\sqrt{3}\frac{U_{1-i} - E_{1-i}}{E_{1-i} + U_{1-i}}\right). \quad (3)$$

In the following, we make **mild assumptions** to assess this solution more comprehensively.

# Simplifying Assumptions

For simplicity, we assume **typical cost structures** for the following propositions. The general case is presented in our paper.

## Typical Cost Assumptions

1. $R = w_1\mu_1 + w_0\mu_0$, i.e., the capital is budgeted according to the expected demand $\mu$.
2. $U_0 = E_0$, i.e., the overage and underage cost for the old bond are equal.
3. $U_1 \geq E_1$, i.e., the newly issued bond is weakly more lucrative than the bonds of the existing inventory.

**Equivalently, in economic terms:**

- On average, the dealers' budget constraint is binding. (Ass. 1)
- The mid-spread equals the funding cost, i.e., under perfect competition, there is no profit. (Ass. 2)
- Dealers have an incentive to participate in the auction. (Ass. 3)

# Propositions

## Proposition 1: Funding Conditions

If the funding cost for the newly issued bond $w_1 > w_0 \frac{E_1+U_1}{E_0+U_0} = w_0 \frac{s_1}{s_2}$, then $\Delta \geq 0$, if and only if:

$$\lambda \leq \tilde{\lambda} = \frac{\frac{U_1}{E_1+U_1} - \frac{U_0}{E_0+U_0}}{\frac{w_1}{E_1+U_1} - \frac{w_0}{E_0+U_0}} \tag{4}$$

- If $w_1 > w_0 \frac{s_1}{s_0}$, a smaller $w_1$ **increases** the threshold $\tilde{\lambda}$ below which lower funding costs lead to higher inventory of the new bond.
- If $w_1 < w_0 \frac{s_1}{s_0}$, the dealer allocates all inventory to the **new issue**.
- Therefore, if the **cost of capital**, i.e., $\lambda$ is high, it is optimal to maintain a higher level of inventory of the old bonds.

## Propositions

### Proposition 2: Costs and Inventory.

We assume typical case cost and $f_i$ to be symmetric. Then, for the old issue bonds:

1. $\frac{dQ_0}{dU_0}, \frac{dQ_0}{dE_1} \geq 0$;
2. $\frac{dQ_0}{dU_1} \leq 0$;
3. $\frac{dQ_0}{dE_0} \leq 0$, if $w_1\sigma_1 \leq w_0\sigma_0\frac{E_1+U_1}{U_1-E_1}$;

and for the new issue bonds

1. $\frac{dQ_1}{dE_1}, \frac{dQ_1}{dU_0} \leq 0$;
2. $\frac{dQ_1}{dU_1} \geq 0$;
3. $\frac{dQ_1}{dE_0} \geq 0$, if and only if $E_0 \geq \frac{1}{2}\frac{w_0}{w_1}\left(U_1 - E_1 - \frac{w_0}{w_1}\frac{\sigma_0}{\sigma_1}(E_1 + U_1)\right)$, suff. cond. $w_1\sigma_1 \leq w_0\sigma_0\frac{E_1+U_1}{U_1-E_1}$.

Thus, the effect for the overage cost only holds if the demand for the new bond is **not too volatile** - otherwise, there is a preference for the old bond!

# Propositions

**Proposition 3: Demand Volatility and Inventory.**

We assume typical case cost and $f_i$ to be symmetric. Then:

(i) **Old bond:** $\frac{dQ_0}{d\sigma_0} \leq 0$, $\frac{dQ_0}{d\sigma_1} \leq 0$;

(ii) **New bond:** $\frac{dQ_1}{d\sigma_1} \geq 0$, $\frac{dQ_1}{d\sigma_0} \geq 0$.

- Greater demand volatility for the **old bonds dampens** the auction cycle.
- Greater demand volatility for the **new bonds amplifies** the auction cycle.
- The result for the new bonds is due to their **greater lucrativeness**.

# Data Description

We collect an extensive data set on European secondary and primary bond markets for the time period from **April 2003 to December 2013** for **8 Eurozone countries**:

- **Countries:** Austria, Belgium, Germany, Spain, France, Italy, Netherlands, Portugal
- **Auction results:** Thomson Reuters, DMO websites
- **Secondary markets:** MTS markets, for the best three bid and ask prices on a high frequency level (binding quotes)
  - MTS Group (majority owned by LSEG) is one of Europes leading electronic fixed income trading markets, with over 500 unique counterparties and average daily volumes exceeding EUR 100 billion.
- **Market characteristics:** VSTOXX, EONIA, Euribor, 3M benchmark yields for each country
- **Observations** 3 million across bonds/countries over the total time horizon.

# Bond Selection

| Country | MTS Code | Bond Type | Description |
|---|---|---|---|
| Austria | ATS | Bills, Bonds | Government Bonds |
| Belgium | BTC | ZCB | Zero Coupon Bonds |
| Belgium | OLO | Bonds | Obligations Lineaires Ordinaires |
| France | BTA | Bills | Bons du Tresor |
| France | OAT | Bonds | Obligations Assimilables du Tresor |
| France | FCO | Bonds | Coupon Bonds |
| France | FTB | ZCB | Zero Coupon Bonds |
| France | TEC | Floater | Floating Rate Bond, 10-year OAT par yield |
| Germany | DEM | Bonds | Government Bonds (Bobls, Bunds) |
| Germany | GTC | Bills | Bubills |
| Italy | BOT | Bills | Buoni Ordinari del Tesoro |
| Italy | BTP | Bonds | Buoni del Tesoro Poliannuali |
| Italy | CTZ | ZCB | Certificati del Tesoro Zero Coupon |
| Netherlands | DSL | Bonds | Dutch State Loan |
| Netherlands | DTC | ZCB | Dutch Treasury Certificates |
| Portugal | PTC | Bills | Portugese Treasury Certificates |
| Portugal | PTE | Bonds | Portugese Government Bonds |
| Spain | BON | Bonds | Bonos del Estado |
| Spain | OBE | Bonds | Oblicaciones del Estado |
| Spain | LET | Bills | Letras del Tesoro |

# Summary Statistics

| Country | Vol | BA | SD | AY | Mat | B2C | #Auctions | #Bonds | #Days |
|---|---|---|---|---|---|---|---|---|---|
| Austria | 0.87 | 0.50 | 0.39 | 1.52 | 12.41 | 2.40 | 153 | 25 | 27.82 |
| Belgium | 1.12 | 0.08 | 0.08 | 0.17 | 3.03 | 2.18 | 840 | 177 | 5.16 |
| France | 2.44 | 0.09 | 0.10 | 0.06 | 2.99 | 2.75 | 1817 | 527 | 2.40 |
| Germany | 4.79 | 0.08 | 0.16 | 0.31 | 4.98 | 1.76 | 446 | 252 | 9.07 |
| Italy | 4.44 | 0.16 | 0.22 | 0.17 | 4.89 | 1.68 | 882 | 397 | 4.88 |
| Netherlands | 1.67 | 0.05 | 0.08 | 0.18 | 2.18 | 2.76 | 868 | 186 | 4.83 |
| Spain | 1.79 | 0.34 | 0.27 | 0.22 | 4.73 | 2.83 | 794 | 167 | 5.50 |
| Portugal | 0.83 | 0.36 | 0.16 | 0.65 | 2.39 | 2.69 | 352 | 98 | 12.02 |

**Vol** is the average auction volume in billion EUR, **BA** is the average bid/ask spread of the issued bond on the auction day in percent, **SD** is the standard deviation of the daily returns in percent, **AY** is the average yield in percent, **Mat** is the average maturity of the auctions in years, **B2C** is the bid-to-cover ratio, **#Auctions** is the number of auctions, **#Bonds** is the number of bonds auctioned, and **#Days** is the average number of business days between auctions.

## Drivers of Auction Cycle

We develop the following, empirically testable, hypotheses:

### Hypothesis 1: Funding Conditions.

The amount of inventory that is liquidated, as well as the amplitude of the observed auction cycle, will be greater when:

A) ...the shadow cost of capital of the average market participant, $\lambda$, as measured by $FUNDL = EUROIS - Bund$, is lower.

B) ...the secured capital rates of the bonds, $w_0$, $w_1$, both measured by the 3M EUR-OIS (*CRATE*), are lower.

C) ...the unsecured financing rate, $l$, as measured by the 3M EURIBOR (*BRATE*), is lower.

# Drivers of Auction Cycle

## Hypothesis 2: Costs and Optimal Inventory.

The amount of inventory that is liquidated, as well as the amplitude of the observed auction cycle will be greater when

A) ...the auctioned bond has a greater lucrativeness, $\frac{p_1^{bid}+p_1^{ask}}{2} - c_1$, as measured by the spread between the mid-price quoted closest to the time of the auction and the auction price ($ASPREAD$).

B) ...the auctioned bond has greater liquidity, $(p_1^{ask} - p_1^{bid})$, as measured by the bid-ask spread of the auctioned bond ($ALIQ$).

C) ...the old bonds have greater liquidity, $(p_0^{ask} - p_0^{bid})$, as measured by the bid-ask spread of the bonds ($LIQ$),and its market average ($MLIQ$).

# Drivers of Auction Cycle

**Hypothesis 3: Demand Volatility and Optimal Inventory.**

The amplitude of the observed auction cycle will be greater when

A) . . . the volatility of demand of the auctioned bonds, $\sigma_1$, as measured by the volatility of the bond's returns and in the market ($ARISK$) and the bond's maturity ($AMAT$), is greater.

B) . . . the volatility of demand of the old bonds, $\sigma_0$, as measured by the volatility of old bond returns and in the market ($RISK$, $MRISK$), the bonds' maturity ($MAT$), the degree of risk-aversion in the market, i.e., the VSTOXX index ($RISKA$), is greater.

# Drivers of Auction Cycle

**Hypothesis 4: Inventory Risk Management.**

The amount of inventory that is liquidated, as well as the amplitude of the observed auction cycle will be greater when

A) the anticipated increase in inventory risk exposure due to the auction, $Q_1$, as measured by the volume issued at the auction ($AVOL$), is greater.

B) the hedging capacities are greater, i.e., the basis risk, as measured by $BRISK = Yield - Bund$, is lower.

To test these hypotheses, we specify a **panel regression with fixed effects**.

# Dependent Variables

For each bond $i \in I$ over the [-5,0] day window leading up to an auction $a \in A$:

- $TVOL_{i,a}$ (main variable) is the change in trading volume before an auction:

$$TVOL_{i,a} = \frac{\frac{1}{5}\sum_{d=-5}^{0} VOL_{i,(a+d)}}{\frac{1}{252}\sum_{d=-252}^{0} VOL_{i,(a+d)}}$$

- $TIMB_{i,a}$ trading imbalance based on seller-initiated trades relative to buyer-initiated trades:

$$TIMB_{i,a} = \frac{\sum_{d=-5}^{0} VOL_{i,(a+d)}^{SELL}}{\sum_{t=-5}^{0} VOL_{i,(a+d)}^{BUY}} - 1$$

- $IMPR_{i,a}$, price change calculated from the mid-price at $d = 5$ days before the auction to the exact time of the auction (in bp):

$$IMPR_{i,a} = \frac{\bar{p}_{i,(a+d)}}{p_{i,a}} - 1$$

# Summary Statistics: Variables

| | Min | Q1 | Median | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| TVOL | 0.00 | 0.70 | 1.50 | 2.10 | 2.90 | 22.40 |
| TIMB | -1.00 | 0.00 | 0.50 | 0.40 | 1.00 | 1.00 |
| IMPR | -34.00 | -7.20 | 0.80 | 11.70 | 20.80 | 36.30 |
| LIQ | 0.00 | 2.10 | 8.00 | 20.70 | 23.90 | 143.80 |
| ALIQ | 0.00 | 5.40 | 15.00 | 30.00 | 35.40 | 525.40 |
| ASPREAD | -100.60 | 0.00 | 0.20 | 0.20 | 0.40 | 102.80 |
| ASIZE | 0.10 | 0.90 | 2.00 | 2.50 | 3.30 | 16.60 |
| MLIQ | 1.80 | 13.40 | 29.60 | 37.70 | 44.50 | 457.60 |
| RISK | 0.00 | 0.00 | 0.20 | 0.40 | 0.50 | 15.30 |
| ARISK | 0.00 | 0.10 | 0.30 | 0.50 | 0.60 | 8.70 |
| MRISK | 0.00 | 0.20 | 0.30 | 0.40 | 0.50 | 11.70 |
| AMAT | 0.10 | 2.60 | 5.10 | 7.30 | 10.10 | 49.80 |
| RISKA | 11.90 | 18.50 | 22.30 | 24.40 | 27.00 | 87.50 |
| CRATE | -0.40 | 0.00 | 0.30 | 0.90 | 2.00 | 4.30 |
| BRATE | -0.30 | 0.20 | 0.70 | 1.20 | 2.10 | 5.10 |
| FUNDL | -0.00 | 0.10 | 0.10 | 0.30 | 0.30 | 2.10 |
| CRISK | -0.20 | 0.00 | 0.10 | 0.10 | 0.20 | 1.40 |
| BRISK | -0.10 | 0.30 | 0.60 | 1.00 | 1.30 | 13.70 |

## Panel Regression

$$y_a^i = \boldsymbol{\alpha} \cdot D_a^i + \boldsymbol{\beta} \cdot X_a + \boldsymbol{\gamma} \cdot X_a^i + \boldsymbol{\delta} \cdot X_a^j + \epsilon_a^i \quad (5)$$

- **Fixed effects** $\alpha$: quartile of the bid-ask spread (Q.LIQ), return volatility (Q.RISK), and the issuing country of the observed bond, $D$.
- $\boldsymbol{\beta}$ specifies the coefficients with respect to overall market conditions $X$.
- $\boldsymbol{\gamma}$ denotes the coefficients with respect to characteristics of the "old" (retapped) bonds $X^i$.
- $\boldsymbol{\delta}$ are the coefficients with respect to the characteristics of the auctioned bond $X^j$.
- **Standard errors** $\epsilon$ **are clustered across maturities and auctions** to account for yield curve dynamics and time periods.

# Results: Full Sample (2003-2013)

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.85 | 0.00 | 0.58 | 0.00 | -0.32 | 0.01 |
| Austria | -0.01 | 0.82 | -0.03 | 0.49 | -0.07 | 0.03 |
| Belgium | 1.08 | 0.00 | -0.23 | 0.00 | 0.07 | 0.19 |
| France | 1.79 | 0.00 | -0.09 | 0.02 | 0.02 | 0.60 |
| Italy | 1.79 | 0.00 | -0.49 | 0.00 | -0.04 | 0.49 |
| Netherlands | 1.54 | 0.00 | -0.08 | 0.04 | 0.07 | 0.03 |
| Portugal | 0.51 | 0.00 | -0.26 | 0.00 | -0.06 | 0.35 |
| Spain | 0.92 | 0.00 | -0.23 | 0.00 | -0.20 | 0.07 |
| Q1.LIQ | 0.39 | 0.00 | -0.06 | 0.00 | -0.00 | 0.83 |
| Q4.LIQ | -0.42 | 0.00 | 0.12 | 0.00 | 0.00 | 0.93 |
| Q1.RISK | -0.41 | 0.00 | 0.09 | 0.00 | 0.01 | 0.60 |
| Q4.RISK | 0.18 | 0.02 | -0.04 | 0.14 | -0.15 | 0.01 |
| LIQ | -0.00 | 0.46 | -0.00 | 0.32 | 0.00 | 0.41 |
| RISK | -0.11 | 0.07 | 0.02 | 0.08 | 0.26 | 0.00 |
| CRATE | -0.13 | 0.00 | -0.01 | 0.25 | 0.05 | 0.23 |
| MAT | 0.00 | 0.29 | 0.00 | 0.40 | 0.01 | 0.00 |
| ASIZE | -0.08 | 0.00 | -0.00 | 0.47 | 0.00 | 0.47 |
| ASPREAD | 0.01 | 0.05 | -0.00 | 0.66 | 0.00 | 0.29 |
| ALIQ | 0.00 | 0.96 | 0.00 | 0.99 | 0.00 | 0.17 |
| ARISK | 0.11 | 0.00 | -0.01 | 0.20 | -0.01 | 0.53 |
| AMAT | -0.01 | 0.00 | -0.00 | 0.04 | 0.00 | 0.32 |
| MLIQ | -0.00 | 0.00 | 0.00 | 0.85 | -0.00 | 0.32 |
| MRISK | 0.17 | 0.05 | -0.02 | 0.14 | 0.06 | 0.28 |
| FUNDL | -0.24 | 0.07 | 0.01 | 0.59 | -0.24 | 0.02 |
| BRATE | -0.00 | 0.97 | -0.02 | 0.75 | 0.55 | 0.11 |
| BRISK | -0.13 | 0.00 | 0.04 | 0.00 | 0.06 | 0.28 |
| RISKA | 0.00 | 0.23 | 0.00 | 0.00 | 0.01 | 0.04 |

# Results: Full Sample (2003-2013), H1

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.85 | 0.00 | 0.58 | 0.00 | -0.32 | 0.01 |
| ... | | | | | | |
| FUNDL | -0.24 | 0.07 | 0.01 | 0.59 | -0.24 | 0.02 |
| BRATE | -0.00 | 0.97 | -0.02 | 0.75 | 0.55 | 0.11 |
| CRATE | -0.13 | 0.00 | -0.01 | 0.25 | 0.05 | 0.23 |
| ... | | | | | | |

## Results: Full Sample (2003-2013), H1

- Greater **funding rate**, FUNDL, dampens the auction cycle (TVOL, IMPR).
- Greater **capital rates**, CRATE, dampens the auction cycle (TVOL).
- Standard errors of BRATE (borrowing rate) and CRATE may be inefficient due to their strong correlation, i.e., **collinearity** between two variables.
- We still control for both variables due to **economic relevance** and importance in our model.

# Results: Full Sample (2003-2013), H2

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.85 | 0.00 | 0.58 | 0.00 | -0.32 | 0.01 |
| ... | | | | | | |
| Q1.LIQ | 0.39 | 0.00 | -0.06 | 0.00 | -0.00 | 0.83 |
| Q4.LIQ | -0.42 | 0.00 | 0.12 | 0.00 | 0.00 | 0.93 |
| LIQ | -0.00 | 0.46 | -0.00 | 0.32 | 0.00 | 0.41 |
| MLIQ | -0.00 | 0.00 | 0.00 | 0.85 | -0.00 | 0.32 |
| ASPREAD | 0.01 | 0.05 | -0.00 | 0.66 | 0.00 | 0.29 |
| ALIQ | 0.00 | 0.96 | 0.00 | 0.99 | 0.00 | 0.17 |
| ... | | | | | | |

# Results: Full Sample (2003-2013), H2

- Bonds with **greater liquidity (low bid-ask spread)** ($Q1.LIQ$) in the portfolio show greater auction cycle than less liquid bonds ($Q4.LIQ$).
- Overall **market liquidity** conditions ($MLIQ$) seem to play a minor role in determining the auction cycle.
- A greater **auction spread** ($ASPREAD$), i.e., the spread between the auction price and the auctioned (retapped) bond's secondary market price, amplifies the auction cycle ($TVOL$).
- There is no indication that the **liquidity of the auctioned bond** $ALIQ$ affects the auction cycle. However, the auctioned bond is usually expected to be (temporarily) very liquid.

## Results: Full Sample (2003-2013), H3

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.85 | 0.00 | 0.58 | 0.00 | -0.32 | 0.01 |
| ... | | | | | | |
| Q1.RISK | -0.41 | 0.00 | 0.09 | 0.00 | 0.01 | 0.60 |
| Q4.RISK | 0.18 | 0.02 | -0.04 | 0.14 | -0.15 | 0.01 |
| RISK | -0.11 | 0.07 | 0.02 | 0.08 | 0.26 | 0.00 |
| MRISK | 0.17 | 0.05 | -0.02 | 0.14 | 0.06 | 0.28 |
| MAT | 0.00 | 0.29 | 0.00 | 0.40 | 0.01 | 0.00 |
| RISKA | 0.00 | 0.23 | 0.00 | 0.00 | 0.01 | 0.04 |
| ARISK | 0.11 | 0.00 | -0.01 | 0.20 | -0.01 | 0.53 |
| AMAT | -0.01 | 0.00 | -0.00 | 0.04 | 0.00 | 0.32 |

# Results: Full Sample (2003-2013), H3

- Bonds with greater **volatility** show a stronger auction cycle ($TVOL$) are more likely to be liquidated ($Q4.RISK$) than less risky bonds ($Q1.RISK$).
- Overall greater **market volatility** ($MRISK$) seems to contribute to an amplified auction cycle ($TVOL$)
- A greater **volatility** ($ARISK$) of the auctioned bond seems to amplify the auction cycle ($TVOL$).

# Results: Full Sample (2003-2013), H4

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.85 | 0.00 | 0.58 | 0.00 | -0.32 | 0.01 |
| ... | | | | | | |
| ASIZE | -0.08 | 0.00 | -0.00 | 0.47 | 0.00 | 0.47 |
| BRISK | -0.13 | 0.00 | 0.04 | 0.00 | 0.06 | 0.28 |
| ... | | | | | | |

# Results: Full Sample (2003-2013), H4

- Greater spreads between the benchmark yield and the German Bund yield (*BRISK*), i.e., the **hedging basis risk**, seem to dampen the auction cycle (*TVOL*).
- Basis risk seems to be an even more important determinant during/ in the aftermath the **sovereign debt crisis**, i.e., when this risk mattered most.
- We do not see an indication that the **auction size** (*ASIZE*) affects the auction cycle. Possibly, auctions are well anticipated and trading is carried out in advance?

# Implications: Increased Cost of Sovereign debt

| Economic Cost of the Auction Cycle | | | | | |
|---|---|---|---|---|---|
| **Country / Maturity** | **0-50Y** | **0-3Y** | **3-10Y** | **10-20Y** | **20-50Y** |
| Austria | 11.20 | 4.30 | 7.70 | 13.70 | 29.40 |
| Belgium | 12.00 | 2.00 | 14.40 | 36.80 | 34.80 |
| France | 12.80 | 2.00 | 10.30 | 30.30 | 53.70 |
| Germany | 2.80 | 1.70 | 1.60 | 2.70 | 11.30 |
| Italy | 8.20 | 1.70 | 13.90 | 20.60 | 23.20 |
| Netherlands | 7.10 | 1.10 | 10.40 | 31.70 | 12.60 |
| Portugal | 20.10 | 5.20 | 33.80 | 21.40 | 49.30 |
| Spain | 6.70 | 1.70 | 5.90 | 9.00 | 30.70 |

The **cost per year of maturity** are calculated based on the return from buying the bond at the mid-price 5 days before the auction and selling it at the exact time of the auction (in bp).

# Conclusions

The following drivers of auction cycle are supported **theoretically** and **empirically**:

- **Hypothesis 1:** Higher funding costs dampen the auction cycle.
- **Hypothesis 2:** Greater lucrativeness of the auction and greater liquidity of the old bonds amplify the auction cycle.
- **Hypothesis 3:** Greater demand uncertainty of the old bond amplifies auction cycle.
- **Hypothesis 4:** Greater hedging capacities amplify the auction cycle (especially in times of distress).

## What can the DMO do about the auction cycle?

- Maintaining a **cash buffer** may allow shifting volumes to later auctions if market conditions, i.e., funding cost, basis risk or market risk, are not beneficial.
- The **issuance cost of a specific bond** should be considered, i.e., the impact of the auctioned bond on secondary markets, in dependence of market conditions.

**Thank you for your attention.**

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The paper is available

# Bond Selection

| Country | MTS Code | Bond Type | Description |
|---|---|---|---|
| Austria | ATS | Bills, Bonds | Government Bonds |
| Belgium | BTC | ZCB | Zero Coupon Bonds |
| Belgium | OLO | Bonds | Obligations Lineaires Ordinaires |
| France | BTA | Bills | Bons du Tresor |
| France | OAT | Bonds | Obligations Assimilables du Tresor |
| France | FCO | Bonds | Coupon Bonds |
| France | FTB | ZCB | Zero Coupon Bonds |
| France | TEC | Floater | Floating Rate Bond, 10-year OAT par yield |
| Germany | DEM | Bonds | Government Bonds (Bobls, Bunds) |
| Germany | GTC | Bills | Bubills |
| Italy | BOT | Bills | Buoni Ordinari del Tesoro |
| Italy | BTP | Bonds | Buoni del Tesoro Poliannuali |
| Italy | CTZ | ZCB | Certificati del Tesoro Zero Coupon |
| Netherlands | DSL | Bonds | Dutch State Loan |
| Netherlands | DTC | ZCB | Dutch Treasury Certificates |
| Portugal | PTC | Bills | Portugese Treasury Certificates |
| Portugal | PTE | Bonds | Portugese Government Bonds |
| Spain | BON | Bonds | Bonos del Estado |
| Spain | OBE | Bonds | Oblicaciones del Estado |
| Spain | LET | Bills | Letras del Tesoro |

# Summary Statistics: Variables

| | Min | Q1 | Median | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| TVOL | 0.00 | 0.70 | 1.50 | 2.10 | 2.90 | 22.40 |
| TIMB | -1.00 | 0.00 | 0.50 | 0.40 | 1.00 | 1.00 |
| IMPR | -34.00 | -7.20 | 0.80 | 11.70 | 20.80 | 36.30 |
| LIQ | 0.00 | 2.10 | 8.00 | 20.70 | 23.90 | 143.80 |
| ALIQ | 0.00 | 5.40 | 15.00 | 30.00 | 35.40 | 525.40 |
| ASPREAD | -100.60 | 0.00 | 0.20 | 0.20 | 0.40 | 102.80 |
| ASIZE | 0.10 | 0.90 | 2.00 | 2.50 | 3.30 | 16.60 |
| MLIQ | 1.80 | 13.40 | 29.60 | 37.70 | 44.50 | 457.60 |
| RISK | 0.00 | 0.00 | 0.20 | 0.40 | 0.50 | 15.30 |
| ARISK | 0.00 | 0.10 | 0.30 | 0.50 | 0.60 | 8.70 |
| MRISK | 0.00 | 0.20 | 0.30 | 0.40 | 0.50 | 11.70 |
| AMAT | 0.10 | 2.60 | 5.10 | 7.30 | 10.10 | 49.80 |
| RISKA | 11.90 | 18.50 | 22.30 | 24.40 | 27.00 | 87.50 |
| CRATE | -0.40 | 0.00 | 0.30 | 0.90 | 2.00 | 4.30 |
| BRATE | -0.30 | 0.20 | 0.70 | 1.20 | 2.10 | 5.10 |
| FUNDL | -0.00 | 0.10 | 0.10 | 0.30 | 0.30 | 2.10 |
| CRISK | -0.20 | 0.00 | 0.10 | 0.10 | 0.20 | 1.40 |
| BRISK | -0.10 | 0.30 | 0.60 | 1.00 | 1.30 | 13.70 |

# Correlation Matrix: Variables

| | TVOL | TIMB | IMPR | LIQ | ALIQ | ASPREAD | ASIZE | MLIQ | RISK | ARISK | MRISK | AMAT | RISKA | CRATE | BRATE | FUNDL | CRISK | BRISK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TVOL | | | | | | | | | | | | | | | | | | |
| TIMB | -0.29 | | | | | | | | | | | | | | | | | |
| IMPR | 0.03 | 0.05 | | | | | | | | | | | | | | | | |
| LIQ | -0.03 | 0.03 | 0.12 | | | | | | | | | | | | | | | |
| ALIQ | 0.01 | 0.03 | 0.05 | 0.03 | | | | | | | | | | | | | | |
| ASPREAD | 0.01 | -0.01 | 0.01 | 0.00 | 0.01 | | | | | | | | | | | | | |
| ASIZE | -0.07 | -0.12 | -0.03 | -0.02 | -0.06 | -0.01 | | | | | | | | | | | | |
| MLIQ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.01 | | | | | | | | | | | |
| RISK | -0.05 | 0.08 | 0.23 | 0.29 | 0.07 | 0.01 | -0.08 | 0.00 | | | | | | | | | | |
| ARISK | 0.03 | 0.06 | 0.10 | 0.09 | 0.13 | 0.03 | -0.18 | -0.01 | 0.28 | | | | | | | | | |
| MRISK | -0.01 | 0.11 | 0.16 | 0.19 | 0.11 | 0.02 | -0.16 | 0.00 | 0.49 | 0.43 | | | | | | | | |
| AMAT | 0.04 | 0.03 | 0.02 | -0.01 | 0.14 | 0.03 | -0.35 | -0.01 | -0.02 | 0.19 | -0.02 | | | | | | | |
| RISKA | -0.01 | 0.09 | 0.13 | 0.09 | 0.09 | 0.00 | -0.03 | 0.00 | 0.19 | 0.23 | 0.28 | -0.01 | | | | | | |
| CRATE | -0.06 | -0.08 | -0.01 | -0.02 | -0.04 | -0.02 | 0.16 | 0.00 | -0.11 | -0.17 | -0.24 | -0.08 | 0.02 | | | | | |
| BRATE | -0.06 | -0.06 | 0.01 | 0.01 | -0.02 | -0.02 | 0.14 | 0.00 | -0.06 | -0.10 | -0.16 | -0.08 | 0.19 | 0.98 | | | | |
| FUNDL | -0.03 | 0.07 | 0.11 | 0.12 | 0.09 | -0.01 | -0.02 | 0.00 | 0.19 | 0.24 | 0.29 | -0.05 | 0.78 | 0.21 | 0.41 | | | |
| CRISK | 0.00 | 0.07 | 0.16 | 0.10 | 0.10 | 0.03 | -0.1 | 0.00 | 0.24 | 0.29 | 0.37 | 0.03 | 0.62 | -0.13 | 0.00 | 0.55 | | |
| BRISK | -0.04 | -0.03 | 0.11 | 0.14 | 0.06 | 0.03 | -0.02 | 0.00 | 0.32 | 0.27 | 0.49 | -0.08 | 0.14 | -0.36 | -0.29 | 0.20 | 0.24 | |

Despite high correlation between *FUNDL* and *BRATE*, we decide not to omit an economically important variable at the risk of potentially producing greater standard errors for the two coefficients.

# Results: Financial Crisis (2007-2009)

| | TVOL | | TIMB | | IMPR | |
|---|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Intercept | 0.48 | 0.07 | 0.65 | 0.00 | -0.07 | 0.05 |
| Austria | 0.10 | 0.55 | -0.09 | 0.26 | -0.26 | 0.02 |
| Belgium | 1.16 | 0.00 | -0.20 | 0.00 | 0.40 | 0.18 |
| France | 1.28 | 0.00 | 0.02 | 0.74 | -0.06 | 0.46 |
| Italy | 1.51 | 0.00 | -0.45 | 0.00 | 0.19 | 0.31 |
| Netherlands | 1.83 | 0.00 | -0.03 | 0.35 | 0.27 | 0.06 |
| Portugal | 0.00 | 0.99 | -0.19 | 0.09 | -0.25 | 0.16 |
| Spain | 0.27 | 0.11 | 0.01 | 0.82 | 0.02 | 0.87 |
| Q1.LIQ | 0.42 | 0.00 | -0.09 | 0.00 | 0.03 | 0.27 |
| Q4.LIQ | -0.25 | 0.37 | 0.15 | 0.01 | -0.08 | 0.59 |
| Q1.RISK | -0.42 | 0.00 | 0.10 | 0.00 | 0.05 | 0.07 |
| Q4.RISK | 0.35 | 0.04 | -0.05 | 0.00 | -0.07 | 0.55 |
| LIQ | 0.00 | 0.65 | -0.00 | 0.00 | -0.00 | 0.07 |
| RISK | -0.06 | 0.73 | -0.10 | 0.18 | 0.62 | 0.01 |
| CRATE | 0.05 | 0.17 | -0.02 | 0.07 | -0.02 | 0.00 |
| MAT | -0.00 | 0.84 | 0.00 | 0.62 | 0.01 | 0.42 |
| ASIZE | -0.04 | 0.00 | -0.00 | 0.71 | -0.01 | 0.11 |
| ASPREAD | -0.00 | 0.61 | -0.00 | 0.71 | -0.00 | 0.24 |
| ALIQ | -0.00 | 0.00 | -0.00 | 0.55 | 0.00 | 0.15 |
| ARISK | -0.13 | 0.00 | 0.01 | 0.62 | 0.04 | 0.05 |
| AMAT | -0.01 | 0.00 | -0.00 | 0.63 | -0.00 | 0.00 |
| MLIQ | -0.00 | 0.11 | -0.00 | 0.62 | 0.00 | 0.52 |
| MRISK | -0.22 | 0.00 | 0.01 | 0.88 | 0.45 | 0.02 |
| FUNDL | -1.05 | 0.00 | 0.09 | 0.34 | 0.22 | 0.09 |
| BRATE | -0.63 | 0.07 | -0.11 | 0.02 | 0.15 | 0.26 |
| BRISK | -0.13 | 0.50 | 0.03 | 0.38 | -0.06 | 0.72 |
| RISKA | 0.03 | 0.01 | 0.00 | 0.56 | -0.01 | 0.20 |