Sovereign Debt Auction Method and Issuance Cost: Evidence from Iceland *

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Abstract

In 2008, the Central Bank of Iceland changed its discriminatory method for auctioning treasury bonds and bills, replacing it with the uniform-price method. By using the Central Bank of Iceland's bid-level data and the Nasdaq Nordic's secondary market transaction data jointly, we measure precisely security underpricing, which reflects an extra debt servicing cost. We find that, after controlling for auction characteristics and financial market conditions, the uniform-price method leads to lower underpricing. Our results provide practical implications for governments, regulators, and market participants.

Keywords: Auctions, discriminatory method, treasury securities, underpricing, uniform-price method.

EFM Classification codes: 340.

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1 Introduction

Governments issue thousands of treasury bills and bonds every month to finance sovereign debt. Primary dealers, who participate in the primary market (the auction), usually hold a fraction of the treasury securities awarded and resell the rest in the secondary market to various investors. A positive difference between the price in the secondary and primary markets can be viewed as a shortfall for the auctioneer, who stands to benefit more by issuing directly to secondary market participants. Hence, such mispricing involves a wealth transfer from issuers to primary dealers. In such a setting, ideas for reducing the shortfall might draw the attention of governments and regulators. In 1960, Milton Friedman argued that the choice of the auction method, by influencing the bidding strategy of each player and the likelihood of collusion between players, determines the auction outcome. Ultimately, the mispricing level is impacted.

Our paper links the choice of the auction method to the magnitude of mispricing. In 2008, the Central Bank of Iceland modified the auction method for the issuance of Government of Iceland bills and bonds. The discriminatory method was replaced with a new uniform-price method.[1] Our paper uses this institutional change in order to assess which method is better when the central bank seeks to minimize the cost of sovereign debt issuance. If the introduction of the uniform-price method lowers this cost significantly, after controlling for various other factors, it provides evidence of the superiority of the uniform-price method over the discriminatory one. By analyzing an exclusive dataset of Icelandic sovereign bond and bill auctions around the switch of auction method, we provide evidence that the uniform-price method is better for the issuer. Under the discriminatory method, the average underpricing is 7.5 cents for 100 Icelandic Krona of face value. Under the uniform-price one, underpricing is -0.5 cents, on average.

Our study does not attempt to introduce new theoretical developments on the link between auction design and auction performance. Neither do we seek to investigate the mechanisms by which risk aversion and winner curse affect bidding behavior, resource allocation and efficiencies. Rather, we verify whether one auction method is better than another under the issuer perspective,

[1] These are the most common methods used by governments or central banks worldwide for sovereign bond issuance. Under the discriminatory method, also called the multiple-price method, securities are awarded to the highest bidder, and the allocations continue along the demand curve up to the amount offered is fully covered. The winning bidders pay what they bid. Under the uniform-price method, also called the single-price method, all winning bidders pay the same price, which is the lowest bid exhausting the supply. This price is called the stop-out price or the market-clearing price. See Brenner, Galai and Sade (2009) for a survey on auction methods used across countries.

taking bidding strategies as a given. We directly assess the strength of the statistical association between auction performance and auction method, using a panel of 516 auctions and controlling for time-varying changes in exogenous factors. We find that the uniform-price method is significantly associated with less revenue transfer from the issuer to the bidders.

Beyond its importance for governments and regulators, our study addresses a long outstanding question about the impact of auction method on treasury borrowing costs. Both theoretical research (Wilson, 1979; Milgrom and Weber, 1982; Bikhchandani and Huang, 1989, 1993; Back and Zender, 1993; Chatterjea and Jarrow, 1998; Viswanathan and Wang, 2000; Wang and Zender, 2002; Kremer and Nyborg 2004; Nybord and Strebulaev, 2004; Kang and Puller, 2008; Kastl, 2011) and laboratory experiments (Goswami et al., 1996; Sade et al., 2006; and Morelas-Carmago et al., 2013) fail to provide clear conclusions on revenue rankings between the discriminatory method and the uniform-price method. Ausubel et al. (2014) state that the ranking of the two auction methods is ambiguous, whether using efficiency or revenue maximization as a criterion. Bidder numbers, risk aversion and informational asymmetry drive the ranking jointly. Hence, determining the superiority of one method over another depends on the particular features of each country's treasury auctions, and thus should be addressed empirically.

A third stream of studies indeed addresses the question of the auction method ranking by using country case studies. These studies also provide contradictory evidence on which method is best for reducing government borrowing cost. Umlauf (1993), working on the 1990 Mexican Treasury auction method change, and Simon (1994), focusing on the mid-1970s US Treasury auction method change, find evidence in favor of the discriminatory method, while Nyborg and Sundaresan (1996), Malvey and Archibald (1998), and Goldreich (2007), studying the second US method change in the 1990s, advocate for replacing the discriminatory method with the uniform-price method. This lack of consensus also emerges from counterfactual exercises (Armantier and Sbaï, 2006; Heller and Lengwiler, 2001; Hortaçsu and McAdams, 2010 ; Marszalec, 2017).

Our data are very unique in four ways. First, our primary market data cover a long period of time, almost two decades of auctions. Second, the data contain bid-level information. We observe, by bidder, winning bids as well as losing ones, quantities demanded and awarded. Third, each primary dealer is assigned with a unique ID consistent across auctions and over time. Fourth,

Nasdaq Nordic provides us with high quality secondary market data, including transactions prices, which make our measures of underpricing very precise. Transaction prices are rare to have as many studies suffer from using indicative bid, ask, or mid prices.

An interesting feature of the Icelandic Treasury market is the low number of primary dealers. The numbers of auction participants are large in the empirical studies mentioned above, and to the best of our knowledge, there is no evidence on underpricing for treasury auctions characterized by either the absence of foreign primary dealers or the low number of bidders resulting from this absence. Our study addresses this gap. Only eight financial institutions have ever been accredited as primary dealers by the Central Bank of Iceland between 2000 - 2018, and the median number of primary dealers participating in an auction is only four. Goldreich (2007) shows that the difference in underpricing between discriminatory and uniform-price methods should be almost null under the assumption of four auction players. However, our analysis shows that the superiority of the uniform-price method still stands even in a context of few players. This result is interesting for some countries, especially for emerging markets, where the number of primary dealers is low, like Bostwana, Bulgaria, Jamaica, Mauritius, South Africa, Uganda or Uruguay.[2]

To shed light on the reduction of underpricing following the introduction of the uniform-price method, we perform several non-parametric tests and run a series of multivariate regressions. We control for the explanatory variables commonly used in the underpricing literature: auction characteristics, treasury security characteristics and market conditions. We also improve the model specification by controlling for time-varying changes in commissions paid to primary dealers and the extent of the security lending program. To the best of our knowledge, the level of commission has never been used as an explanatory variable, which is surprising as numerous auctioneers in the world pay commissions to auction participants. Likewise, while many treasury auctioneers have developed security lending programs, published studies ignore the influence of the amount loaned in each treasury security on that security's underpricing. Our results show that these two variables mobilize predictive powers to explain underpricing. This new finding deserves attention as it suggests that the auction method is not the only institutional setting the auctioneer can change

[2]Most of the empirical studies on treasury auction method analyse the US treasury market, which is characterized by a very large number of primary dealers participating in auctions (24 in 2021). The fact is that most of the countries in the world have fewer participants. By gathering information on 49 governmental agencies and central banks, we find that the average number of primary dealers is 12, and 30 percent of the countries have less than 10 primary dealers. Hence, our study is relevant and useful for many countries, especially for emerging markets.

to influence the issuance cost. An appropriate compensation package for primary dealers and a generous lending program might help reduce the issuance cost.

The literature shows no one single way of calculating underpricing, and in order to persuade that our main result holds, regardless of the way underpricing is calculated, we perform three robustness checks. First, we calculate this variable by replacing prices with implied yield to maturity. Second, we take into account the possibility that the difference between the auction outcome price and the secondary market price observed post-auction might be induced with new information. We derive an adjusted measure of underpricing by removing the expected informational component. Third, we replace end-of-day transaction prices by end-of-day posted quotes to compute underpricing. Our results show that underpricing is significantly lower under the uniform-price method regardless of how underpricing is measured.

The rest of this paper is organized as follows. Section 2 presents a literature review. Section 3 describes the Icelandic Treasury securities market. We analyse the bidding behavior of primary dealers in Section 4. Section 5 deals with the measurement of underpricing. Section 6 presents our results and Section 7 concludes.

2 Treasury Auctions: A Literature Review and Current Practises

A long-standing debate in the treasury auction literature focuses on the ranking of auction methods. One reason is that this issue closely links to studies of single-unit auctions, an area where abundant research has addressed the ranking of different auction methods (Vickrey, 1961). Treasury auctions belong to the more general category of multi-unit auctions in which more than one identical unit of goods (bonds and bills in this case) are sold. The other, more important reason is that the monetary amounts involved in treasury auctions are so large that a tiny improvement in auction performance would generate large amounts of additional revenue for central governments, therefore lowering the cost of debt financing. Within the multi-unit auction setting, governments choose between two widely used auction methods to issue debt: the discriminatory method and the uniform-price method.[3] Roughly speaking, these methods correspond to the first-price and second-price methods

[3] Interchangeably, the discriminatory auctions are also referred to as multiple-price auctions, and the uniform-price auctions are also referred to as single-price auctions in the literature.

in single-unit auctions, respectively. In a discriminatory auction, winning bidders pay their own bids individually, whereas in a uniform-price auction, all winning bidders pay the lowest winning price, called the stop-out price.

Theoretical research on treasury auctions still does not provide conclusive revenue rankings between these two methods (Wilson, 1979; Milgrom and Weber, 1982; Bikhchandani and Huang, 1989, 1993; Back and Zender, 1993; Chatterjea and Jarrow, 1998; Viswanathan and Wang, 2000; Wang and Zender, 2002; Kremer and Nyborg 2004; Nybord and Streabulaev, 2004, Kang and Puller, 2008; Kastl, 2011). In particular, Back and Zender compare the two methods when collusive behavior is possible. They show that implicit collusion among bidders is likely to be more difficult in an auction under the discriminatory method, which may result in higher expected revenue compared to that generated in a uniform-price auction. Nybord and Streabulaev compare the two methods in a setting where bidders can be short-squeezed in the secondary market. They show that the likelihood of being short-squeezed is higher under the discriminatory method, which fosters bidding aggressiveness in the auction, producing larger issuer revenues. Goswami et al. (1996), Sade et al. (2006) and Morelas-Carmargo et al. (2013) organize experimental sessions with students and professionals in order to compare auction performance under the two methods. Their conclusion differs: In Sade et al., the discriminatory method generates the lowest average revenue while in Goswami et al. and in Morelas-Carmago et al., it outperforms the uniform-price method.

Empirically, the ranking of auction methods is based on auction performances, with a particular focus on underpricing. Underpricing in treasury auctions, similar to equity initial public offerings (IPOs), is computed as the percentage difference in price between what winning bidders pay in auction for one security and what they earn by selling this security in the secondary or when-issued market. Underpricing can be viewed as a shortfall for the treasury security issuer, as it is the extra revenue he would have earned had the securities been sold directly on the secondary market. Although the ranking between discriminatory and uniform-price methods is inconclusive, the academic literature agrees that underpricing exists with both methods. In the most recent calibration, Goldreich (2007) reports that in US Treasury bond auctions, underpricing is estimated to be 3.5 cents per \$100 (0.59 basis points in yield) on average in discriminatory auctions, and 1.3 cents per \$100 (0.32 basis points in yield) on average in uniform-price auctions. Therefore, primary

dealers appear to earn a profit, on average, when buying at auctions.

The US Treasury switched from the discriminatory method to the uniform-price method for certain maturities during the 1990s, and completely switched the method for all its auctions in October 1998. These two events offer an interesting laboratory to assess the method ranking empirically and several papers analyse underpricing around these events. Interestingly, their conclusion diverges. On one side, Simon (1994), focusing on the historical mid-1970s method change of the US Treasury auctions, finds evidence in favor of the discriminatory method. On the other side, Nyborg and Sundaresan (1996) and Malvey and Archibald (1998), studying the second US method change in 1992, advocate for the replacement of the discriminatory method with that of uniform-price. Goldreich (2007), who leads his analysis over a large time window, spanning the 1992 experimentation and the 1998 complete switch, finds that the uniform-price method produces lower issuance costs for the US government.

Apart from the US Treasury case, there are few published academic studies on the subject of auction method switching. Umlauf (1993) analyses underpricing (called profit margin in his paper) of a series of auctions that took place around July 1990, when the Mexican Treasury replaced the discriminatory method with the uniform-price one. He finds that the uniform, in contrast to discriminatory, auctions appear to raise more revenue. Kang and Puller (2008) study a series of auctions around a similar switch made by the Korean Treasury in August 2002. They found that the discriminatory auctions produce higher expected revenue and better security allocation. To overcome the lack of events on the treasury auction method change, some papers have developed auction models that make counterfactual exercises possible, and quantify what would have been the benefit/loss for the auction participants if the uniform-price method replaced the discriminatory one. Interestingly, their conclusion diverges. Armantier and Sbaï (2006) and Heller and Lengwiler (2001) show that shifting from the discriminatory to the uniform-price method would reduce the government financing cost, whereas Hortaçsu and McAdams (2010) and Marszalec (2017) provide evidence in favor of the superiority of the discriminatory method.

Hence, empirically, neither counter-factual analysis nor underpricing analysis provides a clear answer to which auction method is the best. How much governments could benefit or lose following a change in auction method is still an open question with no consensus. Thus, verifying the current

practices might be useful to see if one auction method is more popular than the other worldwide. We collect information across government agencies and central banks in charge of the issuance process. **Figure 1** shows a world map of the auction security method used across 59 countries for 2021. It shows that practice is divided, with 46% using the discriminatory method, 39% using the uniform-price method.[4] The fact that one method is not overwhelmingly worldwide is also evidence of the inconclusiveness of method ranking in treasury auctions.

In a cross-country analysis, Brenner, Galai and Sade (2009) show that the uniform-price method is widespread across countries whose legal system follows common law, while the discriminatory method is more popular in countries following civil law. This result suggests that the auction method is, in many cases, more a legacy than the result of an analysis, in terms of efficiencies and revenues.[5] Another interesting fact is that, over the last 30 years, only a few countries have switched auction methods, or at least have experimented over a few issuance cycles. To the best of our knowledge, only six countries have changed their auction methods.[6]

The debate on the superiority of the uniform-price over the discriminatory method is also analysed in a different context than that of treasury security issuance. Tenorio (1993) analyses foreign exchange auctions in Zambia and finds that the uniform-price method yields a higher average revenue than the discriminatory one. Feldman and Reinhart (1995) analyse the International Monetary auctions of its gold reserves and find that the average payout the IMF received under the discriminatory method is lower than the payout received under the uniform-price method.

3 The Icelandic Treasury Market

3.1 Treasury Auction Procedures

In Iceland, the Ministry of Finance and the Central Bank of Iceland (CBI) have an agreement on treasury debt management. Act No. 43 has defined the relation between the Ministry of Finance

[4] We also find that 15% of countries use both methods and two countries use the Spanish method. The Spanish method can be seen as a hybrid of a uniform and a discriminatory auction. For winning bids above the weighted average winning bid, bidders are charged the weighted average winning bid; otherwise they pay their respective bids.

[5] It is also possible that governments, central banks and treasury agencies care more about the liquidity on the secondary market, and the positive spillover effect of the issuance process on the other bonds, than the issuance cost itself. See Dittmar and Yuan (2008) for a discussion of the liquidity service of treasury security issuance on the corporate bond market.

[6] From the discriminatory method to the uniform-price method: Mexico (1990), the United States (1998), Korea (2000), Turkey (2001), Poland (2012). From the uniform-price method to the discriminatory method: Mongolia. This list of events comes from Monostori (2014).

and the CBI since 1990. The division of tasks between the two parties works as follows. On the one hand, the Ministry of Finance takes borrowing decisions based on its financial needs and determines the payment structure, maturity, and characteristics of the individual securities issued. The Ministry is also in charge of debt repayment and liquidity management. On the other hand, the CBI is in charge of the issuance protocol of the treasury securities, and disseminates information to primary dealers and investors about the auction calendar. In addition, the CBI produces prospectus for newly issued securities and handles security listings with the Icelandic Securities Depository.

In the Iceland Treasury market, securities are sold exclusively in auctions and there are no syndicated offerings. These auctions are organized on a regular basis. From 2000 to 2018, each month two auctions have been organized by the CBI on average. Three types of securities are issued: bills ("*RIKV yy mmdd*"), bonds ("*RIKB yy mmdd*") and index-denominated bonds ("*RIKS yy mmdd*").[7] Treasury bonds are reissued multiple times in subsequent auctions, which are called reopening auctions. Sometimes, several securities are auctioned on the same auction day. The CBI communicates on expected issuance volume on annual and quarterly basis, based on the government's estimated borrowing requirement and the auction calendar.[8]

Bids can only be submitted to the CBI through the Bloomberg Auction System between 10:30 a.m. and 11 a.m. on the auction date. Both competitive and non-competitive bids are accepted. Bids are expressed on a price basis, with three decimals. Payments must be received by the CBI before 2 p.m. on the date of payment, and the securities are delivered in electronic form on the same day.[9] Once the auction winners are determined and awarded, the CBI notifies the stock exchange and the media about the auction results.

Primary dealers (PDs) have exclusive access to the auctions. From 2000 to 2018, the list of PDs has always consisted of the largest Icelandic banks, and no foreign financial institution has ever been added to the list. The CBI writes bilateral contract with each PD and renews it every year.[10] One important aspect of the contract is mandatory participation: Each PD is obliged to submit bids at

[7] "yy mmdd" denotes the maturity date. Example of a security name: "RIKB 19 0226".

[8] Estimated volumes of issuance are disclosed under the section "*Annual Prospects*" of the Government Debt Management website. Few days before an auction, a document called "*Terms of Invitation to Tender for Treasury Bills*" for T-bills and "*Terms of Invitation to Tender for Treasury Bonds*" for T-bonds is disclosed for market participants. Hence, the supply of treasury securities is set in advance and not endogenous on bidding activities.

[9] This time schedule has changed over time. For instance, in 2003, bids had to be sent between 10 a.m. and 11 a.m., while payments had to be made before 4 p.m.

[10] The complete list of general agreements, bilateral agreements, revisions, amendments, temporary exemptions and terminations throughout the years is available at http://www.lanamal.is/EN/investors/primary-dealers-for-government-securities.

each auction for a minimum of 100 million ISK of face value. In compensation for this mandatory presence on the primary market, the CBI pays each dealer a commission, which takes the form of a small percentage of the winning bids.[11] In addition, winning PDs have the right to purchase the equivalent of 10% of the nominal value sold in the auction at the average winning price.

The decision to replace the discriminatory with the uniform-price method was taken on November 28, 2008 and announced on the same day to market participants through a press release. The first T-bond auction structured as a uniform-price auction took place on December 03, 2008. The change for T-bill auctions took place almost one year later, with the first auction under the uniform-price format organized on October 13, 2009. As to the motivations for the method change, the head of the Icelandic Government Debt Management told us that he was intrigued by the academic papers advocating the use of the uniform-price method. He also indicated that the switch was motivated by the attempt to increase the volume of transactions in the secondary market as well, and it would have been implemented even if the 2008 financial crisis had not happened.

3.2 Auction Data

Our sample of Icelandic Treasury auctions covers the period from January 2000 to March 2018. Each treasury security and primary dealer has a unique ID consistently throughout. We observe, for each auction, the date, the security issued, the settlement date, the primary dealer bids, the quantity asked per bid and the quantity awarded per bid. Summary statistics are reported in **Table 1**. The total number of auctions is 516. There are 246 auctions of treasury bills (T-bills) representing the issuance of 182 unique securities. For the treasury bonds (T-bonds), there are 270 auctions, representing the issuance of 19 unique securities.[12]

The first important characteristic in our sample is the low number of securities in the T-bond market, which is explained by the CBI's intensive use of reopening cycles. For instance, RIKB 07 0209, RIKB 10 0317, RIKB 13 0517, RIKB 20 0205 and RIKB 31 0124 were re-issued more than 20 times. The second important characteristic in our sample is the low number of PDs: On average, there are only four PDs participating in the Icelandic Treasury auctions. To the best of our

[11] For instance, in 2016, this percentage was 0.10% for securities with a maturity period longer than three years and 0.04% otherwise. The commission was deducted from the primary dealer's payment for the purchase of the securities. There was no commission paid for auctions of T-bills.

[12] The CBI also issued few index-linked securities which are not issued on a regular basis and turn out to be very illiquid in the secondary market. These securities are removed from our analysis.

knowledge, this is the lowest figure among all studies on treasury security auctions.[13] The highest recorded number of PDs participating in an auction is six, which happened for only three auctions. There are five, four, three, and two PDs in 162, 243, 81, and 18 auctions, respectively. When the sample is split according to the auction method, there are 95 auctions of T-bills organized under the discriminatory method, and 151 auctions of T-bills organized under the uniform-price method. For the T-bond market, there are 91 auctions organized under the discriminatory method and 179 auctions organized under the uniform-price method.

3.3 The Secondary Market

The CBI is very active in the secondary market, setting rules and working toward the liquidity improvement of treasury securities. Especially, the CBI provides short-term security lending facilities against cash collateral to investors in the opening hours of the Iceland Stock Exchange. This lending program aims to support trading volume, foster price discovery, and reduce the likelihood of short-squeeze.[14] The CBI regulates PD activity in the secondary market. PDs must submit bids, offers and trading lots to the Nasdaq Iceland Online Trading Platform before the market opens. The CBI imposes a minimum size on trading lots and a maximum tolerated bid-ask spread. The complete terms of the security lending program and market-making rules are described in "*Terms and Conditions for Securities Lending*" and "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*", respectively. These documents are signed by the PDs and updated on a yearly basis.

3.4 Secondary Market Data

The secondary market data are from Nasdaq Nordic, which is the subsidiary of Nasdaq, Inc., operating at market places for financial securities in the Nordic and Baltic regions of Europe. The data include end-of-day last prices paid, end-of-day closing prices and trading volumes for most of the bills and bonds issued by the Icelandic governments. By merging our auction sample with

[13] To compare to another Nordic country, there are between 5 and 10 PDs in the sample of Keloharju et al. (2005) concerning Finland treasury auctions between 1992 and 2000. In a more recent study from Rydqvist and Wu (2016) on Canadian treasury auctions, there are around 10 PDs between 1998 and 2010.

[14] Short-squeeze happens when one or few PDs buy so much in the treasury auction that they obtain strong market power on the secondary market and use this power to set very high prices when trading against investors or PDs with short positions.

Nasdaq Nordic data, we obtain a final sample of 385 auctions (75% of the 516 auctions) for which underpricing is computable.[15] The numbers of observations split across auction methods are as follows: 153 and 232 for the discriminatory and uniform-price methods, respectively.

3.5 Government Debt Management Data

We gather additional information from a governmental agency linked to the Minister of Finance, Governement Debt Management (https://www.lanamal.is/EN), which discloses information on auction schedule, auction results, and some documentations on the terms and conditions of the issuance process. The first source of our additional auction-level data is the series of "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*". This file mentions minimum trading lots and commission amounts explicitly. Two clarifications about commissions are important. First, the exact amounts paid to each primary dealer are unknown and only the annual aggregate amounts to all PDs are reported in the documents. Second, these amounts are the only source of compensation for the PDs. There are no syndicated offerings on the Icelandic Treasury market and hence no syndication fees. Our second source of data is the series "*Terms and Conditions for Securities Lending Facilities for Primary Dealers*". This document indicates the maximum amount that can be loaned to each PD for each treasury security. This maximum amount is positively related to the total security outstanding amount and hence is updated on a regular basis. All marketable treasury securities are eligible for securities loans.

4 Bidding Behavior in the Icelandic Treasury Primary Market

4.1 Annual Statistics

In **Figure 2**, we exhibit several statistics on auctions, security supply, PDs and bids, by year and by security type. First, the number of auctions changes over time. There are progressively more and more auctions of T-bills and T-bonds: between five and 10 for the discriminatory method,

[15] Among these 385 auctions, there are 262 (69.1%) security - auction day observations that find exact matches with secondary market data. For these observations, the security is traded on the secondary market on the same day as the auction. For the other 123 security-auction day observations, the first recorded transaction occur on the secondary market one day, two days, up to five days after the auction takes place. We excluded 130 ($515 - 385$) security-auction day observations from our final sample because the first transactions on the secondary market occur more than five days after the auction, which does not allow us to produce reliable underpricing measures.

and between 10 and 25 under the uniform-price method. Auction size also increases. For the T-bill market, peaks are observed in 2008, 2009, and 2010, consistent with the borrowing needs of the Icelandic government. In Iceland, the outstanding amounts are historically larger for short-term treasury securities than for long-term ones, and the T-bond auction size catches up to the T-bill auction size only in 2013. We can also observe that the number of PDs participating in the auctions is low and stable over time: At least (at most) three (five) PDs participate in a treasury auction. One explanation is that only financial institutions with Icelandic nationality are authorized to participate.

We find an interesting pattern in bidding behavior over time: The number of bids is larger for the T-bill market between 2000 and 2010, but it is larger for the T-bond market between 2011 and 2017, suggesting an asymmetric effect of the method change on T-bills and T-bonds. There is relatively more competition between PDs in T-bond auctions under the new format. The bid-to-cover ratio, a widespread measure of auction performance, defined as the total amount asked by PDs over the total supply, is lower on average for the $2011-2017$ period, for both types of treasury securities. This is due to the fact that the supply of treasury securities is larger on average for the $2011-2017$ period.

4.2 Bidder-level Statistics

Summary statistics on PD bidding behavior and performance are reported in **Table 2**. We do not know the true identities of the primary dealers but our dataset contains consistent bidder IDs over time. These are: PD_1, PD_2, PD_3, PD_4, PD_5, PD_6, PD_7 and PD_8. The arrival of PD_8 among the primary dealers and the withdraw of PD_1, PD_5 and PD_6 coincides with the setup of the new method.

We can observe some heterogeneity in terms of bidding intensity and the amount awarded. For instance, for T-bond auctions during the discriminatory method period, PD_6 submits only one bid on average and is awarded with securities in only eight auctions, that is 24% of the auctions in which the PD participates. The quantity awarded, conditional on winning, to this PD is 9.1% on average. On the opposite side of the panel, PD_3 turns out to be very active: This bidder submits five bids on average, win in 74 auctions (84%) and, conditional on winning, is awarded

46.8%. Interestingly, strong bidding intensity does not necessarily lead to large award amounts. For instance, PD_7 submits on average 9 bids on the T-bill market, which is very high compared to the other PDs. However, that PD is awarded only 19.7% of the securities, on average, and conditioned on winning the auction. Unlike PD_7, PD_1 submits only four bids on average, but is always awarded the auctions he participated in. On average, he is awarded 24.8% of the supply of securities.

PD bidding behavior and performance under the uniform-price method are reported in **Table 3**. We observe that there are more auctions and fewer auction participants, since PD_1, PD_5, and PD_6 have ceased participating. Each PD seems to be very active except for PD_8, who participates in less than half of the auctions organized, submitting one (three) bid only on average during T-bill (T-bond) auctions. However, that PD is awarded 59.7% (20.2%) on average per win. PD_2 is the largest winner, with an average of 60.5% (35.9%) of the total T-bill (T-bond) amount awarded.

5 Underpricing: Measurement and Statistics

5.1 Measuring Underpricing

We measure underpricing as the difference between the price clearing the security supply in the auction and the price observed in the secondary market after auction. This variable captures the auction profit made by PDs who can resell in the secondary market a fraction (or all) of the securities purchased. Auction profit made by PDs translates to a shortfall for the security seller in the primary market: the auctioneer could have raised more money by selling the bonds directly to the buyers in the secondary market. Hence, in the context of sovereign bond issuance, positive underpricing implies revenue transfer from national governments to PDs who participate in the primary market and act as market-makers in the secondary market. If we are able to identify which factors impact the underpricing, we can suggest recommendations for auction organizers in order to reduce the revenue transfer.

To be consistent with the literature, we use the following notation: i for auction, j for bidder, k for bid. Each bidder j sends one or several price-quantity pairs $\{b_{i,j,k}; q_{i,j,k}\}$ to the auctioneer,

who ranks the bids in price descending order. Then, the bids are awarded the treasury securities following the descending order, up to cumulated awards equal the intended volume. The winning pairs are denoted $\left\{b^*_{i,j,k}; q^*_{i,j,k}\right\}$. Under the discriminatory method, each bidder pays $b^*_{i,j,k}$ to receive $q^*_{i,j,k}$. Under the uniform-price method, each bidder pays $\inf\{b^*_{i,j,k}\}$ instead of $b^*_{i,j,k}$ to receive $q^*_{i,j,k}$. That is, all bidders pay a unique price, which is the lowest bid at which demand equals supply. It is commonly called the market clearing price or stop-out price.

Under the discriminatory method, underpricing is measured as follows:

$$U^i_{DISCR} = \frac{P_i - \sum w^*_{i,j,k} \times b^*_{i,j,k}}{\sum w^*_{i,j,k} \times b^*_{i,j,k}} \tag{1}$$

where

$$w^*_{i,j,k} = \frac{q^*_{i,j,k}}{\sum q^*_{i,j,k}}$$

P_i is the price observed in the secondary market after auction i. Under the discriminatory method, underpricing is measured as the scaled difference between the secondary market price observed post-auction and the quantity-weighted average winning price. Under the uniform-price method, underpricing is measured as follows:

$$U^i_{UNIF} = \frac{P_i - \inf\{b^*_{i,j,k}\}}{\inf\{b^*_{i,j,k}\}} \tag{2}$$

5.2 Underpricing Statistics

Figure 3 shows the annual average underpricing from 2000 to 2018. Up to end of 2007, underpricing exhibits small variation, evolving between 2 and 10 basis points. Then, there is a sharp increase in 2008 and 2009, underpricing reaching 17.7 and 19.6 basis points, respectively. A trend reversal takes place in 2010, following by a very large decline in 2011. This year, we observe, for the first time, a negative average underpricing, which means that there is, on average, overpricing. Over 2012 - 2018, we observe that a lot of auctions are associated with overpricing. For instance, in 2014, more than 50% of the auctions produce overpricing. It may be surprising to see this result, because it means that PDs pay for the securities at higher prices in the auction than what they could sell at

in the secondary market. This pattern can be explained by the existence of a compensation scheme for PDs (see Section 3). If the auctioneer provides fees in compensation for active participation in the auction, the dealers can bid aggressively if the commission is viewed as large enough to offset overpricing. The exact compensation scheme is privy to the CBI and the PDs, and we do not have PD-level data to analyse whether and to what extent the commissions would offset overpricing. However, we do observe the total amount of commissions paid to all PDs per year and we explore the link between commissions and underpricing in the next section.

Figure 4 shows the evolution of underpricing in the five days surrounding a treasury bond issuance. The lines are generated using the cross-sectional means, medians, and lower and upper quartiles for the discriminatory and uniform-price methods. For both methods, we observe a decrease in the underpricing level prior to the auction day, before reaching its lowest level on the auction day. This pattern is consistent with what Mercer et al. (2013) observe on the US Treasury market, and can be explained by the following mechanism: as the auction day approaches, the secondary market incorporates more and more information bringing by forward contracts negotiated on the next security to be issued from the auction process (this is called when-issued trading). These forward contracts exist because some market participants are willing to sell the security that has not yet been issued. These forward contracts contribute to the price discovery process and consequently, the auction outcome price is discovered on the secondary market. After auction day, underpricing gradually increases. The decline prior to auction day and the increase after produce a V-shaped pattern over $[t-5 \text{ days} ; t+5 \text{ days}]$. A similar pattern can be observed in Lou, Yan, and Zhang (2013) and Sigaux (2020) in the context of US and Italian treasury issuances, respectively.

Table 4 reports underpricing levels across auction methods. The average underpricing in price space (yield space) is 7.86 (15.14) basis points under the discriminatory method and -0.67 (-12.98) basis points under the uniform-price method. The median numbers are 4.73 (2.99) basis points and 2.98 (1.14) basis points, respectively. A non-parametric test on the medians produces a z-value of 2.03 (3.64), showing that the decline is significant at 5% level. Underpricing for Icelandic Treasury securities seems to be fairly close to what is documented for other countries. Goldreich (2007), working on a set of 283 auctions of US Treasury securities over the 1991 - 2000 period, finds that underpricing is 3.5 basis points for discriminatory auctions on average, while underpricing

in uniform-price auctions is 1.3 basis points. Bjonnes (2001, 2002), working on a set of Norway Treasury securities, finds 3.6 basis points for T-bill issuance under the discriminatory method and 13.3 basis points for T-bonds issued under the uniform-price method. Keloharju et al. (2005) find an average of 4.1 basis points on the Finnish Treasury security market under the uniform-price method.

6 Evidence from Multivariate Regressions

6.1 The Model

To assess whether the change in auction method is associated with a significant change in underpricing level, we estimate the following model using ordinary least square regression:

$$UNDERPRICING_i = \beta_0 + \beta_1 \times AUCTION\_METHOD_i + \delta' \times EXPLANATORY_i + \varepsilon_i \quad (3)$$

where

$$UNDERPRICING_i = \begin{cases} U^i_{DISCR} & \text{if } AUCTION\_METHOD_i = 0 \\ U^i_{UNIF} & \text{if } AUCTION\_METHOD_i = 1 \end{cases} \quad (4)$$

The subscript i denotes the auction. U^i_{DISCR} and U^i_{UNIF} are defined in (1) and (2) and expressed in basis points. $AUCTION\_METHOD$ is a dummy variable that takes the value 0 under the discriminatory method period and the value 1 for uniform-price method period. $EXPLANATORY$ stands for the set of explanatory variables. This set includes auction and security characteristics, auction performance measures, and financial market conditions.

Auction characteristics include auction size ($AUCTION\_SIZE$), measured as the log of the total nominal bond value awarded to winners. This variable is widely used as a control variable in the underpricing literature. More awards in the auction lead to more security supply on the secondary market. If PDs lower the asking price to be able to sell the treasury securities, we should observe a decline in the underpricing measure. Other auction characteristics include a reopening cycle dummy ($REOP\_CYCLES$) that takes the value 1 if the security issued has already been issued in the past. For security characteristic, we introduce a dummy variable, taking the value 0 for T-bills and 1 for T-bonds ($BILL\_BOND\_DUM$).

Participation in auctions, bidding activity, and market making on the secondary market are all regulated by specific rules stated by the auctioneer. For the Icelandic Treasury auctions, the CBI communicates on a regular basis about these rules, which have been updated many times between 2000 and 2018. We believe some changes in the underpricing level over time could have been triggered by updates in these rules. To control for this potential influence, we manually collect all the CBI rule announcements on their website and we create five variables. These variables include the number of bidders authorized to participate in the auction ($NB\_BIDDERS$), the minimum bid size imposed on PDs ($MIN\_TRADING\_LOT$), the maximum amount loaned by the CBI in each treasury security for each primary dealer ($LEND\_FAC$), the commissions paid to primary dealers for their participation in the auctions ($COMMISSION$), and the option to buy the equivalent of 10% of the nominal value sold in the auction ($OPTION\_DUM$).

As for auction performance variables, we use the bid-to-cover ratio (BID_TO_COVER), measured by the total quantity demanded by PDs divided by the supply size. Large bid-to-cover ratios indicate higher relative demand, thus more competition between PDs and more success for security issuer. We also use a measure of bid dispersion ($DISPERSION$) to capture the heterogeneity of security valuation among PDs. To take into account the heterogeneity of security quantities allocated between winners, we measure market power (MKT_POWER) computed as the total security face value awarded to the largest winner divided by supply. A PD awarded by a very large fraction of the securities is likely to have a dominant position in the secondary market. This outcome might be unintentional or intentional. Under this latter scenario, the PD is willing to establish a short-squeeze position, raising secondary market prices and underpricing. For an analysis of the influence of short squeeze on bidding behavior and underpricing, see Rydqvist and Wu (2016).

Finally, we control for local and global financial market conditions. $BOND\_VOL$ is the volatility of treasury security returns on the secondary market. $5Y\_SPREAD$ is the difference between the 5-year Icelandic bond yield benchmark and the 5-year German bond yield benchmark. We also add measures of the performance and volatility of the Icelandic stock market, with the monthly returns ($ICEX\_RTN$) and volatility ($ICEX\_VOL$) of the Icelandic Stock Exchange (ICEX) index. We report all variable definitions in **Appendix 1**. We provide data on lending facilities and commissions in **Appendix 2** and data on minimum trading lot in **Appendix 3.**

6.2 Empirical Results

Table 5 contains the main regression results. If the uniform-price method has led to less underpricing, the coefficient associated with the auction method dummy variable should be negative. The second column shows the result of the univariate regression. β_1 is negative (-0.09) and statistically significant at 1%. Column 3 to 9 show multivariate regression results.[16] β_1 turns out to be negative and statistically significant at 5% in six models out of seven, and significant at 10% in all specifications. When all explanatory variables are included together, β_1 remains negative (-0.17) and significant at 5% level. Hence, our results confirm what has been found with the non-parametric tests. It brings new evidence that there is less underpricing with the uniform-price method than with the discriminatory.

We observe that the adjusted R-squared moves from 1.4% in column 2 to 25.4% in column 9, which put in evidence that some explanatory variables bring a predictive power to explain underpricing. Hence, beyond the role played by the auction method, some mechanisms deserve to be analysed and commented. First, MKT_POWER, defined as the total nominal value awarded to the largest winner, is negative and highly significant. This can be explained by the following mechanism: a PD seeking to be granted a large portion of the securities issued will bid aggressively during the auction, pushing up the stop-out price. In such a case, the difference between the stop-out price and the secondary market price is reduced. Interestingly, it seems that a high concentration of securities in the hands of a single PD does not lead to abusive use of their market power, that would increase the security price on the secondary market with respect to the auction stop-out price. While this mechanism should induce a positive relationship between MKT_POWER and underpricing, this is not what we observe. Hence, it seems that auction participants do not seek to establish short-squeeze positions. Clear rules on market-making in the secondary market made by the CBI, signed by market makers and updated on a regular basis, might prevent this type of behavior.

Second, the treasury bond market volatility is not significant. We also find that the Icelandic stock market return and the Icelandic stock market volatility, pooled in $CONTROL\_VAL$ in

[16] The number of observations change across regressions. There are 4 auctions with one single bidder so that the bid dispersion is not computed (column 5). We also loose 11 observations as the commission level is not observable prior to June 2001 (column 7). Finally, 16 observations are excluded as the Iceland - German credit spread is not observable before October 2001 (column 8). When all explanatory variables are introduced in the model, there are 20 auctions excluded.

the regressions, are not significant either. This result suggests that, in the Icelandic Treasury security market, underpricing is primarily affected by factors related to the auction itself rather than general market or economic trends. This is a surprising result. In Goldreich (2007), bond volatility is significantly associated with underpricing. We think that this difference is linked to organizational differences in treasury security markets. The CBI does not allow foreign financial institutions to participate while the US Treasury does. If these foreign financial institutions are more experienced with and therefore more sensitive to market conditions than domestic banks, then this sensitivity will be reflected in their bidding behavior in the auction, and market-making in the secondary market. As a consequence, underpricing is more likely to be related to market factors when these sophisticated foreign financial institutions are present in the auction. When foreign financial institutions are absent, local market conditions account for the underpricing level.

The third interesting result is the significant negative impact of the commission paid to primary dealers on underpricing. More commissions lead to less underpricing. A possible explanation is that commissions replace the gain made by the PDs when selling the treasury securities on the secondary market higher than what they pay to acquire them. At some point, the level of commissions paid to PDs can become high enough that it is no longer necessary for them to make a margin when selling treasury securities on the secondary market. Our data show some evidence to support this mechanism: the progressive decline in underpricing over the period 2010 - 2012 (see Figure 3) coincides with a strong increase in the commission level over the same period (see Appendix A2.1). The analysis of the compensation policy made by the CBI on PD bidding behavior and market-making in the secondary market is beyond the scope of this study, and this research question will be addressed in another paper.

6.3 Robustness Checks

Underpricing can be measured in price space or yield space and both measures are common in the literature. Underpricing in yield space is the incremental return a market participant earns by winning a security in the auction relative to purchasing the same security on the secondary market. To have consistent signs with respect to the previous measure, underpricing in yield space is defined as the difference between the auction outcome yield and the secondary market yield. We calculate

secondary market yields using the end-of-day closing prices provided in Nasdaq Nordic data. The auction outcome yield is the quantity-weighted average winning yield under the discriminatory method and the stop-out yield under the uniform-price method. Since the relationship between prices and yields is non-linear, replacing underpricing in price space by the same measure in yield space as dependent variable could change coefficients and standard errors in the regressions.

We also set a correction to underpricing. Measuring underpricing requires end of trading day prices, which means that at least that few hours separate the auction outcome price and the secondary market price. If any information relevant for pricing treasury securities arrives after the auction but before the end of the trading day, the secondary market price will incorporate this information, and underpricing becomes biased. To take into account the potential noise in our measure induced by information arrival, we propose the following correction to underpricing[17]:

$$U^*_{DISCR} = U_{DISCR} - \frac{P^{MS}_{a+t} - P^{MS}_{a}}{P^{MS}_{a}} \tag{5}$$

for the discriminatory method and

$$U^*_{UNIF} = U_{UNIF} - \frac{P^{MS}_{a+t} - P^{MS}_{a}}{P^{MS}_{a}} \tag{6}$$

for the uniform-price method, where P^{MS}_{a} is the daily closing price of a matching security on the auction date, while P^{MS}_{a+t} is the closing price recorded t days after. t depends on the availability of the secondary market price for the security used to compute underpricing. For instance, if the secondary market price of this security is recorded 4 days after the auction day, $t = 4$, so the percentage price change of the matching security spans 4 days after the auction. A treasury bill (bond) is matched with another treasury bill (bond) with a comparable maturity.

Regression results are reported in **Table 6**. We have run ($2^3 = 8$) regressions by combining the following criteria: univariate or multivariate, presence or absence of matching securities, and price space or yield space. We find that $AUCTION\_METHOD$ is negative and significant at 90% confidence level for all specifications, and significant at 5% in 6 regressions. This confirms the evidence that there is a lower underpricing level under the uniform-price method with respect to the

[17] A similar correction can be found in Hamao and Jegadeesh (1998).

discriminatory method, and this result holds regardless of how the dependent variable is measured.

Iceland has experienced a financial turmoil that started in September 2008 when the interbank lending market was reduced drastically following the collapse of Lehman Brother in United States.[18] Given that the implementation of the uniform-price auction method takes place in 2008 and 2009, the financial crisis could be a confonding factor generating a spirious association between the auction method and underpricing. Hence, in order to convince that our result is not driven by the financial crisis, we rerun the regressions in a sample that excludes the 104 auctions that took place from September 2008 (the banking crisis started) to August 2011 (The international bailout support programme for Iceland officially ended). Regression results are reported in **Table 7**. We observe that $AUCTION\_METHOD$ is significant at 5% level in all models. Hence, we can conclude that the significant relationship between auction method and underpricing is not induced by the Icelandic financial crisis. [19]

7 Conclusion

In this paper, we connect treasury security auction methods to sovereign debt issuance costs. In 2008, the Central Bank of Iceland decided to leave out the discriminatory method and adopt a new uniform-price method. By using a dataset containing 516 Icelandic Treasury auctions organized between 2000 and 2018, we are able to assess whether the adoption of the uniform-price method leads to a significant change in the underpricing level. Although this research question has been addressed before, our study is unique in three ways: (i) unlike previous studies with limited sample periods, our sample spans almost two decades with detailed auction and secondary market data, (ii) this study is the first to focus on a treasury security market with a very low number of bidders, a feature shared by many emerging markets but often overlooked in US-focused studies, (iii) we incorporate a rich set of control variables in the analysis, and identify the first-order effect of auction-related factors in explaining underpricing.

We find that the Icelandic government benefits from the adoption of the uniform-price method.

[18] For an analysis of the causes of the Icelandic financial crisis, see Aliber and Zoega (2011).

[19] The specific bidding strategy of each PD could be persistent through time and an autocorrelation of bids over successive auctions could generate autocorrelated residuals in our model. To verify the severity of autocorrelation in the models, we compute the Durbin-Watson statistics for each regression in Table 5. We find that the null hypothesis of the absence of autocorrelation must be rejected for 3 regressions. For these regressions, we have computed Newey-West standard errors (unreported results). It turns out that auction method remains significant at 10% level in the three cases.

This result is statistically significant in multivariate regressions and economically important as well. This is because the gain, or the decline in shortfall following the adoption, represents billions of savings on cost of debt. Our study, taken jointly with a similar analysis by Goldreich (2007) in the US Treasury market, shows a dominance of the superiority of the uniform method when auctioneers are trying to reduce issuance costs. While many central banks, on the behalf of their governments, continue to use the discriminatory method to issue treasury bills and bonds, our study supports a change toward the uniform-price method from a revenue/cost perspective.

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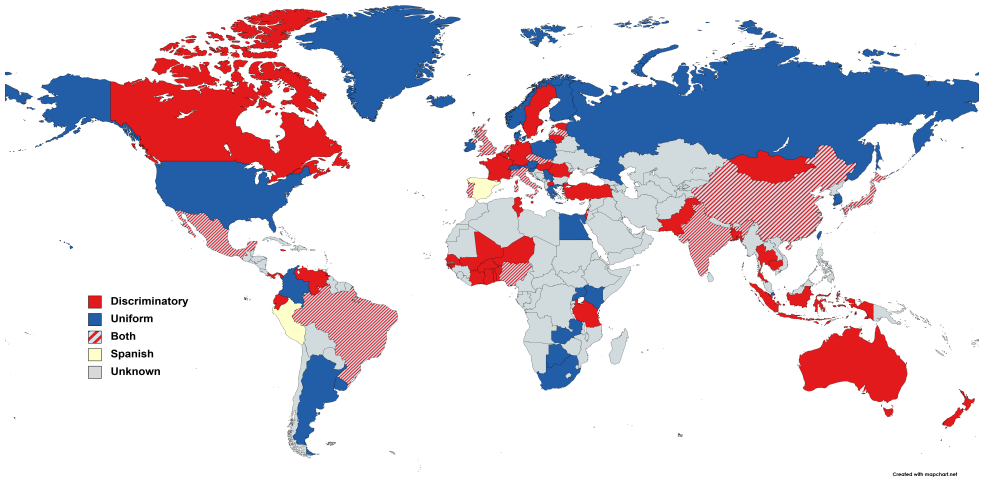
Figures

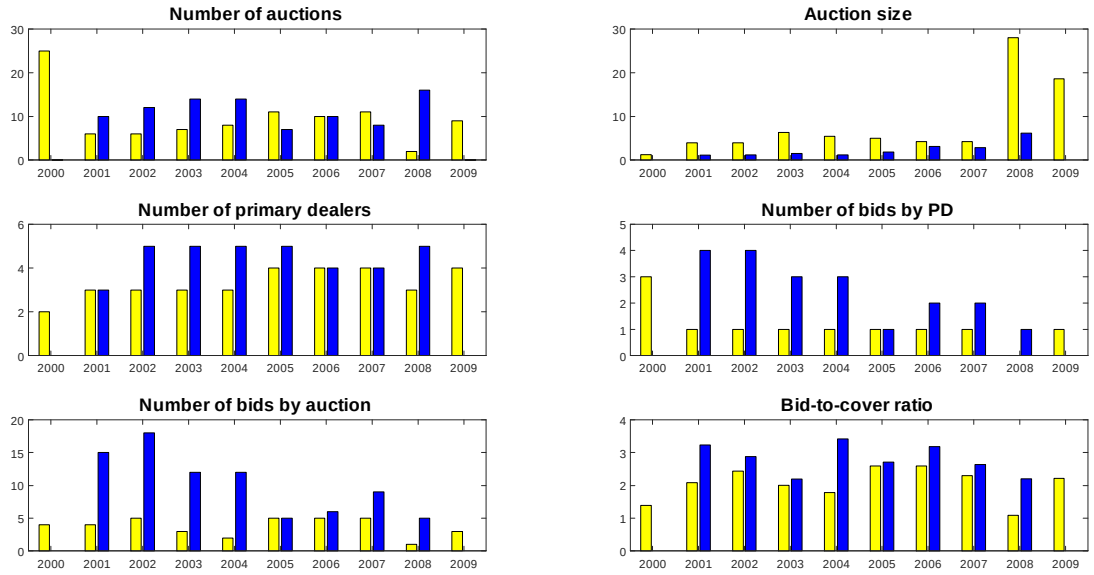
Figure 1: Use of the Treasury Auction Method in the World



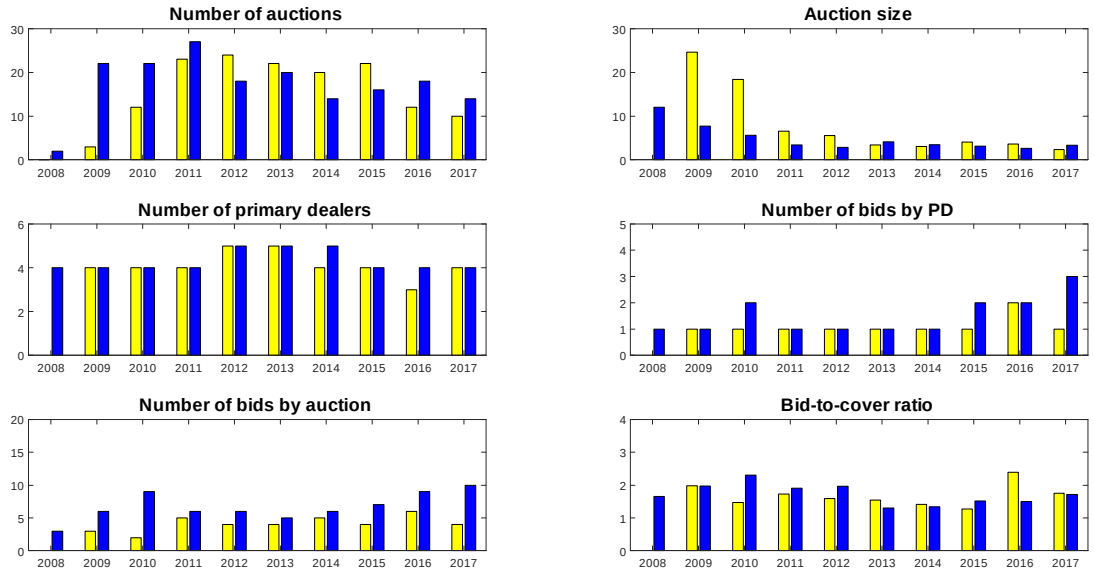
This map shows the choice of the treasury auction method. Data have been gathered from governmental agencies and central banks in November 2021.

Figure 2: Auction Statistics Over 2000 - 2018

Panel A: Discriminatory method

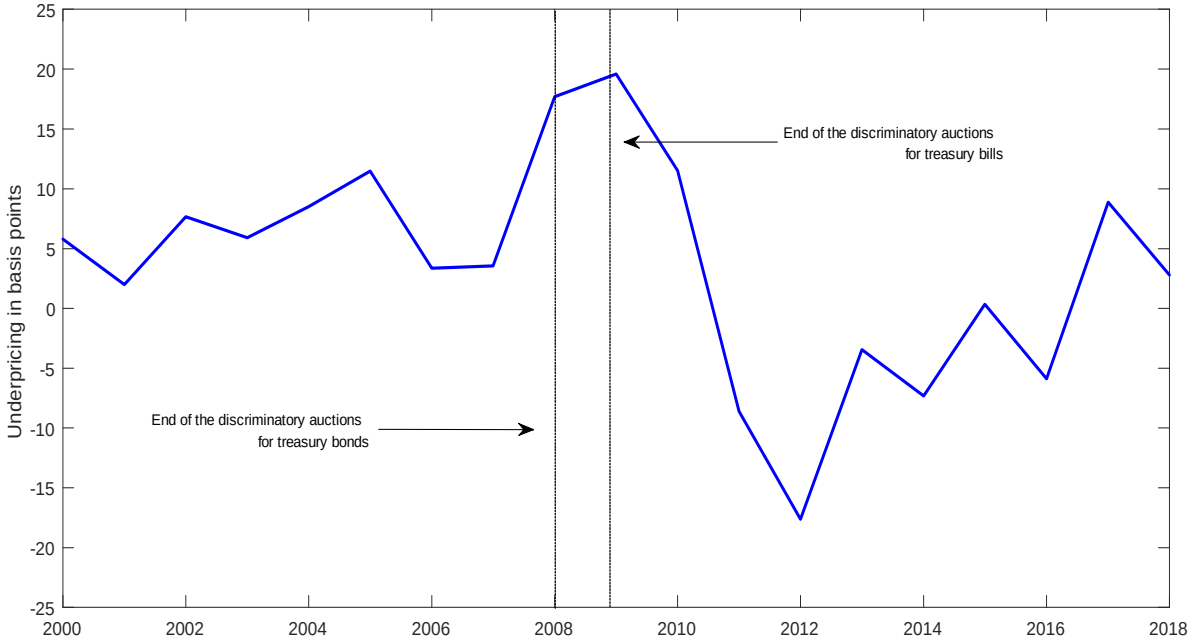


Panel B: Uniform-price method



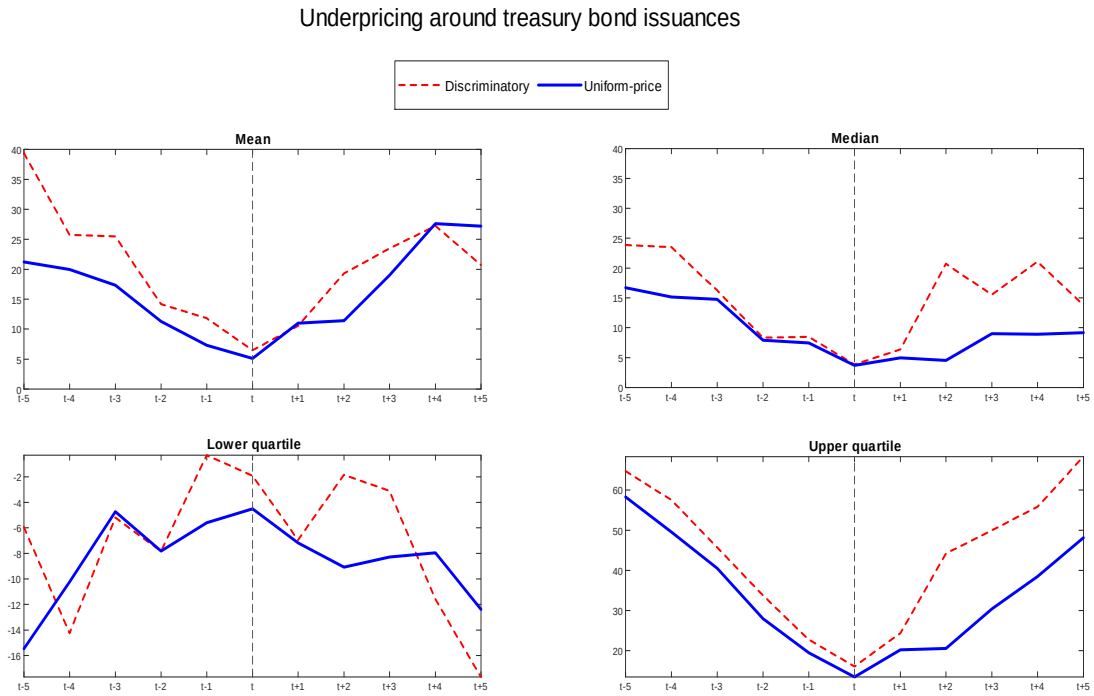
Top left: Number of auction organized each year. Top right: Average auction size, in billions of nominal value of treasury securities. Middle left: Number of primary dealers participating in auctions. Middle right: Number of bids by PD for one billion of nominal value. Bottom left: Total number of bids scaled by one billion nominal value. Bottom right: Bid-to-cover ratio. Numbers are averages across auctions. Yellow: Icelandic Treasury bills, Blue: Icelandic Treasury bonds.

Figure 3: Underpricing in the Icelandic Treasury Security Market



This graph shows the underpricing quarterly average in basis points for Icelandic Treasury securities between January 2000 and March 2018. The vertical lines separate the periods under which the Central Bank of Iceland used the discriminatory and uniform-price methods. The last T-bill (T-bond) auction under the discriminatory method took place the 09/11/2009 (09/25/2008). The first T-bill (T-bond) auction under the uniform-price method took place the 10/13/2009 (12/03/2008). Under the discriminatory method, underpricing is measured as the scaled difference between the secondary market price observed post-auction and the quantity-weighted average winning prices of the auction. Under the uniform-price method, underpricing is measured as the price on the secondary market post-auction minus the stop-out price. The secondary market price is the end-of-trading day price. If no transaction was recorded in the secondary market on auction day, we used the closest available closing price within the next five days instead. Secondary market data are provided by Nasdaq Nordic.

Figure 4: Underpricing Around Treasury Bond Issuances



This panel shows the evolution of underpricing around the issuance of treasury bonds by the Central Bank of Iceland. Top left, top right, bottom left, and bottom right show the mean, median, lower quartile and upper quartile of the cross-section of bonds issued, respectively. X-axis: The timeline around the issuance day t. Y-axis: Underpricing in basis points.

Tables

Table 1: Auction-level Summary Statistics

	Full sample			Discriminatory method			Uniform-price method		
Securities	T-bills	T-bonds	All	T-bills	T-bonds	All	T-bills	T-bonds	All
Number of auctions	246	270	516	95	91	186	151	179	330
Number of securities	182	19	201	85	7	92	97	15	112
Number of bidders	4	4	4	3	5	4	4	4	4
Number of bids	15	21	18	18	17	17	14	23	19

This table shows summary statistics for our sample of Icelandic Treasury auctions between January 2000 and March 2018. The sample is split according to security types and auction method. The first line indicates the total number of auctions organized by the Central Bank of Iceland, while the second line shows the total number of unique securities issued in the auctions. The difference between the total number of auctions and the total number of securities is explained by the existence of reopening cycles for the T-bonds. The third line shows the average number of bidders participating in each auction. The last line reports the average total number of bids received in an auction.

Table 2: Bidder-level Summary Statistics Under the Discriminatory Method Period

Bidder ID	PD_1	PD_2	PD_3	PD_4	PD_5	PD_6	PD_7
	Treasury bills						
1) Number of auctions	9	88	37	89	42		38
2) Number of securities	8	80	37	83	41		38
3) Number of bids	4	6	6	5	4		9
4) Number of winning auctions	9	64	32	74	30		26
5) Winning auctions (%)	100	72.7	86.5	83.1	71.4		68.4
6) Quantity asked (ISK)	1.2	4.6	5.4	3.3	1.6		2.7
7) Quantity asked to supply (%)	29.5	71.2	86.7	72.3	39.1		35.7
8) Quantity awarded (ISK)	1	3	2.6	2.2	1		1.7
9) Quantity awarded to supply (%)	24.8	40.1	38.5	48.1	26.9		19.7
	Treasury bonds						
1) Number of auctions	22	76	88	89	59	33	43
2) Number of securities	2	7	7	7	6	3	7
3) Number of bids	4	4	5	3	2	1	5
4) Number of winning auctions	11	43	74	67	35	8	22
5) Winning auctions (%)	50	56.6	84.1	75.3	59.3	24.2	51.2
6) Quantity asked (ISK)	0.5	0.9	2.4	1.8	0.4	0.1	1.1
7) Quantity asked to supply (%)	49.8	42.6	124.7	65.6	25.5	8.5	38.6
8) Quantity awarded (ISK)	0.2	0.6	1.1	1.2	0.3	0.1	0.5
9) Quantity awarded to supply (%)	18.7	21.7	46.8	40.4	16.5	9.1	15.5

1) Total number of auction days in which the primary dealers sent bids. 2) Number of securities issued for which the bidder bids at least once. The participation measured with auction days differs from the participation measured with security IDs. The difference is explained by the existence of reopening cycles and the fact that several securities can be auctioned on a single day. 3) Rounded average number of bids sent by the bidder across auction days. 4) Number of auction days in which the bidder is awarded at least one bond. 5) Number of winning auctions divided by total number of auctions. 6) Average security amount asked by auction in billions of Icelandic Krona (ISK). 7) Corresponds to Quantity asked (ISK) divided by the total supply of treasury securities. 8) Average security amount awarded by auction in billions of Icelandic Krona (ISK), conditional on winning at least one treasury security in the auction. 9) Corresponds to Quantity awarded (ISK) divided by the total supply of treasury securities.

Table 3: Bidder-level Summary Statistics Under the Uniform-price Method Period

Bidder ID	PD_2	PD_3	PD_4	PD_7	PD_8
			Treasury bills		
1) Number of auctions	141	144	142	132	61
2) Number of securities	95	97	94	91	41
3) Number of bids	4	4	4	2	1
4) Number of winning auctions	127	134	117	39	13
5) Winning auctions (%)	90.1	93.1	82.4	29.5	21.3
6) Quantity asked (ISK)	4.5	2.1	1.3	0.7	0.8
7) Quantity asked to supply (%)	89.3	32	28.3	13.1	18.8
8) Quantity awarded (ISK)	3.4	1.9	1.1	1	2.9
9) Quantity awarded to supply (%)	60.5	28.9	19.8	11.4	59.7
			Treasury bonds		
1) Number of auctions	176	168	174	176	61
2) Number of securities	15	15	15	15	9
3) Number of bids	5	4	6	8	3
4) Number of winning auctions	161	128	147	159	37
5) Winning auctions (%)	91.5	76.2	84.5	90.3	60.7
6) Quantity asked (ISK)	2.4	1	1.3	1.6	0.8
7) Quantity asked to supply (%)	63.9	28.6	34.4	43.5	24.1
8) Quantity awarded (ISK)	1.6	0.8	1.1	1.2	0.9
9) Quantity awarded to supply (%)	35.9	21	25.6	30.9	20.2

1) Total number of auction days in which the primary dealers sent bids. 2) Number of securities issued for which the bidder bids at least once. The participation measured with auction days differs from the participation measured with security IDs. The difference is explained by the existence of reopening cycles and the fact that several securities can be auctioned on a single day. 3) Rounded average number of bids sent by the bidder across auction days. 4) Number of auction days in which the bidder is awarded at least one bond. 5) Number of winning auctions divided by total number of auctions. 6) Average security amount asked by auction in billions of Icelandic Krona (ISK). 7) Corresponds to Quantity asked (ISK) divided by the total supply of treasury securities. 8) Average security amount awarded by auction in billions of Icelandic Krona (ISK), conditional on winning at least one treasury security in the auction. 9) Corresponds to Quantity awarded (ISK) divided by the total supply of treasury securities.

Table 4: Underpricing Statistics

	Full period			Discriminatory method period			Uniform-price method period			ranksum test z-value
	N	Mean	Median	N	Mean	Median	N	Mean	Median	
Price space	385	2.72	3.78	153	7.86	4.73	232	-0.67	2.98	2.03**
Yield space	385	-1.81	1.72	153	15.14	2.99	232	-12.98	1.14	3.64***

This table reports summary statistics on the underpricing level (basis points) under the two auction methods. Underpricing in price space is measured as follows. Under the discriminatory method, this is the scaled difference between the secondary market price observed after the auction and the quantity-weighted average winning prices of the auction. Under the uniform-price method, the quantity-weighted average winning prices is replaced by the stop-out price. The secondary market price is the security closing day price recorded by the Nasdaq Nordic stock exchange. If no transaction were recorded in the secondary market on the auction day, we use the closest available closing price within the next five days instead. To calculate the underpricing in yield space, we extract yield-to-maturities from winning prices, stop-out prices and secondary market prices. In order to obtain an underpricing level in yield space consistent in sign with the underpricing level in price space, we compute secondary market yield minus quantity-weighted average winning yields (or stop-out yields). In the last column, the z-values are derived from Wilcoxon signed-rank tests. *, **, *** denote statistical significance at the 10%, 5%, and 1%, respectively.

Table 5: Regression Results

AUCTION_METHOD	-0.085***	-0.154***	-0.131***	-0.075**	-0.112***	-0.064*	-0.082**	-0.170**
	(0.029)	(0.059)	(0.035)	(0.031)	(0.035)	(0.033)	(0.039)	(0.071)
AUCTION_SIZE		0.107***						0.132***
		(0.021)						(0.026)
NB_BIDDERS		-0.029						-0.013
		(0.023)						(0.031)
REOP_CYCL_DUM		0.246***						0.100
		(0.064)						(0.083)
OPTION_DUM		-0.036						0.031
		(0.057)						(0.072)
BILL_BOND_DUM			0.195***					0.304***
			(0.044)					(0.075)
DISPERSION				2.614				-3.982
				(6.674)				(6.661)
BID_TO_COVER				0.028*				0.055***
				(0.017)				(0.014)
MKT_POWER				-0.291***				-0.199**
				(0.102)				(0.082)
MIN_TRADING_LOT					0.001			0.002***
					(0.001)			(0.001)
LEND_FAC					0.049***			0.003
					(0.011)			(0.015)
COMMISSION						-0.079**		-0.210**
						(0.037)		(0.084)
TREA_BOND_VOL							0.005	0.007
							(0.005)	(0.004)
5Y_SPREAD							-0.006	-0.002
							(0.015)	(0.016)
CONTROL_VAR	No	No	No	No	No	No	Yes	Yes
Number of obs.	385	385	385	381	380	374	369	365
Adjusted R^2	1.4	11.5	8.7	3.9	6.9	1.9	2.2	25.4

This table presents results from regressing underpricing on auction method and a set of explanatory variables. Underpricing is defined as the difference between the winning price observed at the end of the auction and the secondary market price. Under the discriminatory method, the winning price is the quantity-weighted average winning bid. Under the uniform-price method, it is the stop-out price. The secondary market price is the security closing day price recorded by the stock exchange Nasdaq Nordic. If no transaction were recorded in the secondary market on the auction day, we use the closest available closing price within the next five days instead. The explanatory variables are auction characteristics (column 3), security characteristics (column 4), bidding behavior (column 5), institutional rules (column 6 and 7), and market-level variables (column 8). On column 9, all control variables are included. Variables are defined in **Appendix 1**. Standard errors are reported in parentheses below the coefficients. Standard errors are adjusted for heteroscedasticity in the data (Huber-White correction). *, **, *** denote statistical significance at the 10%, 5%, and 1% level respectively.

Table 6: Regression Results- Robustness Measures

	Price space				Yield space			
	Raw underpricing		Adjusted underpricing		Raw underpricing		Adjusted underpricing	
AUCTION_METHOD	-0.085***	-0.170**	-0.058*	-0.147*	-0.281***	-0.528***	-0.124**	-0.329**
	(0.029)	(0.071)	(0.033)	(0.081)	(0.056)	(0.176)	(0.062)	(0.144)
AUCTION_SIZE		0.132***		0.145***		0.142***		0.182***
		(0.026)		(0.028)		(0.053)		(0.057)
NB_BIDDERS		-0.013		-0.036		-0.048		-0.085
		(0.031)		(0.034)		(0.065)		(0.071)
REOP_CYCL_DUM		0.100		0.114		0.213		0.354**
		(0.083)		(0.082)		(0.133)		(0.140)
OPTION_DUM		0.031		0.049		0.079		0.054
		(0.072)		(0.075)		(0.176)		(0.163)
BILL_BOND_DUM		0.304***		0.389***		0.352***		0.515***
		(0.075)		(0.080)		(0.135)		(0.141)
DISPERSION		-3.982		4.366		-12.680		-3.978
		(6.661)		(10.099)		(7.978)		(6.200)
BID_TO_COVER		0.055***		0.065***		0.026		0.050*
		(0.014)		(0.016)		(0.024)		(0.027)
MKT_POWER		-0.199**		-0.314***		-0.364**		-0.505***
		(0.082)		(0.093)		(0.165)		(0.192)
MIN_TRADING_LOT		0.002***		0.002**		0.005***		0.003
		(0.001)		(0.001)		(0.002)		(0.002)
LEND_FAC		0.003		-0.003		0.019		0.018
		(0.015)		(0.016)		(0.039)		(0.037)
COMMISSION		-0.210**		-0.189**		-0.428**		-0.255
		(0.084)		(0.089)		(0.186)		(0.235)
TREA_BOND_VOL		0.007		0.007*		0.005		0.010*
		(0.004)		(0.004)		(0.005)		(0.005)
5Y_SPREAD		-0.002		-0.011		0.038		-0.002
		(0.016)		(0.019)		(0.030)		(0.035)
CONTROL_VAR	No	Yes	No	Yes	No	Yes	No	Yes
Number of obs.	385	365	365	353	385	365	365	365
Adjusted R^2	1.4	25.4	0.3	31.6	5.1	20.7	0.6	23.8

We regress underpricing on auction method and a set of explanatory variables. Under "Price space", raw underpricing is defined as the difference between the winning price observed at the end of the auction and the secondary market price. Under the discriminatory method, the winning price is the quantity-weighted average winning bid. Under the uniform-price method, it is the stop-out price. The secondary market price is the security closing day price recorded by the Nasdaq Nordic stock exchange. If no transaction is recorded in the secondary market on auction day, we use the closest available closing price within the next five days instead. Adjusted underpricing is raw underpricing minus the daily price change of a matching security. The matching procedure is based on security type and maturity. See Section 5 for more details. Under "Yield space", underpricing is defined as the difference between the auction outcome yield and the secondary market yield. Yields are derived with the Newton-Raphson method. Explanatory variables are defined in the **Appendix 1**. Standard errors are reported in parentheses below the coefficients. Standard errors are adjusted for heteroscedasticity in the data (Huber-White correction). *, **, *** denote statistical significance at the 10%, 5%, and 1% level respectively.

Table 7: Regression Results- Excluding Financial Crisis Period

	Price space				Yield space			
	Raw underpricing		Adjusted underpricing		Raw underpricing		Adjusted underpricing	
AUCTION_METHOD	-0.143***	-0.245**	-0.131***	-0.306**	-0.325***	-0.650**	-0.191**	-0.797***
	(0.039)	(0.121)	(0.043)	(0.122)	(0.072)	(0.276)	(0.085)	(0.274)
AUCTION_SIZE		0.127***		0.151***		0.118*		0.172**
		(0.035)		(0.037)		(0.070)		(0.070)
NB_BIDDERS		-0.015		-0.025		-0.027		-0.081
		(0.033)		(0.034)		(0.066)		(0.070)
REOP_CYCL_DUM		0.126		0.211*		0.320*		0.538***
		(0.111)		(0.110)		(0.180)		(0.200)
OPTION_DUM		-0.070		-0.026		-0.146		-0.024
		(0.105)		(0.105)		(0.274)		(0.250)
BILL_BOND_DUM		0.364***		0.430***		0.519***		0.739***
		(0.092)		(0.097)		(0.179)		(0.195)
DISPERSION		-8.207		-16.493*		-14.768		-12.974
		(8.624)		(8.663)		(9.355)		(9.956)
BID_TO_COVER		0.043*		0.060**		0.012		0.038
		(0.023)		(0.026)		(0.044)		(0.044)
MKT_POWER		-0.170*		-0.240**		-0.248		-0.360*
		(0.095)		(0.107)		(0.192)		(0.218)
MIN_TRADING_LOT		0.002		0.002		0.007***		0.007**
		(0.001)		(0.001)		(0.003)		(0.003)
LEND_FAC		-0.003		-0.006		0.023		-0.004
		(0.021)		(0.022)		(0.052)		(0.052)
COMMISSION		-0.257**		-0.284**		-0.658**		-0.596*
		(0.129)		(0.138)		(0.296)		(0.352)
TREA_BOND_VOL		-0.008		-0.009		-0.009		-0.011
		(0.009)		(0.009)		(0.018)		(0.018)
5Y_SPREAD		0.066		0.082*		0.166**		0.196**
		(0.046)		(0.048)		(0.085)		(0.092)
CONTROL_VAR	No	Yes	No	Yes	No	Yes	No	Yes
Number of obs.	281	262	263	252	281	262	263	263
Adjusted R^2	4.3	23.4	2.8	30.8	6.6	21.7	1.4	29.3

We regress underpricing on auction method and a set of explanatory variables. The sample of auctions excludes the period September 2008 - August 2011. Under "Price space", raw underpricing is defined as the difference between the winning price observed at the end of the auction and the secondary market price. Under the discriminatory method, the winning price is the quantity-weighted average winning bid. Under the uniform-price method, it is the stop-out price. The secondary market price is the security closing day price recorded by the Nasdaq Nordic stock exchange. If no transaction is recorded in the secondary market on auction day, we use the closest available closing price within the next five days instead. Adjusted underpricing is raw underpricing minus the daily price change of a matching security. The matching procedure is based on security type and maturity. See Section 5 for more details. Under "Yield space", underpricing is defined as the difference between the auction outcome yield and the secondary market yield. Yields are derived with the Newton-Raphson method. Explanatory variables are defined in the **Appendix 1**. Standard errors are reported in parentheses below the coefficients. Standard errors are adjusted for heteroscedasticity in the data (Huber-White correction). *, **, *** denote statistical significance at the 10%, 5%, and 1% level respectively.

Appendix 1: Definition of Variables

By alphabetic order:

AUCTION_METHOD
A dummy variable that takes the value 1 for the auctions organized under the uniform-price method and the value 0 under the discriminatory method. The last T-bill (T-bond) auction under the discriminatory method took place on 09/11/2009 (03/20/2009). The first T-bill (T-bond) auction under the uniform-price method took place on 10/13/2009 (04/17/2009).

AUCTION_SIZE
Defined as the logarithm of the total values of bonds (Icelandic Krona) plus one.

BID_TO_COVER
It is defined as the total bid amounts sent by primary dealers to the auctioneer divided by the total face value of a security auctioned. A large value reflects a high level of competition between bidders and a success for the auctioneer.

BILL_BOND_DUM
A dichotomous variable taking the value 1 if the issued security is a Treasury bond and 0 for a Treasury bill.

COMMISSION
Commissions paid to primary dealers for their participation in the auctions, in logarithm. The total amount is provided in "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*", disclosed by the Central Bank of Iceland and renewed on a regular basis. Data from 2000 to 2018 are gathered into a table provided in **Appendix 2**.

CONTROL_VAR
This set is made with two variables: *ICEX_RTN* and *ICEX_VOL*.

DISPERSION
The auction-level dispersion is derived by summing the squared values of bidder-level dispersions. A bidder-level dispersion is the quantity-weighted standard deviation of a bidder bids.

ICEX_RTN
The 60-day return over the Iceland All Shares PI index.

ICEX_VOL
The 60-day return volatility over the Iceland All Shares PI index.

LEND_FAC
In 2001, the Central Bank of Iceland introduced a loan program for treasury bonds. This variable is the maximum amount loaned by treasury security by primary dealer. It is provided in "*Terms and Conditions for Securities Lending*", disclosed by the Central Bank of Iceland and renewed on a regular basis. Data from 2000 to 2018 are presented in **Appendix 2**.

MATURITY
The maturity, defined as the number of days between the issuance date and the redemption date, as a fraction of the year.

MIN_TRADING_LOT
Each primary dealer is obliged to propose a minimum trading lot to the counterparts. The minimum trading lot is provided in "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*", disclosed by the Central Bank of Iceland and renewed on a regular basis. Data from 2000 to 2018 are gathered into a table provided in **Appendix 3**.

MKT_POWER
Total T-bill or T-bond face values awarded to the largest winner in an auction, scaled by auction size.

NB_BIDDERS
It is the number of bidders submitting a couple price-quantity in the auction (competitive bids) or just quantity (non-competitive).

REOP_CYCLE_DUM
A dichotomous variable that takes the value 1 if the security issued in the auction has already been auctioned before, 0 otherwise.

OPTION_DUM
In June 2007, the Central Bank of Iceland decided to introduce an option that gives primary dealers the right, but not the obligation, to buy the equivalent of 10% of the nominal value sold in the auction, at the average price of accepted bids. This dummy variable takes the value 0 before June 2007 and 1 after.

UNDERPRICING
Underpricing is defined as the difference between the winning price observed at the end of the auction and the secondary market price. Under the discriminatory method, the winning price is the quantity-weighted average winning bid. Under the uniform-price method, it is the stop-out price. The secondary market price is the security closing day price recorded by the stock exchange Nasdaq Nordic. If no transaction were recorded in the secondary market on the auction day, we use the closest available closing price within the next five days instead. We also measure underpricing in yield space. Under the discriminatory method, underpricing is defined as the quantity-weighted average winning yields minus the secondary market closing day yield. Under the uniform-price method, underpricing is measured as the stop-out yield minus the secondary market closing day yield. Yields are derived with the Newton-Raphson method given a settlement date, a maturity date, a coupon rate, and day conventions of treasury securities.

TREA_BOND_VOL
Monthly average volatility on the treasury bond market. Bond volatility is computed with the prices of the issue RIKB 130517 from 05/21/2002 to 01/26/2011 and RIKB 310124 from 01/27/2011 to 03/28/2018. This variable lags by one month relative to the auction dates.

5Y_SPREAD
Difference between the 5-year Icelandic Treasury bond return and the 5-year German treasury bond index return extracted from Capital IQ.

Appendix 2: Commissions and Lending Facilities for Primary Dealers

Table A2.1: Commissions Paid to Primary Dealers

Beginning date	Ending date	Security	Commissions
06/01/2001	05/31/2002	Bonds	8.75
06/01/2002	05/31/2003	Bonds	112
06/01/2003	05/31/2004	Bills	55
06/01/2003	05/31/2004	Bills	112
06/29/2004	05/29/2006	Bills	52
06/01/2004	05/29/2006	Bonds	102
05/30/2006	05/31/2007	Bonds	160
06/01/2007	05/31/2008	Bonds	160
12/01/2008	05/31/2009	Bonds	160
06/01/2009	05/31/2010	Bonds	100
06/01/2010	05/31/2011	Bonds	110
06/01/2011	03/31/2012	Bonds	150
04/01/2012	03/31/2013	Bonds	180
04/01/2013	03/31/2014	Bonds	180
04/01/2014	03/31/2015	Bonds	180
04/01/2015	03/31/2016	Bonds	180
04/01/2016	03/31/2017	Bonds	180
04/01/2017	03/31/2018	Bonds	180

Level of commissions paid to primary dealers, in millions of Icelandic Krona. These data have been manually collected from the files "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*" disclosed by the CBI. Beginning dates and ending dates are dates when the agreement takes effect and when it expires, respectively. The numbers reported are the total amounts at all primary dealers' disposal. The fraction of these amounts earned by a primary dealer is equal to his share of total transactions recorded on the trading system during the first six months of the agreement. Commissions are paid on two dates.

Table A2.2: Maximum Loan Granted to Primary Dealers

Treasury bonds	Start	End	Loan
RIKB 07 0209	01/01/2001	03/19/2003	0.4
	03/20/2003	08/31/2004	1
	09/01/2004	06/19/2005	1
	06/20/2005	05/30/2006	1.2
	05/30/2006	02/09/2007	2
RIKB 08 0613	05/30/2006	01/04/2007	2
	01/05/2007	09/05/2007	3
	09/06/2007	01/30/2008	3
	01/31/2008	06/13/2008	5
RIKB 08 1212	05/30/2006	01/04/2007	2
	01/05/2007	09/05/2007	5
	09/06/2007	01/30/2008	3
	01/31/2008	05/12/2008	5
	05/13/2008	09/25/2008	7
	09/26/2008	12/12/2009	7
RIKB 09 0612	01/05/2007	09/05/2007	3
	09/06/2007	01/30/2008	3
	01/31/2008	05/12/2008	5
	05/13/2008	09/25/2008	7
	09/26/2008	10/07/2008	7
	10/08/2008	06/02/2009	8
	06/03/2009	06/12/2009	3
RIKB 10 0317	09/01/2004	06/19/2005	1
	06/20/2005	05/30/2006	1.2
	05/30/2006	01/04/2007	2
	01/05/2007	09/05/2007	3
	09/06/2007	01/30/2008	3
	01/31/2008	09/25/2008	5
	09/26/2008	10/07/2008	5
	10/08/2008	06/02/2009	8
	06/03/2009	03/17/2010	3
RIKB 10 1210	09/26/2008	06/02/2009	5
	06/03/2009	04/05/2010	3
	04/06/2010	05/13/2010	3
	05/14/2010	05/31/2010	5
	06/01/2010	12/10/2010	3
RIKB 11 0722	06/03/2009	04/05/2010	3
	04/06/2010	05/31/2010	3
	06/01/2010	12/09/2010	2
	12/10/2010	07/22/2011	5
RIKB 12 0824	06/01/2010	04/28/2011	1*
	04/29/2011	07/21/2011	2
	07/22/2011	08/24/2012	5
RIKB 13 0517	09/01/2004	06/19/2005	1
	06/20/2005	05/30/2006	1.2
	05/30/2006	01/04/2007	2
	01/05/2007	09/05/2007	3
	09/06/2007	01/30/2008	3
	01/31/2008	09/25/2008	5
	09/26/2008	06/02/2009	5
	06/03/2009	04/05/2010	3
	04/06/2010	05/31/2010	3
	06/01/2010	03/15/2012	3
	03/16/2012	08/23/2012	3
	08/24/2012	05/17/2013	5
RIKB 14 0314	03/09/2012	10/09/2012	1
	10/10/2012	03/14/2013	2
	03/15/2013	05/15/2013	2
	05/16/2013	03/14/2014	4
RIKB 15 0408	03/15/2013	07/09/2013	1
	07/10/2013	03/20/2015	2
	03/31/2015	04/08/2015	4

Maximum amount, in billions of Icelandic Krona, loaned by the CBI in each treasury security for each primary dealer. These data have been manually collected from the files "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*". Beginning dates and ending dates are dates when the agreement takes effect and when it expires, respectively. If the security reaches maturity before the agreement ends, the beginning date is replaced with the maturity date. *: in this series, the maximum amount loaned to each primary dealer is one billion ISK nominal value but rises to two billions when the size of the issue has reached 20 billions.

Table A2.3: Maximum Loan Granted to Primary Dealers (continued)

Treasury bonds	Start	End	Loan
RIKB 16 1013	06/01/2010	03/20/2015	1*
	03/31/2015	10/13/2016	1*
RIKB 17 0206	02/06/2015	11/24/2015	1
	11/25/2015	02/06/2017	2
RIKB 19 0226	01/31/2008	09/25/2008	5
	09/26/2008	06/02/2009	5
	06/03/2009	04/05/2010	3
	04/06/2010	05/31/2010	3
	06/01/2010	03/20/2015	1*
	03/31/2015	06/25/2017	1*
	06/26/2017	03/31/2018	1*
RIKB 20 0205	06/01/2010	03/11/2014	1
	03/12/2014	09/09/2014	1
	09/10/2014	03/30/2015	2
	03/31/2015	03/31/2018	1*
RIKB 22 1026	06/01/2010	03/20/2015	1*
	03/31/2015	06/25/2017	1*
	06/26/2017	03/31/2018	1*
RIKB 25 0612	06/03/2009	04/05/2010	3
	04/06/2010	05/31/2010	3
	06/01/2010	03/20/2015	1*
	03/31/2015	06/25/2017	1*
	06/26/2017	03/31/2018	1*
RIKB 28 1115	03/31/2015	01/25/2017	1
	01/26/2017	03/07/2017	1
	03/08/2017	03/31/2018	2
RIKB 31 0124	06/01/2010	03/20/2015	1*
	03/31/2015	06/25/2017	1*
	06/26/2017	03/30/2018	1*

Table A2.4: Maximum Loan Granted to Primary Dealers (continued)

Treasury bills	Start	End	Loan
All	01/01/2000	01/04/2006	0
	01/05/2006	01/04/2007	1
	01/05/2007	09/05/2007	3
	09/06/2007	01/30/2008	0
	01/31/2008	09/25/2008	5
	09/26/2008	06/02/2009	5
	06/03/2009	04/05/2010	3
	04/06/2010	03/31/2018	0
RIKV 07 0301	09/06/2007	01/30/2008	3
RIKV 07 0402	09/06/2007	01/30/2008	3

Appendix 3: Market making on the Secondary Market

Table A3.1: Minimum Trading Lot

Beginning date	Ending date	Securities	Minimum trading lot
06/01/2000	05/31/2001	Bonds	30
06/01/2000	05/31/2001	Bills	100
06/01/2001	05/31/2002	Bonds	50
06/01/2002	05/31/2003	Bonds	60
07/01/2003	05/31/2004	Bills	100
07/01/2003	05/31/2004	Bonds	60
06/01/2004	05/31/2005	Bills and bonds	100
05/30/2006	05/31/2007	Bills and bonds	100
06/01/2007	05/31/2008	Bills and bonds	100
12/01/2008	05/31/2009	Bills and bonds	50
06/01/2009	03/31/2018	Bills and bonds	100

Minimum trading lot, in millions of Icelandic Krona, that each primary dealer is obliged to submit for secondary market bids and offers, before the trading day opens. These data have been manually collected from the files "*Agreement Concerning Issuance of Treasury Securities and Market Making in the Secondary Market*".