Online Appendix for "Auction Mechanisms and Treasury Revenue: Evidence from the Chinese Experiment"

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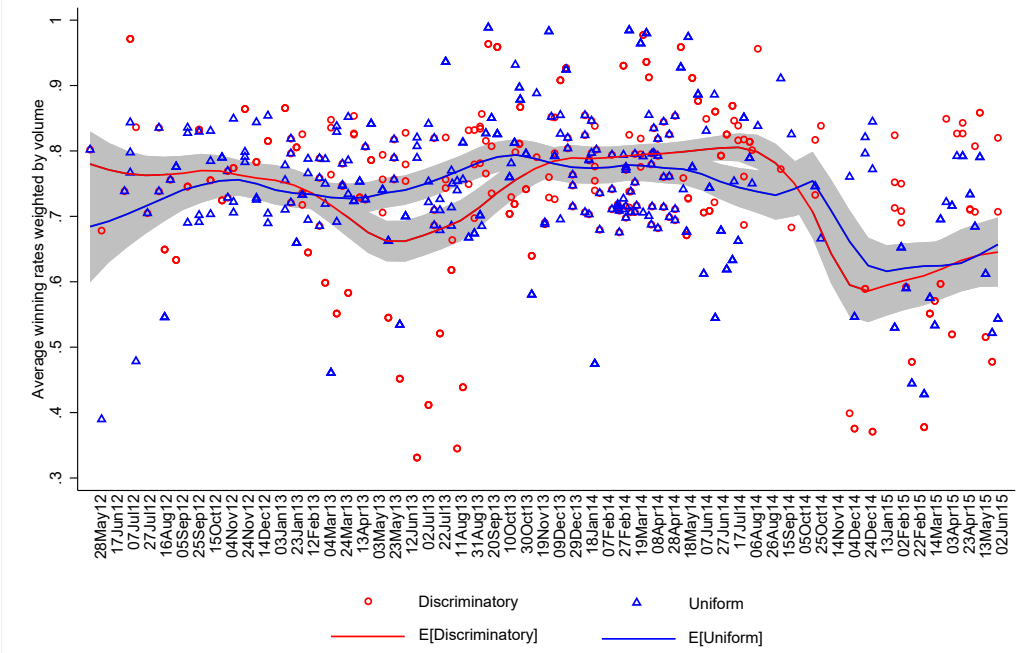
Online Appendix

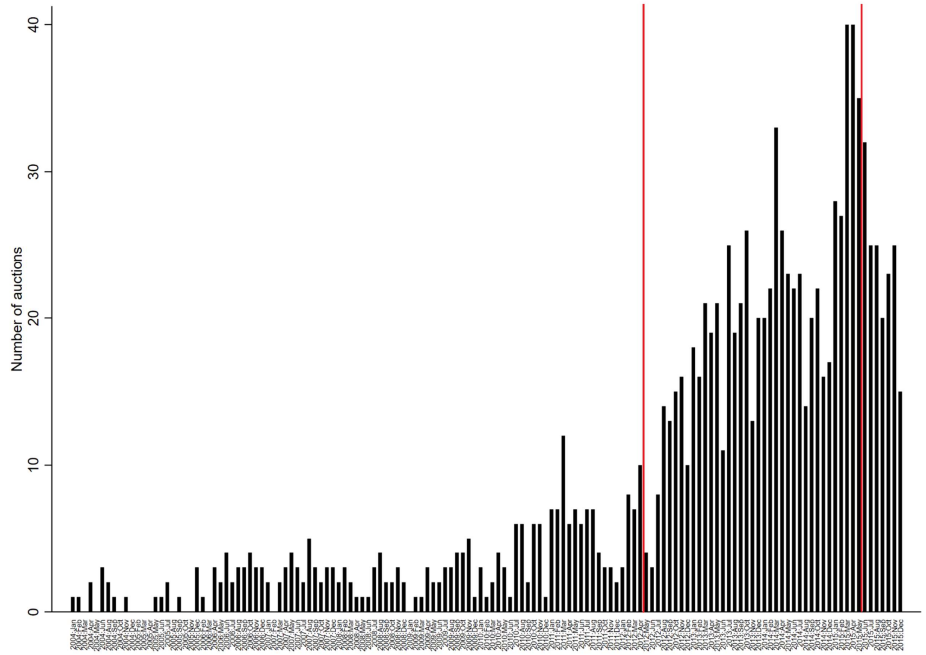
A.1 Extra Figures and Tables

Figure A.1: Normalized average winning rates by auction type



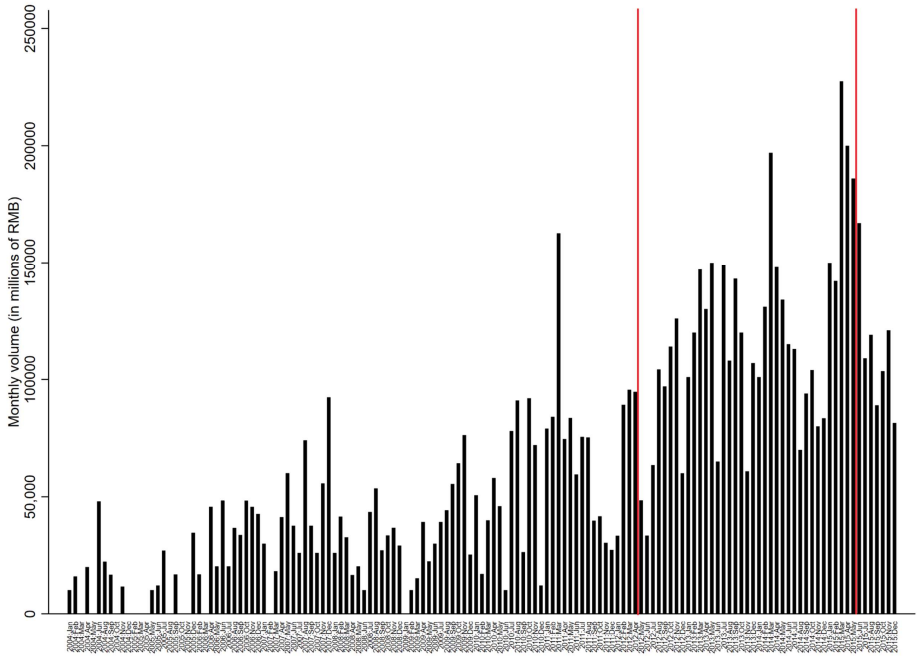
Notes: This figure plots the normalized volume-weighted average of winning rates by auction format by date during the experiment. The lines represent the expected winning rates by auction format estimated by a local polynomial mean with 95% confidence intervals.

Figure A.2: Frequency of auctions by month



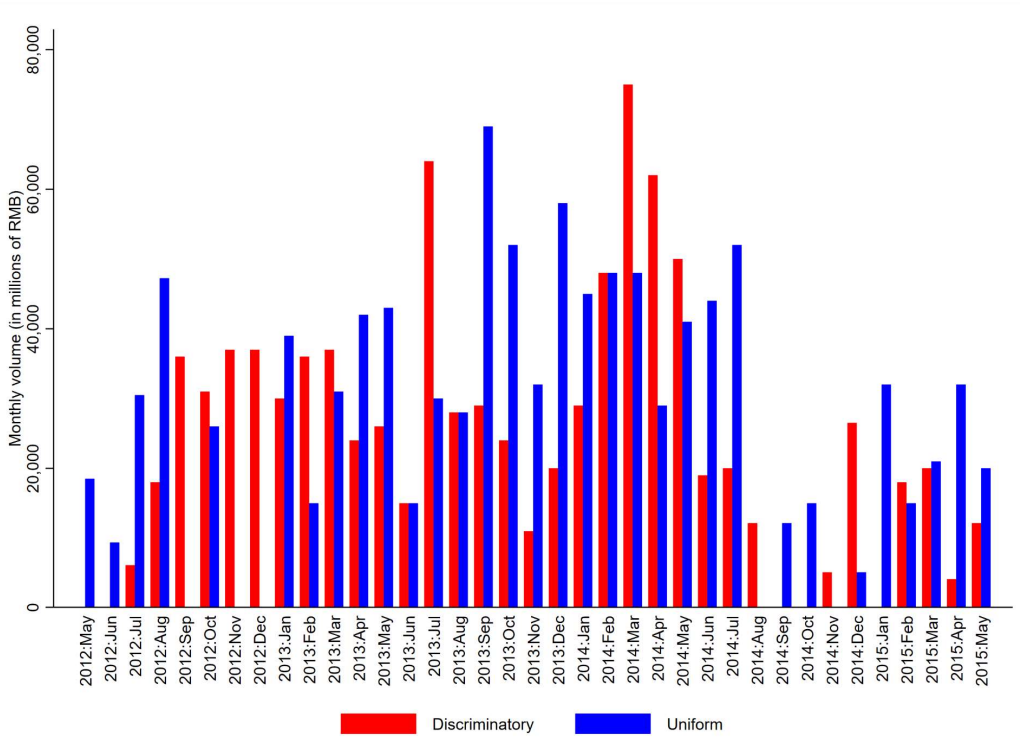
Notes: This figure plots monthly frequency of bonds issued from January 2004 to December 2015.

Figure A.3: Volume of bonds issued



Notes: This figure plots monthly volume of bonds issued from January 2004 to December 2015.

Figure A.4: Volume of bonds issued during the experiment



Notes: This figure plots monthly volume of bonds issued during the experiment (May 2012 - May 2015).

Table A.1: Chinese government and policy banks' security credit ratings

Year	Fitch			Moody's			Standard & Poor's		
	MOF	CDB	EIB	MOF	CDB	EIB	MOF	CDB	EIB
Panel A: Long-term									
2012	A+	A+	A+	Aa3	Aa3	Aa3	AA-	AA-	AA-
2013	A+	A+	A+	Aa3	Aa3	Aa3	AA-	AA-	AA-
2014	A+	A+	A+	Aa3	Aa3	Aa3	AA-	AA-	AA-
2015	A+	A+	A+	Aa3	Aa3	Aa3	AA-	AA-	AA-
Panel B: Short-term									
2012	F1	F1	F1	P-1	—	—	A-1+	A-1+	A-1+
2013	F1	F1	F1	P-1	—	—	A-1+	A-1+	A-1+
2014	F1	F1	F1	P-1	P-1	—	A-1+	A-1+	A-1+
2015	F1	F1	F1	P-1	P-1	—	A-1+	A-1+	A-1+

This table reports the long-term and short-term credit ratings awarded by Moody's, Standard Poor's, and Fitch to the Chinese government bonds issued by the Minister of Finance (MOF), the Chinese Development Bank (CDB) and the Export- Import Bank (EIB). If a rate was updated in the middle of a calendar year, the updated rate is listed. "—" denotes that no rate was given by a credit rating agency.

Table A.2: Example of alternating pattern for the CDB and EIB

Panel A: CDB			Panel B: EIB			
Date	Maturity in years	Auction mechanism	Date	Bond ID	Maturity in years	Auction mechanism
Jan 08, 2013	3, 5, 7	Discriminatory	Panel B.1: Alternating rule by date			
Jan 15, 2013	3, 5, 7	Uniform	Jul 31, 2013		2 (t)	Discriminatory (Uniform)
Jan 22, 2013	5, 7	Discriminatory	Aug 15, 2013		2 (t)	Discriminatory (Uniform)
	3	Uniform	Sep 24, 2013		2 (t)	Discriminatory (Uniform)
Jan 29, 2013	3, 5, 7	Uniform	Oct 21, 2013		2 (t)	Uniform (Discriminatory)
Feb 05, 2013	3, 5, 7	Discriminatory	Nov 04, 2013		2 (t)	Uniform (Discriminatory)
Feb 19, 2013	3, 5, 7	Uniform	Apr 11, 2014		3 (t)	Discriminatory (Uniform)
Apr 09, 2013	3, 7	Discriminatory	May 15, 2014		3 (t)	Uniform (Discriminatory)
	5	Uniform	May 23, 2014		3 (t)	Discriminatory (Uniform)
Apr 16, 2013	3, 5, 7	Uniform	Jun 06, 2014		3 (t)	Uniform (Discriminatory)
Apr 23, 2013	3, 7	Discriminatory	Panel B.2: Alternating rule by bond			
	5	Uniform	Nov 28, 2014	14 EXIM 78 (initial)	2	Discriminatory
May 07, 2013	3, 5, 7	Uniform	Dec 04, 2014	14 EXIM 78 (reissue)	2	Uniform
May 14, 2013	3, 7	Discriminatory	Dec 17, 2014	14 EXIM 78 (reissue)	2	Discriminatory
	5	Uniform	Apr 15, 2015	15 EXIM 09 (initial)	3	Uniform
May 21, 2013	3, 5, 7	Uniform	Apr 24, 2015	15 EXIM 09 (reissue)	3	Uniform
May 28, 2013	3, 7	Discriminatory	Apr 30, 2015	15 EXIM 09 (reissue)	3	Uniform
	5	Uniform	May 06, 2015	15 EXIM 09 (reissue)	3	Discriminatory
Jun 04, 2013	3, 5, 7	Uniform	May 13, 2015	15 EXIM 09 (reissue)	3	Discriminatory
Jun 18, 2013	3, 5, 7	Discriminatory	May 21, 2015	15 EXIM 09 (reissue)	3	Discriminatory
Jul 02, 2013	3, 5, 7	Discriminatory				
Jul 09, 2013	3, 5, 7	Uniform				
Jul 16, 2013	3, 5, 7	Discriminatory				
Jul 23, 2013	3, 5, 7	Uniform				
Jul 30, 2013	3, 5, 7	Discriminatory				

This table reports the stylized pattern of this alternating auction-rule experiment conducted by the CDB and EIB. Panel A shows that the auction mechanism alternated between discriminatory and uniform auction rules for CDB. Note that all bills (maturity less or equal to one year) and bonds (maturity) equal or more than 10 years) were sold using uniform. The alternating auction-rule experiment period for CDB was from May 2012 – July 2014. Panel B reports the stylized pattern of this alternating auction-rule experiment conducted by the EIB. The EIB conducted bi-weekly (or often much longer interval) auctions, held typically on Fridays, usually with two to four different maturities. The EIB alternated the two different auction rules for different maturities (Panel B.1 – Alternating auction rule by date) and, in the latter half of the experimental period, the institution used the two auction rules on the same type of bond when reissuing (Panel B.2 – Alternating auction rule by bond type). The alternating auction-rule experiment period for CDB was from July 2013 – May 2015. The index t in the upper panel denotes other maturity in years that were auctioned off in the same day.

Table A.3: Description of the variables

Variable	Description
Discriminatory auctions	This variable takes the value one when the auction format is discriminatory and zero when the auction mechanism is uniform.
Floating bonds	The floating bonds variable is a binary indicator, which is equal to one if an auction is for floating bond, zero otherwise. Note that all of the floating bonds are sold through the uniform-price format only.
Market yield of Chinese bonds one day before the auction date	This variable is the publicly announced yield curve rates by the CCDC. Each business day, the CCDC publicly announces the yield curves for bonds issued by the CDB and EIB by maturity, which are based on previous resale market transactions. These yield curves provide official benchmarks to general investors. The CCDC constructs the official yield curve mainly using settlement prices of government bonds in the inter-bank market. When they are unavailable, the CCDC uses bilateral quotes in the inter-bank market, bilateral quotes in the OTC market, transaction prices in the exchange market, quotes and final prices in fixed income platform of the exchange market, quotes of money broking corporations, and the estimated value of yield rate from market members.
Duration	The duration variable refers to Macaulay duration, which is the weighted average term to maturity of the cash flows from a bond. A similar duration variable is used by Simon (1994).
Bid-to-cover ratio	This variable is the ratio of the total amount of submitted bid quantities for securities divided by supply (allotment) volume. This variable controls the strength of demand and the degree of competitions in an auction. A similar measure is used by Cordy (1999) and Goldreich (2007). In our sample, total submitted bid quantities was always more than the allotment.
Lag time between auctions	This variable measures the business days since the last auction held by an institution.
Value of maturing bonds by institution for a given month	This is the sum of face values, which the issuer has to pay in a specific month. This variable controls the possibility that financial institutions may recycle their liquidity obtained through matured securities to bid for new issuance.
Number of bidders	This is the number of bidders in an auction.
CDB	This variable is a binary indicator variable that takes the value of one when auctions are let by the CDB and zero otherwise.
First and last week of the month	This indicator variable is equal to one if the auction date takes place seven days before or seven days after the end of the month, and equal to zero otherwise.
Market drift	This variable is constructed by counting the number of weeks since the start of the experiment by dividing each week by the number of total weeks in which the CDB and EIB conducted their market experiment. Simon (1994) notes that a market-drift variable controls for gradual unobservable changes that bidders face during the market experiment period. Although a model of long-term relationships with dynamic trade-offs is beyond the scope of this study, other studies point out that a repeated auction environment can sustain a variety of strategies in equilibria (see e.g., Skrzypacz and Hopenhayn, 2004) , and this time-shifting variable parsimoniously controls for potential gradual changes in long-term interactions among bidders, regardless of the auction formats.

Table A.4: Results for normalized rate in the first– and second–half of the experiment

Variable	Normalized rate			
	OLS		Bayesian	
	First–half	Second–half	First–half	Second–half
	(1)	(2)	(3)	(4)
Panel A: All auctions				
Discriminatory auction	-0.021	0.009	-0.021	0.002
	[-0.184, 0.142]	[-0.090, 0.109]	[-0.121, 0.084]	[-0.074, 0.075]
Floating bond	-0.765	0.160	-0.753	0.134
	[-1.055, -0.475]	[-0.342, 0.662]	[-0.864, -0.646]	[0.023, 0.243]
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	148	200	148	200
R^2	0.524	0.547		
Log marginal likelihood			-201.260	-158.042
Panel B: Without floating bonds				
Discriminatory auction	-0.032	0.015	-0.018	-0.003
	[-0.102, 0.038]	[-0.085, 0.114]	[-0.057, 0.017]	[-0.075, 0.056]
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	104	197	104	197
R^2	0.879	0.567		
Log marginal likelihood			-37.590	-136.970

This table reports OLS and Bayesian regressions for the normalized rates auctioned off in the first– and the second–half of the experiment. In all Columns, we control for all auction format, other auction, and market controls in addition to floating bonds, monthly effects, year effects, market drift, and bond-issuer fixed effects as in Table 2 Column 3 and 6. In Columns 1 and 2, 95% confidence intervals calculated based on robust standard errors are in brackets and in Columns 3 and 4, 95% credible intervals are in brackets.

Table A.5: Results for number of bidders during the experiment

Variables	Number of bidders			
	All auctions		Without floating bonds	
	PPML	OLS	PPML	OLS
	(1)	(2)	(3)	(4)
Discriminatory auction	-0.008	-0.019	-0.024	-0.687
	(0.026)	(0.982)	(0.026)	(1.018)
Second half	-0.074	-2.194	-0.162***	-5.242**
	(0.053)	(1.854)	(0.055)	(2.036)
Second half × Discriminatory auctions	0.011	0.114	0.032	0.934
	(0.030)	(1.114)	(0.031)	(1.159)
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	348	348	301	301
R^2	0.576	0.590	0.606	0.616

This table presents the estimates for the number of bidders in an auction, controlling auction type, institutions, market conditions, the time gap between auctions by institutions, bid-to-cover ratio, and institution effects which are denoted by auction and market controls. Additionally, we have included month effects, year effects, and market drift. Robust standard errors are in parentheses.

Table A.6: Bidder behavior in uniform auctions during and after the experiment

Variable	All auctions		Without floating bonds	
	Number of bidders	Normalized Winning rate	Number of bidders	Normalized Winning rate
	(1)	(2)	(3)	(4)
After (12 months)	-0.001	-0.111	0.054	-0.026
	(0.026)	(0.080)	(0.021)	(0.059)
Floating bond	-0.061	-0.549		
	(0.037)	(0.122)		
Market yield of Chinese bonds one day	-0.075		-0.040	
before the auction date	(0.024)		(0.024)	
Other controls	Yes	Yes	Yes	Yes
Observations	359	359	309	309
R^2	0.393	0.391	0.450	0.357

This table presents the estimates for the number of bidders and normalized winning in auctions controlling for after experiment period, institutions, market conditions, time gap between auctions by institutions, bid-to-cover ratio, institution effects, and all other market and time controls. The Columns 1 and 3 are estimated using the Poisson Pseudo Maximum Likelihood (PPML) method and Column 2 and 4 are estimated using OLS. Robust standard errors are in parentheses.

Table A.7: Results for normalized rates with highest and lowest discriminatory auction rates

Variable	Normalized rate			
	OLS		Bayesian	
	Highest	Lowest	Highest	Lowest
	(1)	(2)	(3)	(4)
Panel A: All auctions				
Discriminatory auction	0.028	-0.007	0.029	0.003
	[-0.053, 0.110]	[-0.089, 0.074]	[-0.035, 0.090]	[-0.050, 0.063]
Floating bond	-0.491	-0.497	-0.485	-0.483
	[-0.727, -0.256]	[-0.733, -0.260]	[-0.556, -0.416]	[-0.583, -0.385]
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	348	348	348	348
R^2	0.499	0.492		
Log marginal likelihood			-269.235	-281.385
Panel B: Without floating bonds				
Discriminatory auction	0.022	-0.015	0.031	-0.007
	[-0.058, 0.102]	[-0.095, 0.066]	[-0.016, 0.079]	[-0.052, 0.036]
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	301	301	301	301
R^2	0.480	0.481		
Log marginal likelihood			-162.473	-165.701

This table reports OLS and Bayesian regressions of normalized rates with highest and lowest discriminatory auction bids. Our dependent variables is the auction-specific normalized highest (Columns 1 and 3) and the lowest (Columns 2 and 4) winning rate on a given date. In all columns, we control for auction format, other auction, and market characteristics in addition to month effects, year effects, market drift, and bond-issuer fixed effects. In Columns 1-2, 95% confidence intervals calculated based on robust standard errors are in brackets while in 3-4, 95% credible intervals are in brackets.

Table A.8: Quantile regression results for normalized rates

Variable	Normalized rate				
	Quantile				
	0.15	0.25	0.50	0.75	0.85
Panel A: All auctions					
Panel A.1: With weighted averages of discriminatory auction winning rates					
Discriminatory auction	-0.008	-0.051	-0.037	-0.029	-0.030
	(0.060)	(0.053)	(0.032)	(0.030)	(0.035)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	348	348	348	348	348
R^2	0.417	0.327	0.263	0.337	0.406
Panel A.2: With highest discriminatory auction winning rates					
Discriminatory auction	0.014	-0.016	-0.011	-0.014	-0.008
	(0.059)	(0.059)	(0.027)	(0.030)	(0.040)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	348	348	348	348	348
R^2	0.418	0.328	0.265	0.340	0.407
Panel A.3: With lowest discriminatory auction winning rates					
Discriminatory auction	-0.027	-0.042	-0.036	-0.047	-0.060
	(0.059)	(0.045)	(0.033)	(0.039)	(0.033)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	348	348	348	348	348
R^2	0.417	0.325	0.260	0.336	0.403
Panel B: Without floating bonds					
Panel B.1: With weighted averages of discriminatory auction winning rates					
Discriminatory auction	-0.046	-0.042	-0.038	-0.046	-0.039
	(0.054)	(0.040)	(0.033)	(0.029)	(0.034)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	301	301	301	301	301
R^2	0.264	0.225	0.337	0.453	0.519
Panel B.2: With highest discriminatory auction winning rates					
Discriminatory auction	-0.013	-0.026	-0.022	-0.019	-0.014
	(0.055)	(0.045)	(0.032)	(0.028)	(0.029)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	301	301	301	301	301
R^2	0.258	0.250	0.335	0.453	0.519
Panel B.3: With lowest discriminatory auction winning rates					
Discriminatory auction	-0.064	-0.045	-0.046	-0.048	-0.059
	(0.056)	(0.040)	(0.033)	(0.029)	(0.031)
All controls	Yes	Yes	Yes	Yes	Yes
Observations	301	301	301	301	301
R^2	0.264	0.254	0.333	0.453	0.518

This table reports quantile regressions for the 15^{th}, 25^{th}, 50^{th}, 75^{th} and 85^{th} quantiles of the normalized rates. Panel A considers the full sample, an Panel B includes only the non-floating bonds. In Panel A.1 and B.1, the dependent variables are the normalized auction-specific weighted-average winning rate. In Panel A.2, A.3, B.1 and B.2, the dependent variables are the normalized auction-specific highest and lowest discriminatory auction winning bids respectively in addition to normalized uniform auction bids. All controls include auction format, other auction, and market controls in addition to floating bonds, monthly effects, year effects, market drift, and bond-issuer fixed effects as in Table 2, Column 3. Bootstraped standard errors are in parentheses.

Table A.9: Regression results for normalized rates by institution

Variable	Normalized rate					
	OLS			Bayesian		
	CDB		EIB	CDB		EIB
	(1)	(2)	(3)	(4)	(5)	(6)
Discriminatory auction	0.001	-0.020	-0.008	0.018	-0.012	-0.017
	[-0.099, 0.100]	[-0.111, 0.071]	[-0.078, 0.061]	[-0.062, 0.100]	[-0.075, 0.049]	[-0.057, 0.025]
Floating bond	-0.451			-0.417		
	[-0.700, -0.202]			[-0.504, -0.325]		
Auction and market controls	Yes	Yes	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes	Yes	Yes
Monthly and year effects	Yes	Yes	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes	Yes	Yes
Observations	269	222	79	269	222	79
R^2	0.511	0.545	0.880			
Log marginal likelihood				-237.193	-165.631	-56.380

This table reports results for normalized rates by institution. We estimate the models presented in Table 2, Columns 3 and 6, by institution. In Columns 1, 2, 4 and 5 we present the results for the CDB with and without floating bonds. In Column 3 and 6, we report the results for the EIB. Models in Column 1 and 3, we include floating bond dummy. In all columns, we control for auction format, auction, and market characteristics in addition to month effects, year effects, market drift, and bond-issuer fixed effects. In Columns 1-3, 95% confidence intervals calculated based on robust standard errors are in brackets and in Columns 4-6, 95% credible intervals are in brackets.

Table A.10: Regression results controlling for within-day variation

Variable	OLS		Bayesian		PPML	OLS
	Normalized		Normalized		Number of bidders	
	Winning rate	Worst rate	Winning rate	Worst rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Discriminatory auction	0.071	0.060	0.042	0.029	0.013	0.412
	[-0.025, 0.167]	[-0.070, 0.191]	[-0.020, 0.104]	[-0.036, 0.096]	(0.016)	(0.539)
Auction and market controls	Yes	Yes	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes	Yes	Yes
Date effetcs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	168	168	168	168	168	168
R^2	0.757	0.758				0.774
Log marginal likelihood			85.275	77.182	-467.676	

This table reports results for normalized rates and the number of bidders for the within-day exercise. Models in Columns 1 and 3 provide the results winning rates, and Columns 2 and 4 reports the results for worst bids. In Columns 5 and 6, we report the results for the number of bidders. In Columns 1 through 4, we include date fixed effects. In all columns, we control for auction format, bond-issuer effects, volatility, bid-to-cover ratio, the time lag between auctions, number of bidders, and value of maturing bonds by the institution that vary with a day and/or by auction. In Columns 1, and 2, 95% confidence intervals calculated based on robust standard errors are in brackets and in Columns 3 and 4, 95% credible intervals are in brackets. The regressions in Columns 4 and 5 report robust standard errors in parentheses.

Table A.11: Regression results for normalized rates: alternate specification

Variable	Normalized rate			
	OLS		Bayesian	
	(1)	(2)	(3)	(4)
Discriminatory auction	0.012	0.003	0.014	0.007
	[-0.071, 0.095]	[-0.078, 0.084]	[-0.052, 0.078]	[-0.040, 0.051]
Floating bond	-0.576		-0.548	
	[-0.808, -0.344]		[-0.591, -0.501]	
Reissued bond	-0.116	-0.096	-.0936	-0.099
	[-0.232, -0.001]	[-0.190, -0.002]	[-0.165, -0.029]	[-0.152, -0.049]
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Monthly and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	348	301	348	301
R^2	0.499	0.489		
Log marginal likelihood			-277.547	-169.586

This table reports results for normalized rates while controlling for reissue bonds (alternate specification). In Columns 1 and 3 we present the results with floating bonds. In Column 2 and 4, we report the results without floating bonds. In all columns, we control for auction format, auction, and market characteristics in addition to month effects, year effects, market drift, and bond-issuer fixed effects. In Columns 1 and 2, 95% confidence intervals calculated based on robust standard errors are in brackets and in Columns 3 and 4, 95% credible intervals are in brackets.

A.2 Complementary analysis: Auction formats and bidder types

In this section of the Appendix, we perform a series of statistical tests to examine if there is statistical evidence of bidder types selecting into auction formats. These tests analyze the worst bidder type (marginal valuation), the average submitted bid quantities for securities, the average allotment per bidder, and the primary dealers' secondary-market debut-day return and examine whether they do or do not statistically vary with auction format. Together, as we show next, they indicate that an insignificant statistical revenue difference between uniform and discriminatory auctions is not driven by a selection of types in an auction format. However, as mentioned in Section 2.1 in the paper, note that there is an important institutional feature in the CDB and EIB Treasury auctions that restrain bidders from strategically picking the auctions and the auction format that suit them better.

Marginal valuation of the worst bidder type. Theoretical results from auction models with endogenous entry (Samuelson, 1985; Marmera et al., 2013; Gentry and Li, 2014) show that the marginal valuation (type) of the worst entering bidder in an auction characterizes the equilibrium entry behavior. These results indicate that the types of bidders in two different auctions are the same (no selection of bidders' type) if the pool of potential bidders and the marginal valuation of the worst bidders (lowest bidder type) are the same in both formats. In this spirit, we examine whether the marginal valuation of the worst bidder (lowest type) is the same in both auction mechanisms. The preceding analysis starts investigating whether bidder types select into an auction, given the pool of pre-qualified primary dealers–potential bidders–are the same in both auction formats.

To evaluate whether the marginal valuation of the lowest bidder types are the same in both auction formats, we rely on the theoretical results in Ausubel et al. (2014). Focusing on the modeling framework of their Proposition 1 and Theorem 1, Ausubel et al. (2014) describe the bidder's bidding strategy in the uniform auction. They precisely show that, if a bidder has a positive probability of influencing the price in a situation where the bidder wins a positive quantity, then the bidder has incentives to shade her/his bid. However, if a bidder cannot be pivotal for small quantities (which could happen with a large number of bidders), then s/he bids her/his expected values for them. If the same bidder is pivotal with positive probability for large quantities, then s/he shades her/his bid for such quantities. In a similar vein, Kastl (2011) and Hortacsu, Kastl and Zhang (2018) show that, whenever there is a positive probability of the market clearing price (rate) being below (above) her/his bid, a bidder's bid will be higher than her/his marginal valuation for the corresponding quantity.

Note that the market clearing price (rate) in a uniform auction will never be below (above) the worst losing bid. Therefore, based on Kastl (2011), Ausubel et al. (2014) and Hortacsu, Kastl and Zhang (2018), the bidder of a worst losing bid in a uniform auction optimally sets a bid that corresponds to her/his marginal valuation. From their results, one can conclude that the worst losing bid in a uniform auction for Treasury securities corresponds to the true marginal valuation of a bidder for the corresponding quantity.

Next, in Proposition 2 of the same paper, Ausubel et al. describe the bidder's bidding strategy in the discriminatory auction that is characterized in their Equation (6). From an inspection of Equation (6), one can also conclude that the worst losing bid in a discriminatory auction for Treasury securities corresponds to the true marginal valuation of a bidder as well. Therefore, based on Ausubel et al.'s (2014) results, one can conclude that the worst losing bids in both auction formats indicate the true marginal valuation of a bidder for the corresponding quantity.

Following these results, we empirically investigate whether the worst losing bid rates are not statistically different across auction formats. If the worst losing bid rates are not statistically different, it implies that the marginal valuation of worst losing bidder types are the same in uniform and discriminatory auctions. This is because the demand for a given bond (the submitted bid quantities) are statistically equal in both auction formats, as shown below in the section "*Submitted bid quantities for securities*". Note that, in the context of Treasury auctions, in which a bid consists of a step demand function represented by pairs composed by a bid rate and amount of securities, the worst losing bid is the highest bid rate in an auction.

To compare the worst losing bid rates in uniform and discriminatory auctions, we consider the empirical model described in equation (2) using the normalized worst losing bid rate as a dependent variable. Table A.12 reports the estimated parameters based on the sample containing only all bonds (Columns 1 and 2) and non-floating bonds (Columns 3 and 4) using OLS and Bayesian estimation methods and two different samples. (The table is presented below as well.) OLS results are presented in Columns 1 and 3 of Table A.12 while Bayesian results are presented in Columns 2 and 4. Our OLS results indicate that normalized worst losing bid rates are not statistically different between uniform and discriminatory auctions. In our OLS results, the point estimates range from 0.000 to 0.008 percent depending on the empirical specification. The results from Bayesian models indicate that our estimated coefficients of the dummy variable that capture the difference in the worst losing bid rates in the two auctions are not statistically significant, with point estimates ranging from 0.022 to 0.032. This empirical exercise reveals that the worst losing bidder's type is not statistically

different in uniform and discriminatory auctions. This empirical exercise on the worst losing bidder's type, combined with the fact that the pool of pre-qualified primary dealers are the same in both auction formats, and the statistical equality of number of bidders in both formats, provides our first set of results suggesting that there is no bidder type selection into auction formats.

Additionally, we examine the robustness of normalized worst rates results to investigate the differences of these outcomes just before and after the experiment using uniform auctions during the experiment period and 12 months later. Our results indicate that the normalized worst rates from uniform auctions were not statistically different during and after the experiment period (See Table A.13).

Although our results provide supporting evidence that bidders do not select into auction formats, they should be interpreted cautiously as the foundations of our empirical strategy were inspired by theoretical findings for single-unit auction models (Samuelson, 1985; Marmera et al., 2013; Gentry and Li, 2014). However, note that, to the best of our knowledge, bidder entry behavior is still a developing area in multi-unit auction models. Hence, the characterization of the equilibrium entry behavior in a multi-unit auction is still an open question in the auction literature. Given the relevance of this subject, we believe that it is an interesting path for future research on the topic.

Submitted bid quantities for securities. We also examine whether the total submitted bid quantities for securities normalized by supply (bid-to-cover ratio) and the total submitted bid quantities (total demand) varies with auction format. After controlling for market conditions, the submitted bid quantities for securities in an auction reveals information about bidders' appetite for these debt instruments, which turns out to unveil information about the type of bidders that are ultimately acquiring these securities in an auction. Hence, if the bid-to-cover ratio as well as the total submitted bid quantities for securities does not vary with the auction format, it also suggests that the bidder types are likely to be the same in both auction formats. Note that the total submitted bid quantities corresponds to the end-points of the demand schedule.

To compare the bid-to-cover ratio and the total submitted bid quantities in uniform and discriminatory auctions, we consider a similar empirical model described in equation (2). In Panel A of Table A.14, we show the estimated parameters for bid-to-cover ratio based on the sample containing all bonds (Columns 1-3) and only non-floating bonds (Columns 4-6) using OLS estimation methods. Our results indicate that the bid-to-cover ratio is not statistically different between uniform and discriminatory auctions in all specifications. In Panel B, we

report the findings for total submitted bid quantities. They are also not statistically different between the auction formats.[1] This shows that the end-points of the demand schedule are not statistically different between uniform and discriminatory auctions.

Average allotment per bidder. Further, we investigate the average submitted bid quantities for securities and allotment per bidder between auction formats. Here also, our results indicate that the average submitted bid quantities and average allotment per bidder are statistically not different between the two auction mechanisms.[2]

Primary dealers' secondary-market return. Finally, we examine whether the short-term returns of primary dealers, measured by the difference between primary and secondary market returns on the debut-day (the initial secondary market trading day in which a given security is allowed to be resold), vary with auction format.[3] In this analysis, the primary dealer's return is defined as the difference between the yield of a bond acquired in a primary market auction minus the yield of the same bond sold in a secondary market transaction.[4] That corresponds to the primary dealers' actual debut-day return in the secondary market, as it is based on primary-to-secondary transaction data. The primary-secondary market return is a matter of interest to primary dealers in China as primary dealers buy to make markets. During the market experiment period, we observe that they sold about 95% of the bonds they acquired in the primary auctions a few days later, on the debut-day. (See Barbosa et al., 2020 for more details on that.) Therefore, any statistical difference in the secondary-market debut-day return of primary dealers (that could be explained by the auction format) would also unveil a selection on bidder types in an auction format.

In Table A.15, we report the effect on auction format on the primary-to-secondary return of primary dealers. Our estimations indicate that the secondary-market debut-day measurement of primary dealers' short-term returns are statistically not different in uniform and discriminatory auctions in all specifications. This also indicates that primary bidders are indifferent between the two auction mechanisms as they yield the same returns, further supporting our

[1] These point-estimates are about 3 percent of the total submitted bid quantities.

[2] The average mean of submitted bid quantities for securities per bidder for uniform auctions was 39,302.85 [37,595.87, 41,009.83] while, for discriminatory auctions, it was 38,985.95 [37,707.27, 40,224.63]. Similarly, the average mean of the allotment per bidder for uniform auctions was 16,627.91 [15,915.53, 17,340.30] while, for discriminatory auctions, it was 38,985.95 [15,524.70, 16,611.93]. All values are in ¥ 10,000 and 95 percent confidence intervals are in parentheses.

[3] Dealers are strictly prohibited from having resale trades (of auctioned securities) before the bond's debut day, typically five days after an auction.

[4] A bond's yield is defined as the discount rate that makes the present value of all of the bond's cash flows equal to its agreed price.

main regression outcome.

Summary. In a nutshell, the above empirical tests show that the lowest type (marginal valuation), the average submitted bid quantities for securities, the average allotment per bidder, and the primary dealers' secondary-market debut-day return do not statistically vary with auction format. These statistical tests, to an extent, successfully eliminated possible type selection patterns.

We would also like to re-emphasize that these non-statistical differences in various exercises are in line with practitioners' views of the market. Regardless of no-profitability-difference or institutional background reason, the results did not reveal any statistical evidence of dealers selecting into different formats. Consequently, the market experiment we study is quite advantageous to measure the effects of the auction mechanism: in addition to the (bi-)weekly alternating rule advantage, we also have a similar pool of bidders in both auction formats, which further supports the otherwise equivalent market environment in our main regression analyses.

Table A.12: Results for worst losing rates

Variables	Normalized worst rate			
	All auctions		Without floating bonds	
	OLS	Bayesian	OLS	Bayesian
	(1)	(2)	(3)	(4)
Discriminatory auction	0.008	0.032	-0.0003	0.022
	[-0.080, 0.097]	[-0.045, 0.122]	[-0.089, 0.088]	[-0.023, 0.070]
Floating bond	-0.458	-0.397		
	[-0.691, -0.226]	[-0.453, -0.327]		
Auction and market controls	Yes	Yes	Yes	Yes
Institution effects	Yes	Yes	Yes	Yes
First and last week of the month	Yes	Yes	Yes	Yes
Month and year effects	Yes	Yes	Yes	Yes
Market drift	Yes	Yes	Yes	Yes
Observations	348	348	301	301
R^2	0.576	0.590	0.606	0.616
Log marginal likelihood		-311.033		-177.206

All regressions include log of duration, log of bid-to-cover ratio, volatility, log of time lag between auctions by institution, log value of maturing bonds by institution for a given month, and log number of bidders. In OLS estimates, 95% confidence intervals calculated based on robust standard errors are in brackets and in Bayesian estimates, 95% credible intervals are in brackets.

Table A.13: Bidder behavior in uniform auctions during and after the experiment

Variables	Normalized worst rate	
	All auctions	Without floating bonds
	(1)	(2)
After (12 months)	0.005	0.104
	(0.087)	(0.065)
Floating bond	-0.552	
	(0.123)	
Other controls	Yes	Yes
Observations	359	309
R^2	0.386	0.332

This table presents the estimates for the normalized worst rates in auctions controlling for after experiment period, institutions, market conditions, time gap between auctions by institutions, bid-to-cover ratio, institution effects, and all other market and time controls. All models are estimated using OLS. Robust standard errors are in parentheses.

Table A.14: Relation between bid-to-cover ratio, submitted bid quantities and auction format

Variables	All bonds			Without floating bonds		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Bid-to-cover ratio						
Discriminatory auction	-0.043	0.040	0.030	-0.105	0.048	0.041
	(0.079)	(0.093)	(0.096)	(0.095)	(0.094)	(0.097)
Floating bond		0.031	-0.175			
		(0.132)	(0.141)			
Bank effects	No	Yes	Yes	No	Yes	Yes
Year and month effects	No	Yes	Yes	No	Yes	Yes
Market drift	No	Yes	Yes	No	Yes	Yes
Other variables	No	No	Yes	No	No	Yes
Observations	348	348	348	301	301	301
R-squared	0.001	0.160	0.202	0.004	0.186	0.232
Panel B: Submitted total bid quantities						
Discriminatory auction	48,839.761	51,149.832	50,396.770	66,898.273	50,289.752	45,862.608
	(42,662.788)	(51,683.729)	(53,588.759)	(45,460.939)	(51,459.393)	(53,365.247)
Floating bond		44,754.909	-48,090.852			
		(84,721.548)	(86,290.515)			
Bank effects	No	Yes	Yes	No	Yes	Yes
Year and month effects	No	Yes	Yes	No	Yes	Yes
Market drift	No	Yes	Yes	No	Yes	Yes
Other variables	No	No	Yes	No	No	Yes
Observations	348	348	348	301	301	301
R-squared	0.004	0.155	0.193	0.007	0.171	0.219

This table reports OLS results for bid-to-cover ratio (Panel A) and submitted total bid quantities (Panel B). We use an indicator variable (Discriminatory auction) which takes the value of one when auction format is discriminatory and zero otherwise. In Column 1-3, we use all bonds while in Columns 4-6 we present results without floating bonds. Robust standard errors are in parentheses.

Table A.15: Regression results for market gap during the alternating-rule experiment

Variable	Primary rate – secondary rate				
	(1)	(2)	(3)	(4)	(5)
Panel A: All auctions					
Discriminatory auction	-0.043	-0.050	-0.042	-0.049	-0.050
	(0.033)	(0.034)	(0.033)	(0.034)	(0.034)
Floating bond	-0.791	-0.799	-0.792	-0.800	-0.801
	(0.089)	(0.087)	(0.089)	(0.087)	(0.087)
Log number of bidders	0.350	0.341	0.350	0.341	0.342
	(0.169)	(0.164)	(0.170)	(0.165)	(0.166)
Lag of days between primar market and	-0.036	-0.045	-0.034	-0.042	-0.038
secondary market	(0.045)	(0.046)	(0.044)	(0.046)	(0.047)
Log of trading volume on the previous month	-0.099	-0.122	-0.096	-0.119	-0.119
	(0.041)	(0.044)	(0.041)	(0.044)	(0.044)
Volatility	0.392	0.115	0.516	0.289	0.301
	(0.655)	(0.664)	(0.701)	(0.706)	(0.711)
Volatility of FTSE bank index at the day before		4.758		4.908	4.983
secondary market		(2.212)		(2.218)	(2.229)
Government yield gap between primary auction			0.092	0.135	0.142
date and day before the secondary market			(0.153)	(0.154)	(0.155)
Log value of maturing bonds by institution for a					0.007
given month					(0.010)
Institution effects	Yes	Yes	Yes	Yes	Yes
Month & year effects	Yes	Yes	Yes	Yes	Yes
Observations	348	348	348	348	348
R^2	0.553	0.559	0.553	0.560	0.560
Panel B: Without floating bonds					
Discriminatory auction	-0.042	-0.040	-0.041	-0.039	-0.038
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Other controls as in Panel A	Yes	Yes	Yes	Yes	Yes
Observations	301	301	301	301	301
R^2	0.484	0.485	0.486	0.487	0.487

This table reports the OLS results for the market gap between uniform and discriminatory auction formats during the alternating experiment period. All explanatory variables are similar as Table 2. Two policy banks, CDB and EIB, conducted auction experiment from 2012 to 2015. The experiment period of CDB is between May 2012 and July 2014, while the experiment period of EIB is between July 2013 and May 2015. Robust standard errors are in parentheses.