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Inventory Capacity and Corporate Bond Offerings

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Inventory Capacity and Corporate Bond Offerings

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Abstract

We study how underwriters' inventory capacity effects the initial allocation, pricing and trading of corporate bond offerings. We theoretically show that a decrease in aggregate inventory capacity incentivizes those underwriters having access to relationship investors to excessively allocate bonds to them. In exchange, relationship investors obtain increased underpricing and resell their excessive holdings in the secondary market. Using an instrumental variable we empirically show that, through the relationship channel, the post-crisis drop in inventory capacity leads to a simultaneous increase in underpricing and customer sales. Our results suggest that a lowering of inventory imposes a negative externality on bond issuers.

JEL-Classification: G12, G32

Keywords: U.S. corporate bond market, underwriter, inventory, initial allocation, underpricing, trading of newly issued bonds, underwriter-investor relationships

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Investors aren't being treated equally.

Jeffery Elswick, Frost Investment Advisors, Bloomberg 2014-03-04

1 Introduction

Underwriters play a central role in the corporate bond market. They provide placement services to issuers and shape the initial allocation of bonds across investors. Moreover, they act as dealers in the secondary market and intermediate bonds between customers. U.S. corporate bonds trade in an over-the-counter (OTC) market, where the ability of dealers to hold inventory is synonymous with liquidity provision to issuers and investors alike. In this paper, we provide a first investigation of how the inventory capacity of underwriters effects the initial allocation of corporate bonds, and thus their pricing and post-issuance trading activity.

There are two important reasons to examine the role of inventory capacity for corporate bond offerings. First, underwriters' dual role (i.e., placing bonds at issuance and acting as a dealer in the secondary market) could give rise to an agency conflict that results in allocations that increase the issuance costs for firms. In fact, there is some anecdotal evidence that, post-crisis, investors complain about having only restricted access to new issuances.[1] Second, the existing literature exclusively examines the implications of inventory frictions in the secondary market. Specifically, recent studies (e.g., Bessembinder, Jacobsen, Maxwell, and Venkataraman, 2018; Friewald and Nagler, 2018) document that dealers are less willing to hold inventory, post-crisis, potentially due to tighter regulation. As a result, Choi and Huh (2018) and Anand, Jotikasthira, and Venkataraman (2018) further find that liquidity provision has partly moved to the non-dealer sector.

To begin understanding the role of dealer inventory for corporate bond offerings, we

[1]The opaqueness of the issuance process is recently discussed by The Credit Roundtable (2015). Levin (2014) and Abramowicz, Mead, and Robinson (2014) discuss that in 2014 the SEC started an investigation against Goldman Sachs and Citigroup. The aim of the investigation is to determine whether they gave preferential treatment to certain investors in some bond offerings. There is also some anecdotal evidence of a post-crisis increase in the cost of issuing bonds (see, e.g., discussions by Alloway, 2016, on Bloomberg).

propose a theory that links inventory capacity to the initial allocation of bonds across investors. In the model, which builds on Green (2007), a decrease in aggregate inventory capacity incentivizes those underwriters having access to relationship investors to excessively allocate bonds to them. This effect arises because underwriters want to secure intermediation in the secondary market of newly issued bonds. In other words, they outsource the lost inventory capacity to relationship investors as they are more likely to trade with them. In turn, relationship customers accept the excessive holdings because they are rewarded through increased underpricing–an increased differential between the secondary market price and the offering price.

The model has two main testable predictions. First, underpricing increases in the post-crisis period, when aggregate inventory capacity is low, because underwriters with access to relationship customers allocate disproportionate amounts of bonds to them. Second, these relationship investors sell their excess holdings in the secondary market and thus generate additional selling activity. Consequently, the "relationship channel" leads to a simultaneous increase in underpricing and customers sales, post-crisis, for those bond offerings that are underwritten by a syndicate with strong customer relationships.

We test these predictions by combining transactions data from the Trade Reporting and Compliance Engine (TRACE), quarterly holdings data of institutional investors from Lipper-eMAXX and underwriter information from the Mergent Fixed Income Securities Database (FISD). Our sample comprises 5,172 corporate bond offerings of non-financial firms and 39 underwriters over the period from 2003 to 2013. Controlling for several variables at the bond, issuer and underwriting syndicate level, we document that underpricing and customer sales of bond offerings are indeed higher in a period when dealers are inventory-constrained. That is, we find that underpricing increases by 43 basis points (bps) and customer sales volume by 3.9% from the pre- to the post-crisis period.[2] These figures

[2] We measure underpricing as the relative differential between the secondary market price and the

imply that, post-crisis, the average bond offering generates $2.4 million less in proceeds for the issuer and customer sales volume is higher by close to $22 million.

In the main part of the empirical analysis we indeed show that, post-crisis, the relationship channel explains the simultaneous increase in underpricing and customer sales. The identification of the relationship channel confronts us with two main challenges. First, we do not observe the true initial allocation but holdings data at a quarterly frequency. Second, we do not observe in which bond offerings the initial allocation is more affected by the relationship channel. To identify the relationship channel, we thus need a source of cross-sectional variation in the strength of underwriter-customer relationships that affects underwriters' decision to allocate bonds to relationship investors.

To address these issues we use an instrumental variables approach. We propose using the concentration of institutional investors' past holdings of underwriters' own bonds as an instrument for the strength of underwriter-investor relationships. The underlying identification assumption is that underwriters that place their own bonds with a concentrated set of institutional investors have stronger relationships. They should thus be more likely to use them, post-crisis, when aggregate inventory capacity is low. Our instrument likely satisfies the exclusion restriction. There is no reason to assume that the concentration of underwriters' own bonds directly effects the fundamental values of bond offerings of non-financial issuers. The instrument therefore effects underpricing and selling activity only indirectly via underwriters' decision to allocate bonds to relationship investors.

Consistent with our model, we find that the relationship channel is only present in the post-crisis period, that is, when aggregate inventory capacity is low. The average post-crisis increases in underpricing and customer sales are thus related to bond offerings underwritten by syndicates that are more likely to have access to relationship investors. Our two-stage least squares (2SLS) estimates are economically sizeable. Specifically, the

offering price adjusted by the market return over five days after issuance. Similarly, sales are defined as the cumulative customer sale volume relative to the offering amount over five days after issuance.

results imply a 39 bps and 5.2% increase in underpricing and customer sales, respectively, for an allocation of 10% of a bond's notional to relationship investors. A Wald-test suggests that a 30% to 35% allocation to relationship customers completely explains the average post-crisis increase in underpricing and customer sales. These are plausible magnitudes given that institutional investors hold on average 44% of a bond in our data.

We run an array of robustness tests and additional analyses to corroborate our findings. First, we validate the strength of our instrument. Here, we employ a placebo test by randomly assigning bond offerings to underwriters. As expected, the randomized instrument does not work, suggesting that our previously employed identification approach indeed captures significant variation across underwriters in their decision to allocate bonds. We further examine alternative definitions of relationships, and we show that our results are robust over a different estimation horizon for underpricing and customer sales.

An additional concern could be that time-variation in the control variables effects underpricing and customer sales, post-crisis, in the same direction as implied by the mechanism of the relationship channel. To address this point we factor out any time-variation in our control variables and find that our previously obtained results remain highly robust. That is, our findings are not explained by time-variation in bond characteristics (i.e., time to maturity, coupon and bond size) and initial public offerings (IPO). Further, they are not driven by changes in the pricing of credit risk, changes in industry characteristics and by changes in the structure of underwriting syndicates (i.e., changes in competition).

Our findings suggest that, following a drop in aggregate inventory capacity, the dual role of underwriters creates an agency conflict that imposes a negative externality on corporate bond issuers in the form of lower issuance proceeds. To further support this claim, we exploit the fact that underwriters are themselves issuers of bonds and construct a separate sample of 601 bond offerings of the underwriters in our sample. We find that neither underpricing nor customer sales increase, post-crisis, for underwriters' own bonds. This result indicates that the uncovered relationship channel might indeed result from an agency conflict as underwriters can avoid higher underpricing.

Existing research (e.g., Goldstein, Jiang, and Ng, 2017; Choi and Kronlund, 2017) documents that mutual funds substantially increase their holdings in corporate bonds, post-crisis, due to reaching for yield behavior. Hence, we exclude the possibility that changes in the composition of investor types affect our results. That is, we show that the post-crisis increase in underpricing and customer sales are not driven by mutual fund holdings. Overall, our article opens a discussion of the effect of inventory capacity on the incentives of underwriters in shaping the initial allocations across investors, and their impact on pricing and trading of corporate bond offerings.

In investigating how underwriters' inventory capacity effects corporate bond offerings, we differ from other studies that examine initial pricing and trading. Datta, Iskandar-Datta, and Patel (1997) empirically show that underpricing is more pronounced among speculative-grade bonds, while Cai, Helwege, and Warga (2007) argue that underpricing arises due to informational as opposed to liquidity frictions. Helwege and Wang (2017) show that mega-bonds exhibit higher underpricing compared to smaller issues. Brugler, Comerton-Forde, and Martin (2019) elaborate on the impact of post-trade transparency, due to mandatory reporting to TRACE, on underpricing. Goldstein, Hotchkiss, and Pedersen (2019) examine the impact of measures of expected secondary market liquidity on the offering price, and Goldstein, Hotchkiss, and Nikolova (2019) study dealer behavior and trading in newly issued corporate bonds.[3]

Our article is further distinct from studies that examine underpricing in the equity market.[4] Specifically, the mechanism that we analyze does not play out in an environment

[3] The initial pricing of fixed-income securities has also been studied in the municipal bond market (Green, Hollifield, and Schürhoff, 2007), as well as recently in the syndicated loan market (Bruche, Malherbe, and Meisenzahl, 2018). None of these studies examines how inventory frictions effect the allocation, pricing and trading of newly issued securities.

[4] Welch (1989), Allen and Faulhaber (1989), Booth and Chua (1996) or Liu and Ritter (2011), among

where primary and secondary markets are separated. While equity underwriters place stocks to investors in the primary market, they are not dealers in the secondary market, which is organized through centralized exchanges. In the corporate bond market instead, underwriters act as dealers in the secondary market as well; thus, the initial allocation matters because it determines their future shares of secondary market intermediation. Moreover, due to the OTC structure of this market, the trading between counterparties occurs on a bilateral basis. Hendershott, Li, Livdan, and Schürhoff (2017) and Di Maggio, Kermani, and Song (2017) indeed show that relationships between dealers and investors effect the prices in the secondary market.

Finally, we further differ from studies that focus on market making in the secondary market and post-crisis implications. Trebbi and Xiao (2017), Anderson and Stulz (2017), Schultz (2017), Bao, O'Hara, and Zhou (2018), Goldstein and Hotchkiss (2019) and Dick-Nielsen and Rossi (2019) examine the time-varying liquidity provision of dealers. These studies generally conclude that, post-crisis, liquidity is more sensitive to dealer constraints.

2 Why does inventory capacity matter for corporate bond offerings?

In this section, we discuss institutional features in the issuance process of corporate bonds that give rise to frictions that are distinct from other markets (e.g., equities). We then start to theoretically investigate how underwriters' inventory capacity effects the initial allocation, and thus equilibrium pricing and trading, of bond offerings. We use the framework to derive testable predictions for our empirical analysis.

others, theoretically study equity underpricing. Empirically, Beatty and Ritter (1986), Ruud (1993), Brennan and Franks (1997), Corwin (2003), Cliff and Denis (2004), Liu and Ritter (2004), Ellul and Pagano (2006), Chambers and Dimson (2009), Massa and Zhang (2012) or Fu, Lyandres, and Li (2018), among others, investigate the determinants of equity underpricing.

2.1 Institutional background

The issuance process in the U.S. corporate bond market is opaque and does not follow the standard book building process used in equity offerings (Ritter and Welch, 2002, provide a detailed discussion). Instead, investment banks have a dual role, that is, they act as underwriters at issuance of a bond as well as dealers in the secondary market. Generally, the structure of the issuance process is as follows: Underwriters buy the bond from the issuer at the offering price net of fees, which is the effective amount of financing the firm receives. They then allocate a fraction of the bond at the offering price to investors, where they are free in choosing the initial allocation. They keep the remaining part of the bond on their own inventories and sell it later on in the secondary market.[5]

Hence, underwriters have two main decisions to make. First, how much they want to keep in their own inventories. For this decision, the inventory constraint of the dealer matters. As discussed before, while this constraint is not a concern in the pre-crisis period, when dealer inventories are high, the landscape changes significantly in the post-crisis period. Second, underwriters must decide how to allocate the bond across investors. In making this decision, underwriters consider the impact of the allocation on their share of intermediation in the secondary market, which represents a great part of their revenues.[6] Here, due to the OTC nature of the market, the underwriter prefers to allocate the bond to an investor that generates more volume in the secondary market. Subsequently, we present a theory that features the key institutional aspects of corporate bond offerings.

[5]The opaqueness and lack of standardization of the issuance process of corporate bonds has been discussed, among others, in Levin (2014).

[6]According to Gandel (2014), Goldman Sachs generated in 2013 around $2.4 billion from underwriting practices and $8.7 billion from intermediation in the secondary market of fixed-income instruments.

2.2 A theory of corporate bond allocation

To link the inventory capacity of dealers to the allocation of newly issued bonds we build on the framework of Green (2007). That is, we study two underwriters i and j that act as dealers in the secondary market of corporate bonds. Each dealer has a limited inventory capacity denoted by S. The inventory is used to reach investors with high valuations, $\bar{p}$, in the secondary market. The dealers have monopoly access to these investors. Instead of distributing the bonds through their inventories to the secondary market, underwriters can directly place the bonds with institutional investors that have lower valuations. There are two institutional investors: a relationship customer, x, and a non-relationship customer, y. Specifically, they differ in the likelihood of trading with the underwriter in the secondary market.[7] The relationship customer uses the underwriter with probability, p, while the non-relationship customer has a probability of $q < p$.

Underwriters compete in the price space for getting the bond of size K from an issuer. They place the part of the issue they get, denoted by Q_h with $h = \{i, j\}$, in the secondary market. If Q_h exceeds their inventory capacity, S, they allocate the remaining part to institutional investors, that is, they offer them $Q_h - S = X_h + Y_h > 0$. Here, X_h and Y_h are the amounts offered by underwriter h to the relationship and non-relationship customer, respectively. We assume that $X + Y = X_i + Y_i + X_j + Y_j = K - 2S > 0$, which implies that some amount must be sold to institutional investors even if underwriters split the issue equally. Hence, dealers cannot fully distribute the new issue through their inventories to the secondary market.

Underwriters purchase the bond at the offering price, b. They place the amount in excess of their capacity, $K - 2S$, to institutional investors. The institutional price for the

[7] We do not model the microfoundations of trading relationships. Hendershott, Li, Livdan, and Schürhoff (2017) and Di Maggio, Kermani, and Song (2017) empirically document the existence of trading relationships in the U.S. corporate bond market.

relationship customer is given by

$$I_x = \begin{cases} n & X_i + X_j \leq \bar{Q} \\ n - \lambda & X_i + X_j > \bar{Q} \end{cases} \tag{1}$$

and, similarly, we define the institutional price for the non-relationship customer by I_y. We assume that $n \geq \lambda$, so that the price cannot be negative. The institutional price is perfectly elastic up to a threshold $\bar{Q}$, which is the target amount of the bond that the institutional investor wants to hold in the portfolio. That is, any institutional investor requires a premium, λ, for entering an excessive position, which she is likely to sell later on in the secondary market. Overall, in this setup there are two departures from the original model of Green (2007). First, we differentiate between a relationship and a non-relationship customer. Second, the institutional price is not infinitely elastic in the size of the offer.

Dealers charge a commission, θ, for intermediation in the secondary market. Thus, the profit that an underwriter earns from winning a part of the offering is:

$$\Pi(b, Q_h) = \begin{cases} (\bar{p} - b)Q_h & Q_h \leq S \\ (\bar{p} - b)S + (I_x - b)X_h + (I_y - b)Y_h + I_{\{X_h \geq \bar{Q}\}} p\theta + I_{\{Y_h \geq \bar{Q}\}} q\theta & Q_h > S \end{cases} \tag{2}$$

This implies that for $p, q > 0$, the underwriter internalizes the commission, θ, arising if relationship and non-relationship customers are holding an excessive position that they are likely to sell in the secondary market. We focus on situations in which the relationship channel could be beneficial for underwriters, that is, we assume $\lambda(K - S) < p\theta$.

Any allocation that absorbs the entire issue $Q_i + Q_j = K$ is *feasible*. The underwriter that offers the highest price gets the entire issue. They compete with each other in a Bertrand game, taking into account the issuer's response in their strategies. An *equilibrium* is defined as a set of bid prices and quantities $\{b_i^*, b_j^*, Q_i^*, Q_j^*\} = \{b_i^*, b_j^*, X_i^*, X_j^*, Y_i^*, Y_j^*\}$

such that the allocation is *feasible*, no underwriter has an incentive to change the bid, and profits are nonnegative. Hence, the underwriter takes into account the bid of the other underwriter and the issuer's response. Formally, the following conditions must be met in equilibrium:

$$\begin{cases} Q_i + Q_j = K \\ \Pi(b^*, Q_h^*) \geq \Pi(b^* + \epsilon, K) & \text{for } \epsilon > 0,\ h = \{i, j\} \\ \Pi(b^*, Q_h^*) \geq 0 & h = \{i, j\} \end{cases} \tag{3}$$

We define underpricing as the differential between the secondary market price and the offering price, $\bar{p} - b^*$. We further define abnormal customer sales in the secondary market as the unwinding of excessive positions of institutional investors, given by the expression $\sum_h \left[(X_h^* - \bar{Q}) I_{\{X_h^* > \bar{Q}\}} + (Y_h^* - \bar{Q}) I_{\{Y_h^* > \bar{Q}\}} \right]$. In the subsequent discussion, we focus on the equilibrium effects that guide our empirical analysis. We delegate proofs to Appendix A.

2.3 Model equilibria and empirical implications

We want to investigate how a drop in dealers' inventory capacity effects the initial allocation of bonds, and thus underpricing and trading activity. We consider therefore levels of high inventory capacity, S^H, and low inventory capacity, S^L. We think of these capacities as the one prevailing in the pre-crisis, S^H, and post-crisis period, S^L, respectively. Specifically, we describe the regime shift from the pre-crisis to the post-crisis period by the following conditions:

Pre-crisis. In this period, inventory capacities are large. We assume $K - S^H < \bar{Q}$, that is, none of the two investors requires a premium and the institutional price is equal to n. We are therefore in the original setup of Green (2007).

Post-crisis. In this period, inventory capacities are small. We describe the post-crisis regime by assuming $\frac{K-2S^L}{2} < \bar{Q} < K - 2S^L$. This condition implies that the amount of the issue exceeding the inventory capacity could be above the target holding of any of the institutional investors. In this case, underwriters' intermediation commission, θ, and institutional investors' premium, λ, will be triggered. However, if the amount is split equally among the relationship and non-relationship investor then none of them reaches the target, $\bar{Q}$. This assumption implies that relative to the pre-crisis period the inventory capacity is more than halved, that is, $2S^L < S^H$, which corresponds well to figures reported in the literature (e.g. Randall, 2015).

In Table 1 we present the equilibrium outcomes under the above conditions for the initial allocation, underpricing and selling activity. For the discussion, we focus on the most profitable equilibria and consider two different scenarios. In Panel A, we examine the equilibria in the presence of the relationship customer, that is, we assume that $0 < q < p$. In Panel B, however, we shut down the relationship channel and assume that $0 < q = p$. In this way, we see how a drop in inventory capacity affects the allocation depending on the existence of the relationship customer. Hence, one can think of Panels A and B as two different underwriting syndicates that vary in their access to a relationship investor.

TABLE 1 ABOUT HERE

In Panel A the allocation to the relationship and non-relationship customer is different in the pre-crisis compared to the post-crisis period. In the pre-crisis period, the relationship and non-relationship investor equally share the amount in excess of underwriters' capacity, $\frac{K-2S^H}{2} < \bar{Q}$. However, in the post-crisis period, the relationship investor receives the entire amount in excess of underwriters' capacity, $K - 2S^L > \bar{Q}$. This allocation triggers the premium, λ, and underpricing increases from the pre-crisis to the post-crisis period. Moreover, the excessive position, post-crisis, of the relationship investor results in additional selling activity of $K - 2S^L - \bar{Q} > 0$.

The above allocation arises in equilibrium because the low inventory capacity, post-crisis, implies that underwriters can reach fewer investors in the secondary market with high valuations, $\bar{p}$, which would lower underwriters' profits. They then start to internalize the expected commission in the secondary market and trade it off against the lower institutional price. While allocating the entire amount in excess of their capacity to the relationship investor triggers the premium, λ, and results in a low price, $n - \lambda$, this strategy maximizes underwriters' expected commission in the secondary market.

In contrast, in the absence of the relationship channel in Panel B, underpricing and selling activity do not change in response to the drop in inventory capacity. In both periods, the amount in excess of underwriters' inventory capacity is split equally between the two customers. The reason is that underwriters' expected commission in the secondary market is too low to justify the triggering of the premium, λ.

The results show that a decrease in inventory capacity can have a different impact on the allocation and thus on underpricing and trading activity. The impact depends on the relationship channel. That is, there is an increase in both underpricing and in selling activity if the relationship customer is available. The unwinding of relationship customer's excessive holdings obtained at bond issuance generates the selling activity. Contrary, in the absence of the relationship customer, there is no change in underpricing and trading activity. These insights have two main implications: A drop in aggregate inventory capacity leads to (i) an increase in underpricing and simultaneously to (ii) an increase in customer sales, if relationship customers are accessible. When empirically studying the dynamics of bond offerings from the pre-crisis to the post-crisis regime, it is thus important to account for variation in access to relationship customers across underwriters.

3 Empirical analysis

In this section, we empirically investigate how aggregate inventory capacity affects the initial allocation, pricing and trading of corporate bond offerings through the relationship channel. We first define our main measures and describe the dataset used in the analysis. We further discuss our identification strategy of the relationship channel and show the main results. Finally, we present an array of robustness tests.

3.1 Definition of underpricing and customer sales

3.1.1 Underpricing

We define underpricing, UP, as a bond's average return relative to the offering price in excess of the market return. Specifically, UP of a bond issued on day k, over n days after issuance, is given by:

$$UP = \frac{1}{n} \sum_{s=0}^{n} \left[\frac{P_{k+s} - OP}{OP} - \frac{M_{k+s} - M_{k-1}}{M_{k-1}} \right] \tag{4}$$

OP is the offering price of the bond, P_{k+s} is the volume-weighted transactions price on day $k+s$ including the accrued interest. Depending on the issuers credit rating, M_{k+s} is the value of the Bloomberg-FINRA investment-grade or speculative-grade corporate bond index, respectively, on day $k+s$. We calculate underpricing for $n \in [5, 10]$ days. In our main tests we use $n = 5$.

3.1.2 Customer sales

We define sales, $SALE$, as the cumulative customer sales volume scaled by the amount issued of the bond within $n \in [5, 10]$ days after issuance. Again, we use $n = 5$ days after issuance for our main tests.

3.2 Data

We make use of several databases to establish our findings. First, we use the TRACE database to obtain transactions data including prices and volumes of the underlying bonds. We apply standard filters as for Dick-Nielsen (2014) to clean the data. We obtain bond characteristics and underwriter information from the Mergent FISD. We retrieve information on investors' quarterly corporate bond holdings from Lippers eMAXX fixed-income database (see Dass and Massa, 2014; Becker and Ivashina, 2015, for a detailed descriptions). Moreover, we download the FINRA corporate bond indices from Bloomberg.

Our dataset covers bond issuances from the beginning of 2003 to the end of 2013. We consider three sub-periods and follow Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) in defining the pre-crisis period from January 2003 to June 2007, the crisis period from July 2007 to April 2009, and the post-crisis period from May 2009 to December 2013. We match bond characteristics from Mergent FISD with bond trades from TRACE by using the CUSIP code. We exclude financial bonds (SIC codes 6000–6999) and consider only corporate debentures (bond type 'CDEB') with fixed coupons. We further exclude small bonds with an amount issued of less than $10 million or bonds with a maturity at issuance above 30 years. In total, we end up with 5,172 corporate bond offerings.

For each bond, we are able to identify every agent that participates in the offering and its corresponding role (e.g., lead underwriter, underwriter, financial agent). We focus on the leading underwriter of the issue and, whenever bonds have multiple lead underwriters we consider the entire syndicate. We exclude underwriters from the sample that have participated in fewer than 25 corporate bond offerings over our sample period. In this way rather inactive underwriters do not affect the results. In total, we have 39 unique lead underwriters in our sample. The median bond is issued through a syndicate that consists of two underwriters.

We further match our sample with quarterly bond holdings from eMAXX by using the CUSIP identifier. At the end of each quarter we know for each bond the identity of institutional investors' funds that hold the bond and how much of the offering amount is in their portfolios. We aggregate all institutional holdings at the bond level and construct the measure $INST$, which is the fraction of a bond's offering amount held by institutional investors at the end of the issuance quarter.[8] We further know the type of each fund reported in the dataset. For additional tests, we construct the fraction of a bond's offering amount held by mutual funds, MUT, at the end of the issuance quarter.

Our empirical identification strategy requires us to identify underwriters' own issued bonds. Mergent FISD does not provide a unique identifier that links underwriters to their own bonds. We therefore manually match each underwriter in our sample with its bonds, using the underwriter and issuer name available in the databases. Moreover, we use eMAXX to estimate measures of the ownership structure of each underwriter's own bonds. We can identify 14,986 bonds that are issued by the underwriters in our sample.[9] To the best of our knowledge, we are the first to link explicitly corporate bond transactions, bond holdings and underwriter information in a database.

Table 2 about here

In Table 2 we describe the detailed construction of the control variables and provide the descriptive statistics of our sample in Table 3. The average value of UP is 75 bps with a standard deviation of 96 bps. The average value of $SALE$ is 12% (standard deviation is 12%). The percentage of a bond's offering amount held by institutional investors at the end of the issuance quarter, $INST$, is 44%. The average fraction of a bond held by mutual funds, MUT, is 13%. The average bond amount issued is \$566 million with a maturity at

[8] Our holdings data are both at the fund and firm level, meaning that if an investor (e.g., Blackrock) has multiple corporate bond funds, we know all the single holdings of each of them. In our analysis, we work at the fund level, but results do not change if we aggregate the data at the fund-family level.

[9] Note that our main sample includes only non-financial bonds. Hence, there is no overlap with underwriters' own bonds.

issuance of 12 years. The average coupon is 5.5% of face value and the rating is close to 9, which corresponds to one notch above the speculative-grade threshold.

TABLE 3 ABOUT HERE

3.3 *UP* and *SALE* with low and high inventory capacity

Our aim is to investigate how the low inventory capacity, post-crisis, impacts corporate bond offerings relative to the pre-crisis period where inventory capacity is high. We therefore run the following baseline model that we subsequently augment:

$$UP_i = post\_crisis + crisis + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \tag{5}$$

We regress UP, estimated over $n = 5$ days, against the post-crisis and crisis dummy, respectively, as well as a set of controls (bond size, IPO, maturity, coupon). The post-crisis dummy captures the average difference in UP relative to the pre-crisis period and thus between periods of low and high aggregate dealer inventories. Further, α_{rat} is a rating fixed-effect based on 21 notches, α_{ind} is an industry fixed-effect based on the 4-digit SIC code, and α_{sys} is a syndicate structure fixed-effect reflecting the number of underwriters participating in the syndicate. We thus factor out any differences across credit risk, industries and syndicate structures. We cluster the standard errors at the syndicate-period level.

The results are in columns (1)-(3) in Panel A of Table 4. We find that UP is significantly higher by 43 bps (t-stat 11.4) in the post-crisis compared to the pre-crisis period. This estimate is economically sizeable, implying that the average bond with an issue amount of $566 million generates around $2.4 million less in proceeds for the issuer, post-crisis, compared to the pre-crisis period.

TABLE 4 ABOUT HERE

We run the regression of equation (5) using $SALE$ as the dependent variable and present the results in columns (1)-(3) in Panel B. We find that the estimate of $post\_crisis$ is highly significant and exhibits a value of 3.9% (t-stat 6.0). Considering the average bond, this estimate implies that, post-crisis, customers sell around $22 million more of the bond shortly after the offering compared to the pre-crisis period. This finding also indicates that some investors received a fraction of the bond notional at issuance, which they are subsequently selling in the secondary market.

Overall, we document that, post crisis, underpricing and customer sales in newly issued bonds increase. These time-series patterns are in line with the notion that a drop in aggregate inventory capacity incentivizes some underwriters to allocate newly offered bonds to relationship customers. Subsequently, we provide causal evidence for this conjecture.

3.4 Identifying the relationship channel

Our theory implies that allocations to institutional investors per se, that is, without separating between relationship and non-relationship customers, do not explain the post-crisis increase in UP and $SALE$. To test this implication we run the following specification:

$$
\begin{aligned}
UP_i = post\_crisis + crisis + \beta_1 INST_i + \beta_2 (post\_crisis \times INST_i) \\
+ \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i
\end{aligned}
\tag{6}
$$

The coefficient β_1 thus measures the impact of $INST$ on UP outside the post-crisis period, while β_2 measures the marginal post-crisis impact. We present the results in model (4) in Panel A of Table 4, where we find a significant β_2-estimate with a value of -0.5 (t-stat 3.0). Moreover, the post-crisis dummy remains highly significant with a value of 66 bps (t-stat of 7.2). These results indicate that post-crisis variation in institutional holdings per se do not drive the increase in UP. Similarly in model (5) in Panel B, where $SALE$ is the dependent variable, we do not find that the post-crisis increase in customer sales is due to variation in $INST$.

Our main goal is to identify whether allocations to relationship investors in the post-crisis period cause the increases in UP and $SALE$. In this respect, the variable $INST$ gives rise to two main issues. First, we observe holdings data at a quarterly frequency, implying that our best estimate of the initial allocation of bonds are the holdings at the end of the issuance quarter. Second, the holdings data do not discriminate between allocations to relationship and non-relationship customers. In other words, we do not see the share of relationship customers in $INST$. We therefore need an instrumental variable, IV, that (i) correlates with the allocation to institutional investors, $INST$, and (ii) affects UP and $SALE$ only through the decision of allocating bonds to relationship customers.

To construct our novel instrument, we exploit the fact that underwriters are themselves bond issuers. Specifically, we use the concentration of institutional investors' past holdings of underwriters' own bonds. Our identifying assumption is that underwriters that place their own bonds with a concentrated set of investors are likely to have tighter relationships. Specifically, we estimate IV_i for each bond offering i as follows:

$$IV_i = \frac{1}{N} \sum_{u=1}^{N} \frac{h_u}{w_u} \tag{7}$$

The variable h_u is the amount of underwriter u's bonds held by the top 25% of its own investors in the previous quarter, and w_u is the total bond amount outstanding of u in the previous quarter.[10] Further, N is the number of lead underwriters participating in the underwriting syndicate of bond i. This measure provides us with a source of cross-sectional variation in the strength of underwriter-investor relationships: a higher value of

[10]We identify the top 25% of u's investors by ranking the institutional investors' holdings in u's bonds in the previous quarter. Our results do not depend on the definition of h_u. We obtain basically identical results when using the top 10% or 40% of investors; see Section 3.5 for further discussions.

IV_i indicates that the underwriting syndicate of bond i is more likely to engage in the relationship channel.[11] The necessary condition for our identification strategy is having variation in the concentration of institutional investors across underwriters. Table 3 shows that the average value of IV is 15.8% with a standard deviation of 5.1%; thus, there is considerable heterogeneity in our IV across bond offerings.

According to our theory a bond offering with a higher value of IV (syndicate with better access to relationship customers) is only affected by the relationship channel in the low inventory period (post-crisis). Our baseline model in equation (6) contains two endogenous variables, $INST$ and $post\_crisis \times INST$. As in Tsoutsoura (2015) we therefore use two instruments, IV and $post\_crisis \times IV$. That is, we run the following first-stage regressions:

$$\begin{aligned} INST_i = & post\_crisis + crisis + \theta_1 IV_i + \theta_2 (post\_crisis \times IV_i) \\ & + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \\ post\_crisis \times INST_i = & post\_crisis + crisis + \theta_3 IV_i + \theta_4 (post\_crisis \times IV_i) \\ & + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \end{aligned} \tag{8}$$

We present the results of the first stages in Panel A of Table 5. The results confirm condition (i) as our IV correlates with $INST$. In both models the instrument is highly significant (first-stage F-stats of 20.3 and 29.9) and exhibits the expected positive sign. That is, a bond offering underwritten by a syndicate with tighter relationships has a higher value of $INST$, and the more so in the post-crisis period when aggregate inventories are low. We further provide a placebo test to strengthen the validity of our instrument. In

[11] Consider two underwriters, UW1 and UW2, with the same total bond amount outstanding. Each of them has in total 100 investors in their own bonds. UW1 allocates its bonds equally across the 100 investors, that is, each holds 1% of the total amount outstanding. UW2 instead allocates 50% to 25 investors, while 50% are divided equally among the remaining 75 investors. Our IV assigns a higher value to UW2 (50%) than to UW1 (25%), meaning that UW2 is more likely to engage in the relationship channel. Also, it implies that a syndicate consisting of UW1 and UW2 has weaker relationships than UW2 alone, but a stronger one than UW1 alone.

Panel B we show the results of the first stages when we assign the bond offerings randomly to an underwriting syndicate. As expected, we find that there is neither a significant nor a positive relation to $INST$ (F-stats close to zero).[12]

Table 5 about here

Economically, our instrument likely satisfies condition (ii), that is, IV effects UP and $SALE$ only indirectly through underwriter-customer relationships, while IV does not directly affect the fundamental values of bond offerings. IV is based on past institutional ownership of underwriters' own issued bonds. Hence, there is no industry overlap between the bonds that we use to construct IV and the offerings for which we estimate UP and $SALE$. It is well known that there is no test to empirically verify condition (ii). However, in Table IA2 in the Internet Appendix, we provide some qualitative evidence that is consistent with our arguments. Specifically, we show that there is no difference in bond characteristics (fundamentals) between offerings with high and low values of IV – they are basically identical in terms of offering amount, maturity, coupon, rating, and syndicate structure. Our IV would be further valid if institutional investors act strategically. For example, suppose they increase ownership in underwriters' own bonds in anticipation of favorable allocations in future offerings. Also in this case the effect of IV on UP and $SALE$ takes place only indirectly through the relationship channel.[13]

[12] We present additional robustness tests of our instrument in Table IA1 in the Internet Appendix. That is, instead of using IV_i as a continuous variable, we sort IV_i in each time period (pre-crisis, crisis and post-crisis) into five bins and assign a value of 1, 2, 3, 4 or 5 depending on the quintile of i (from lowest to highest). In other words, we only use the ranking to classify whether a syndicate is relatively more or less likely to engage in the relationship channel in a given time period. In this way we also shift the mean of the fitted values in the first-stage regression but make sure that the correction is not driven by outliers of IV. Our IV remains valid, that is, a higher ranking correlates positively and significantly with $INST$.

[13] An alternative IV could be using the concentration of institutional investors' holdings in all bonds underwritten by a specific underwriter (hence not only of underwriters' own bonds). Such a measure presents a noisier proxy for underwriter-customer relationships. These allocations might take place long after bond issuance, hence, not necessarily due to relationships. Moreover, previous issued bonds that were issued by firms that are included in our sample of bond offerings might enter into the calculation. In this case, condition (ii) could be violated because the IV would affect UP and $SALE$ not only through the relationship channel, but also through the past fundamental value of the bonds of the same issuer.

3.5 Main results

In this section, we present the results of the 2SLS-estimates of equation (6). That is, we investigate whether allocations to relationship customers in the post-crisis period cause the increases in UP and $SALE$. The results are in Table 6. The reported t-statistics are adjusted for the 2SLS-bias (see Roberts and Whited, 2012).

We first discuss the findings for UP in Panel A. For comparison, we present in model (1) again the OLS-estimates while model (2) shows the 2SLS-estimates. We find that UP indeed increases, post-crisis, due to allocations to relationship customers. The obtained 2SLS-estimate of β_2 is 3.9 (t-stat of 3.1), and thus flips its sign compared to the OLS-estimate. The post-crisis dummy also flips sign and turns negative to a value of -127 bps (t-stat of 2.3). Further, the instrumented coefficient of $INST$, β_1, is insignificant, that is, the relationship channel does not affect UP in a period when dealers are relatively unconstrained. Overall, these results confirm the prediction of the model: a drop in aggregate inventory capacity causes an increase in underpricing through allocations to relationship customers.

The positive 2SLS-estimate of β_2 indicates that the endogeneity of $INST$ in the post-crisis period induces a downward bias on the OLS-coefficient. $INST$ contains the allocation to both types of investors, that is, those with and without tight relationships to the underwriters. Theory, however, postulates that when inventory capacity drops, underwriters with access to relationship customers increase the allocation towards them. Our IV isolates allocations to relationship customers who obtain higher underpricing compared to non-relationship customers, thereby explaining the downward OLS-bias. In line with theoretical predictions, the 2SLS-procedure further shows that the relationship channel only matters in the post-crisis period, when underwriters are inventory-constrained.

The impact of the relationship channel on UP in the post-crisis period is substantial. Specifically, the 2SLS-estimate of β_2 implies that a 10% allocation to relationship investors results in a 39 bps difference in UP. We further employ a Wald-test to conjecture the allocations under which the relationship channel explains the average post-crisis increase in UP. To do so, we identify the average values of $INST$ where the restriction $post\_crisis + \beta_2 \cdot (post\_crisis \times \bar{INST}) = 0$ is not rejected at the 5% level. We find that allocations of 30% to 35% satisfy the restriction. These are plausible magnitudes given that institutional investors hold on average 44% of a bond in our sample.

Table 6 about here

We now turn to the analysis of customer sales of newly issued bonds in the secondary market. According to our model, a drop in inventory capacity incentivizes some underwriters to excessively allocate bonds to relationship customers, causing a simultaneous increase in underpricing and relationship customers' sales. In other words, the same mechanism outlined above for underpricing should play out for customer sales as well. We find strong support for this prediction. Specifically, we use $SALE$ as the dependent variable in equation (6) and apply the same instruments. Panel B of Table 4 shows the results for both, that is, OLS and 2SLS, respectively. As expected, the 2SLS-coefficient of β_2 exhibits a positive and significant value of around 0.5 (t-stat of 2.1). The 2SLS-estimate of β_1 is insignificant, showing that, pre-crisis, there are no excess sales due to the relationship channel. These results confirm the prediction that the post-crisis environment causes larger customer sales of newly issued bonds through the relationship channel. Further, the post-crisis dummy flips sign and turns negative to a value of -19.7% (t-stat of 1.9).

The 2SLS-estimate of β_2 is again more positive than the one that obtains through OLS–indicative of a downward bias. $INST$ does not differentiate between relationship and non-relationship customers. In our model, underwriters with no relationships ($p = q$) outsource their inventory to all investors. Consequently, investors do not receive excessive allocations and thus do not generate additional sales in the secondary market. This mechanism can explain the downward bias. The post-crisis impact of the relationship channel is considerable, that is, a 10% allocation to relationship customers implies a 5.2% difference in $SALE$. We again conduct a Wald-test and find that excess sales, post-crisis, can be explained by an average allocation of 30% to 35% to relationship customers.

Overall, the results of the 2SLS-analysis confirm the implications of the model. That is, a drop in aggregate inventory capacity leads to a simultaneous increase in UP and $SALE$ through allocations to relationship customers.[14]

3.5.1 UP and $SALE$ over different horizon

We further provide estimates of the impact of the relationship channel on UP and $SALE$ estimated over $n = 10$ days. The obtained results in Table 7 are similar compared to before. That is, we obtain 2SLS-estimates of β_2 of 5.0 for UP and 0.6 for $SALE$, respectively. Further, the estimates remain highly significant (t-stats of 3.5 and 2.4). These results indicate that UP and $SALE$ do not show any short-term reversal. This insight corroborates the idea that offering prices are below fundamental values, and thus that bond offerings generate smaller proceeds for issuers, post-crisis, due to the relationship channel.

TABLE 7 ABOUT HERE

3.6 Exploring the channel further

In this section, we provide additional analyses that strengthen our main results and thus the identification of the underlying mechanism. We focus on our baseline horizon of $n = 5$ days. First, we show that the results are robust to any potential post-crisis changes in our control variables. Second, we explore underwriters own issued bonds, where the

[14] We present the corresponding results of the 2SLS-procedure when using the ranking of IV in Table IA3 in the Internet Appendix. Further, in Table IA4 in the Internet Appendix we show the results when using alternative definitions of relationship investors, that is, using either the top 10% or 40% of investors. In both cases we find that the main insights of our results remain basically unaffected.

agency conflict is not present and thus we do not expect any negative post-crisis changes in the initial pricing and trading of bonds. Third, we show that the post-crisis market entry of mutual funds cannot explain the increases in UP and $SALE$.[15]

3.6.1 Testing alternative explanations

It could be that structural changes in the control variables affect UP and $SALE$, post-crisis, in the same direction as implied by the mechanism of our model. The instrument might then pick up time-variation in the control variables, thereby affecting the inference regarding the relationship channel. To address this concern, we perform the entire 2SLS-estimation for variants of the following regression:

$$\begin{aligned} UP_i = {} & crisis + \beta_1 INST_i + \beta_2 (post\_crisis \times INST_i) + \gamma_1' X_i \\ & + \gamma_2' (post\_crisis \times X_i) + \alpha_{post\_crisis \times rat} + \alpha_{post\_crisis \times ind} + \alpha_{post\_crisis \times sys} + \epsilon_i \end{aligned} \tag{9}$$

We thus allow bond characteristics to have different coefficients in the low and high inventory period, thereby absorbing the impact of their time-variation on UP. We also allow the rating, industry and syndicate structure fixed-effects to take different values, post-crisis, compared to the pre-crisis period. In this way, we factor out the effect of time-variation in the fixed-effects. For example, if the pricing of credit risk is different in the post-crisis period, then this effect is absorbed by the time-varying rating fixed-effect. Similarly, changes in the competitive nature among underwriters would be captured by the time-varying syndicate structure fixed-effect.

[15] An interesting additional test to validate our mechanism, similar as in Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018), would be looking at bank versus non-bank affiliated underwriters. The latter are not directly affected by post-crisis regulation, such as the Volcker rule, and hence these underwriters might be less constrained in their inventory capacity. However, we are left with only 34 observations when we isolate in our sample bonds underwritten by syndicates that include only non-bank affiliated underwriters. In other words, the vast majority of underwriters are bank-affiliated. Such a small sample limits our possibility to perform meaningful tests.

We present the results of the 2SLS-estimates for UP in Panel A of Table 8. We report the estimates of β_2 for different specifications. For comparison, model (1) shows the main result of equation (6). Models (2)–(5) show the β_2-estimates when allowing some controls to have different post-crisis coefficients, while in model (6) we present the results when testing the full specification of equation (9). We find that β_2 remains economically and statistically significant in all specifications. In model (6) we obtain a β_2-value of 5.8 (t-stat of 3.0). Hence, one can interpret the estimate of 3.9 of our main result obtained through equation (6) as a lower bound of the impact of the relationship channel.[16]

Table 8 about here

In Panel B we further present the results for $SALE$. The estimates remain highly significant and we also obtain a higher value for β_2 of 1.0 (t-stat of 2.6) in model (6) compared to the 0.5 of our specification in equation (6). This result shows again that, if anything, we underestimate the effect of the relationship channel on corporate bond offerings. From an identification perspective it is further reassuring that both β_2-estimates (for UP and $SALE$) always move in the same direction. In other words, both estimates either increase or decrease once we control for additional variables. This observation confirms the notion that the relationship channel drives the time-series variation in UP and $SALE$. Overall, we conclude that inventory constraints have a first-order impact on the pricing and trading of corporate bond offerings through the relationship channel.

3.6.2 What happens to underwriters' own bonds?

Underwriters are themselves issuers of bonds. A natural question that arises in our study is how the post-crisis environment affects the pricing and trading of their own bonds.

[16] The results of the first-stage regressions of equation (9) are in Table IA5 in the Internet Appendix. In Panel A we repeat the first-stage regressions as in equation (8) while Panel B shows the corresponding first-stage regressions of equation (9). We find that the instrument remains highly robust and significant.

Underwriters might avoid underpricing their own securities to maximize the proceeds from the offering. Our results so far suggest that the drop in aggregate inventory capacity creates an agency conflict that imposes a negative externality on issuers in the form of lower issuance proceeds. Hence, due to the absence of agency issues, we would not expect any significant increases in UP and $SALE$, post-crisis, for underwriters' own bonds.

To investigate this question, we construct a sample of bond offerings of the 39 underwriters of our main sample. We estimate UP and $SALE$ as described in Section 3.1 and apply the same sample construction procedure of Section 3.2. In total, we end up with 601 bond offerings. We provide descriptive statistics in Table IA6 in the Internet Appendix. The average value of UP is 18 bps and thus lower than the 75 bps of our main sample. Further, also $SALE$ and $INST$ are lower with values of 11% and 28%, respectively. The average bond amount issued of $1,343 is considerably larger, though, than the $566 million of the main sample. The average rating is close to five, which corresponds to scale "A+", and thus indicates lower credit risk compared to our main sample.

Table 9 about here

We run the baseline regression of equation (6) on the sample of underwriters own bonds and present the results in Table 9. In Panel A we show the estimates for $n = 5$ days. When using UP as the dependent variable we find that the estimate of *post_crisis* is 11 bps and insignificant (t-stat of 0.7). Similarly, for $SALE$ we find an insignificant post-crisis dummy of 0.6 (t-stat of 0.2). Further, for both UP and $SALE$, neither $INST$ nor the interaction term *post_crisis* $\times$ $INST$ exhibit significant estimates. In Panel B we repeat the tests when calculating UP and $SALE$ over $n = 10$ days. We obtain qualitative similar insights, that is, neither for UP nor $SALE$ the post-crisis dummy is significant.

Overall, these results support the idea that a drop in aggregate inventory capacity creates an agency conflict that imposes a negative externality on non-financial issuers.

3.6.3 Can mutual fund holdings explain results?

Existing research (e.g., Goldstein, Jiang, and Ng, 2017; Choi and Kronlund, 2017) documents that mutual funds substantially increase their holdings in corporate bonds, post-crisis, due to reaching for yield behavior. We therefore want to exclude the possibility that mutual funds drive the post-crisis increases in UP and $SALE$. We thus examine whether changes in the composition of institutional investors affect our results. To do so, we use the variable $MUTINST = MUT/INST$ to capture the relative importance of mutual funds within institutional investors.

Table 10 about here

We rerun our baseline regression of equation (6) and replace the variable $INST$ by $MUTINST$. We present the results in Panel A of Table 10, where we find that UP and $SALE$ remain significantly higher, post-crisis, by 47 bps (t-stat of 9.8) and 1.9% (t-stat of 1.9), respectively. The coefficient β_2 of the interaction term $post\_crisis \times MUTINST$ is significantly negative for UP and positive for $SALE$, providing thus mixed results. We further run the first-stage regressions of equation (8) when using IV only based on mutual funds holdings. We show the estimates in Panel B where we find that the instruments are insignificant and weak (F-stats of 1.5 and 0.6). This result implies that mutual funds alone cannot explain our findings. Overall, we conclude that changes in the holdings of mutual funds in the post-crisis period cannot capture the increases in UP and $SALE$.

3.7 Discussion about long-term implications

Our theoretical and empirical findings indicate that dealers' inventory frictions generate an agency conflict that translates into costs for bond issuers in the form of increased underpricing. Which measures could limit such distortions? A more transparent and standardized issuance process, for example, could help avoiding that certain investors receive preferential treatment in the initial allocation. In turn, this could foster competition among investors and thus decrease issuance costs. Alternatively, market participants could engage in self-correcting mechanisms. Given the concentrated nature of the underwriting market, it is unlikely that issuers could threaten underwriters to switch to alternative sources of debt financing.[17] However, the attractiveness of the underwriting business might encourage new market entry that could increase competition at the benefit of issuers.

Some recent developments in the process of corporate bond offerings deserve attention. First, regulators started to take action. In 2014, the SEC has begun to investigate whether Goldman Sachs and Citigroup gave preferential treatment to some investors at bond issuance (see Abramowicz, Mead, and Robinson, 2014). Moreover, there are ongoing discussions on how to reform corporate bond offerings (see, e.g., The Credit Roundtable, 2015). The regulator's main concern is the opaqueness of the issuance process. Their efforts focus on establishing more transparent market practices, with the goal of protecting investors and guaranteeing issuers the possibility of getting financing through capital markets at reasonable costs.

Second, there are signs of increased competition within the underwriting business. Investment funds are getting more actively involved in setting up corporate bond offerings and some of them (e.g., Blackstone or KKK) obtained underwriting licenses (see Abramowicz, 2015; Sender, 2013). This evidence is consistent with investors reacting to the underwriting practices of inventory-constrained investment banks. As a response to increased competition, in January 2019 the largest underwriters have launched an electronic platform for corporate bond offerings, to preserve market share in the underwriting business. The aim of the new platform is to allow for a more transparent exchange of bond offering information between issuers, underwriters and investors as well as a more competitive allocation of new

[17]Evidence of high switching costs for issuers is provided by Yasuda (2005) and Daetz, Dick-Nielsen, and Stenbo Nielsen (2018).

issues.[18] All these measures are in line with regulators' objectives. Overall, this discussion shows that inventory-constrained underwriters can have far-reaching implications on the design of corporate bond offerings.

4 Conclusion

This article theoretically and empirically investigates how underwriters' inventory capacity affects the initial allocation, pricing and trading of corporate bond offerings. Our model predicts that a decrease in aggregate inventory capacity incentivizes some underwriters to allocate excessive amounts of bonds to relationship customers. These investors require compensation in the form of increased underpricing and resell their excessive holdings in the secondary market. An instrumental variable strategy allows us to empirically demonstrate that, through the relationship channel, the post-crisis drop in aggregate inventory capacity leads to a simultaneous increase in underpricing and customer sales. Overall, our findings suggest that a lowering of inventory capacity creates an agency conflict that imposes a negative externality on bond issuers in the form of lower issuance proceeds.

[18] The platform has been created by Bank of America, JP Morgan and Citigroup. Goldman Sachs, Wells Fargo, BNP Paribas and Deutsche Bank joined the initiative later. For details, see Platt (2018).

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Table 1: Model equilibria and comparative statics. This table provides comparative statics for the most profitable equilibria of the model presented in Section 2. We examine the equilibrium implications of a change in the inventory capacity, S, from the pre-crisis (where $S = S^H$) to the post-crisis period (where $S = S^L$) with $S^H > 2S^L$. K is the issue size and $\bar{Q}$ is the target holding of institutional investors. Panel A presents the results in the presence of the relationship channel. That is, in choosing the initial allocation of bonds the underwriter internalizes through trading relationships the commission, θ, of the secondary market. p is the probability that the relationship customer uses the underwriter also as a dealer in the secondary market and q is the corresponding probability for the non-relationship investor where $0 < q < p$. In Panel B, the relationship channel is not active, that is, $0 < q = p$. We present model equilibria in the pre-crisis and post-crisis period as well as the difference between the two, that is, Δ = Post-crisis − Pre-crisis.

	Panel A			**Panel B**		
	$0 < q < p$			$0 < q = p$		
	Pre-crisis	Post-crisis	Δ	Pre-crisis	Post-crisis	Δ
Inventory capacity	$K - S^H < \bar{Q}$	$\frac{K-2S^L}{2} < \bar{Q} < K - 2S^L$	$2S^L - S^H < 0$	$K - S^H < \bar{Q}$	$\frac{K-2S^L}{2} < \bar{Q} < K - 2S^L$	$2S^L - S^H < 0$
Allocation						
To institutional investor	$K - 2S^H$	$K - 2S^L$	$2(S^H - S^L) > 0$	$K - 2S^H$	$K - 2S^L$	$2(S^H - S^L) > 0$
To relationship investor	$\frac{K-2S^H}{2}$	$K - 2S^L$	$\frac{K}{2} + S^H - 2S^L > 0$	$\frac{K-2S^H}{2}$	$\frac{K-2S^L}{2}$	$S^H - S^L > 0$
Underpricing and customer sales						
Underpricing	$\bar{p} - n$	$\bar{p} - (n - \lambda)$	$\lambda > 0$	$\bar{p} - n$	$\bar{p} - n$	0
Excess customer sales	0	$K - 2S^L - \bar{Q}$	$K - 2S^L - \bar{Q} > 0$	0	0	0

Table 2: Definition of variables. We describe the construction of the variables used in our analysis and their corresponding data sources. The sample is based on 5,172 U.S. corporate bond offerings obtained from Mergent FISD and transaction data of corporate bonds from TRACE for the period from January 2003 to December 2013. We retrieve information on investor's holdings of corporate bonds from Lippers eMAXX.

Variable	Definition	Source
$post\_crisis$	Dummy equal to one if the bond is issued between May 2009 and December 2013	MERGENT
$crisis$	Dummy equal to one if the bond is issued between July 2007 and April 2009	MERGENT
$INST$	Percentage of bond's offering amount held by institutional investors at the end of the issuance quarter	eMAXX
IV	This variable indicates, for each underwriter, the quarterly percentages of the offering amount of the underwriter's own bonds held by its top 25% of investors	MERGENT, eMAXX
MUT	Percentage of bond's offering amount held by mutual funds at the end of the issuance quarter	eMAXX
Bond Size	Natural logarithm of the offering amount of bond	MERGENT
IPO	Dummy equal to one if the offering is an initial public offering (IPO)	MERGENT
Maturity	Maturity of bond at issuance in years	MERGENT
Coupon	Coupon of bond in percent of notional	MERGENT
Rating	Lowest bond rating across the three major rating agencies (*Fitch*, *Moody's*, *Standard and Poor's*) in the issuance quarter	MERGENT
Syndicate Structure	Number of lead underwriters involved in the syndicate	MERGENT
Industry	4-digit SIC code of issuer	MERGENT

Table 3: Summary statistics. We summarize descriptive statistics for underpricing, UP, customer sales volume, $SALE$, the fraction of a bond's offering amount held by institutional investors at the end of the issuance quarter, $INST$, the fraction of a bond's offering amount held by mutual funds at the end of the issuance quarter, MUT, the instrumental variable, IV, amount issued, rating, maturity, coupon and the syndicate structure. UP is defined as the average return of a newly issued bond over five days relative to the offering price in excess of the market return over the corresponding days. $SALE$ is defined as the cumulative customer sales volume scaled by the amount issued within five days after issuance. We assign integer numbers to the ratings (i.e., AAA=1, AA+=2, ..., D=22). We report across all bonds the means, standard deviations, and the 25%, 50%, and 75% quantiles. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX.

Variable	Unit	Mean	Stdv	q25	q50	q75
UP	[bps]	74.453	95.979	13.574	50.301	113.958
$SALE$	[%]	12.066	12.008	4.286	9.664	16.805
$INST$	[%]	43.604	16.493	32.155	42.952	54.232
MUT	[%]	13.402	12.243	4.416	9.836	18.631
IV	[%]	15.790	5.061	12.770	15.814	18.697
Amount Issued	[millions]	566.203	408.338	300.000	450.000	700.000
Maturity	[years]	11.848	8.491	6.995	10.019	10.134
Coupon	[%]	5.549	2.220	4.124	5.500	6.750
Rating	[integer]	9.405	3.508	7.000	9.000	11.000
Syndicate Structure	[integer]	2.473	1.188	1.000	2.000	3.000

Table 4: Underpricing and customer sales. We present results of explaining underpricing, UP, and customer sales volume, $SALE$, of newly issued bonds. In Panel A we run the following regression:

$$UP_i = post\_crisis + crisis + \beta_1 INST_i + \beta_2(post\_crisis \times INST_i) \\ + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

We regress UP_i, estimated over five days, of bond i on dummies ($post\_crisis$ and $crisis$), on institutional investors' holdings, $INST_i$, and an interaction term, $post\_crisis \times INST_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. In Panel B we run the same regression with $SALE_i$ as the dependent variable. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

Panel A: UP

	(1)	(2)	(3)	(4)
$post\_crisis$	29.068***	27.730***	43.003***	66.498***
	(8.664)	(8.787)	(11.412)	(7.178)
$crisis$	52.579***	67.831***	42.981***	43.168***
	(9.692)	(12.695)	(7.843)	(7.859)
$INST$				0.161
				(1.266)
$post\_crisis \times INST$				−0.528***
				(−3.020)
Bond Size			7.749**	7.655**
			(2.064)	(2.041)
IPO			13.182***	12.722***
			(2.736)	(2.648)
Maturity			0.023	−0.011
			(0.113)	(−0.052)
Coupon			17.309***	17.408***
			(11.019)	(10.954)
Observations	5,172	5,172	5,172	5,172
Adjusted R^2	0.031	0.173	0.228	0.230
Rating FE	No	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Syndicate Structure FE	No	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 4 continued on next page.

Table 4 continued from previous page.

Panel B: *SALE*				
	(1)	(2)	(3)	(4)
post_crisis	3.798***	4.161***	3.903***	3.641***
	(5.199)	(6.710)	(5.968)	(2.979)
crisis	−2.374***	−2.047***	−0.826	−0.768
	(−3.235)	(−2.987)	(−1.098)	(−1.014)
INST				0.022
				(0.937)
post_crisis × *INST*				0.003
				(0.103)
Bond Size			−0.887**	−0.794**
			(−2.468)	(−2.315)
IPO			−1.726***	−1.670***
			(−2.960)	(−2.844)
Maturity			0.162***	0.167***
			(5.866)	(5.796)
Coupon			−0.562***	−0.596***
			(−2.947)	(−3.067)
Observations	5,172	5,172	5,172	5,172
Adjusted R^2	0.039	0.164	0.177	0.177
Rating FE	No	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Syndicate Structure FE	No	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 5: First-stage regressions. We present results of the first-stage regressions:

$$\begin{aligned} INST_i = & post\_crisis + crisis + \theta_1 IV_i + \theta_2 (post\_crisis \times IV_i) \\ & + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \\ post\_crisis \times INST_i = & post\_crisis + crisis + \theta_3 IV_i + \theta_4 (post\_crisis \times IV_i) \\ & + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \end{aligned}$$

In Panel A we regress $INST_i$ and $post\_crisis \times INST_i$ of bond i on dummies ($post\_crisis$ and $crisis$), on our instrumental variable, IV_i, and an interaction term, $post\_crisis \times IV_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. IV_i is based on the concentration of past institutional holdings of underwriters' own bonds. In Panel B we present a placebo test where we randomly assign our instrument to bond offerings. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

	Panel A Standard IV		**Panel B** Placebo IV	
	(1)	(2)	(1)	(2)
Dependent variable:	$INST$	$post\_crisis \times INST$	$INST$	$post\_crisis \times INST$
$post\_crisis$	4.848***	38.450***	4.500***	45.992***
	(2.583)	(24.305)	(2.922)	(47.657)
$crisis$	−1.804**	−0.725	−2.561***	−0.423
	(−2.016)	(−1.586)	(−2.832)	(−0.929)
IV	0.284***	−0.069**	−0.033	0.004
	(4.507)	(−2.476)	(−0.482)	(0.200)
$post\_crisis \times IV$	0.053	0.491***	0.093	0.024
	(0.489)	(5.470)	(1.068)	(0.431)
Observations	5,172	5,172	5,172	5,172
Adjusted R^2	0.223	0.804	0.216	0.801
First stage F-stat	20.311	29.925	0.154	0.074
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 6: Second-stage regressions, relationship channel. We present results of the following second-stage regression:

$$UP_i = post\_crisis + crisis + \beta_1 \hat{INST}_i + \beta_2 (post\_crisis \hat{\times} INST_i) \\ + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

In Panel A we regress UP_i, estimated over five days, of bond i on dummies ($post\_crisis$ and $crisis$), on the instrumented institutional investors' holdings, $\hat{INST}_i$, and an instrumented interaction term, $post\_crisis \hat{\times} INST_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. Column (1) shows the OLS-estimates of Table 4 while column (2) shows 2SLS-estimates. In Panel B we run the regression with $SALE_i$ as the dependent variable. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level, and are adjusted for the 2SLS-bias in the second-stage regressions.

	Panel A UP		**Panel B** $SALE$	
	(1)	(2)	(1)	(2)
	OLS	2SLS	OLS	2SLS
$post\_crisis$	66.498***	−126.911**	3.641***	−19.723*
	(7.178)	(−2.262)	(2.979)	(−1.910)
$crisis$	43.168***	40.449***	−0.768	−0.803
	(7.859)	(5.812)	(−1.014)	(−0.786)
$INST$	0.161	−1.645	0.022	−0.078
	(1.266)	(−1.426)	(0.937)	(−0.280)
$post\_crisis \times INST$	−0.528***	3.877***	0.003	0.520**
	(−3.020)	(3.060)	(0.103)	(2.106)
Observations	5,172	5,172	5,172	5,172
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 7: Second-stage regressions, relationship channel at different horizon. We present results of the following second-stage regression:

$$UP_i = post\_crisis + crisis + \beta_1 \hat{INST}_i + \beta_2 (\widehat{post\_crisis \times INST_i}) + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

In Panel A we regress UP_i, estimated over ten days, of bond i on dummies ($post\_crisis$ and $crisis$), on the instrumented institutional investors' holdings, $\hat{INST}_i$, and an instrumented interaction term, $\widehat{post\_crisis \times INST_i}$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. Column (1) shows the OLS-estimates of Table 4 while column (2) shows 2SLS-estimates. In Panel B we run the regression with $SALE_i$ as the dependent variable. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level, and are adjusted for the 2SLS-bias in the second-stage regressions.

	Panel A UP		**Panel B** $SALE$	
	(1)	(2)	(1)	(2)
	OLS	2SLS	OLS	2SLS
$post\_crisis$	74.834***	−172.053***	2.664**	−22.722**
	(7.081)	(−2.740)	(2.033)	(−2.183)
$crisis$	56.036***	54.639***	−1.473*	−1.796
	(8.677)	(6.827)	(−1.808)	(−1.644)
$INST$	0.181	−1.289	0.009	−0.214
	(1.226)	(−0.972)	(0.362)	(−0.757)
$post\_crisis \times INST$	−0.514**	5.001***	0.012	0.588**
	(−2.563)	(3.500)	(0.421)	(2.364)
Observations	5,172	5,172	5,172	5,172
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 8: Second-stage regressions, robustness of relationship channel. We present results of the following second-stage regression:

$$UP_i = crisis + \beta_1 \hat{INST}_i + \beta_2 (\widehat{post\_crisis \times INST_i}) + \gamma_1' X_i \\ + \gamma_2' (post\_crisis \times X_i) + \alpha_{post\_crisis \times rat} + \alpha_{post\_crisis \times ind} + \alpha_{post\_crisis \times sys} + \epsilon_i$$

In Panel A we regress UP_i, estimated over five days, of bond i on the crisis-dummy, on the instrumented institutional investors' holdings, $\hat{INST}_i$, and an instrumented interaction term, $\widehat{post\_crisis \times INST_i}$, as well as a set of controls, X_i, and their interaction, $post\_crisis \times X_i$, and rating-time, $\alpha_{post\_crisis \times rat}$ (based on 21 notches), industry-time, $\alpha_{post\_crisis \times ind}$ (based on 4-digit SIC) and syndicate structure-time, $\alpha_{post\_crisis \times sys}$ (number of lead underwriters), fixed-effects. Column (1) shows the 2SLS-estimates of Table 6 while columns (2)-(6) show the 2SLS-estimates of the above equation. In Panel B we run the regression with $SALE_i$ as the dependent variable. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level, and are adjusted for the 2SLS-bias in the second-stage regressions.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: UP						
$post\_crisis \times INST$	3.877***	4.035***	6.191***	3.879***	5.878***	5.784***
	(3.060)	(3.021)	(3.083)	(3.099)	(3.138)	(2.965)
Panel B: $SALE$						
$post\_crisis \times INST$	0.520**	0.568**	1.059**	0.529**	0.980***	0.961**
	(2.106)	(2.436)	(2.398)	(2.378)	(2.666)	(2.567)
Observations	5,172	5,172	5,172	5,172	5,172	5,172
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Rating, Industry and Syndicate Structure FE	Yes	No	No	No	No	No
$post_crisis \times$Controls	No	No	No	No	No	Yes
$post_crisis \times$Rating FE	No	Yes	No	No	Yes	Yes
$post_crisis \times$Industry FE	No	No	Yes	No	Yes	Yes
$post_crisis \times$Syndicate Structure FE	No	No	No	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: Underpricing and customer sales of underwriters' own bonds. We present results of explaining underpricing, UP, and customer sales volume, $SALE$, of underwriters' own issued bonds. We run the following regression:

$$UP_i = post\_crisis + crisis + \beta_1 INST_i + \beta_2(post\_crisis \times INST_i) + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

We regress UP_i and $SALE_i$, estimated over five days, of bond i on dummies ($post\_crisis$ and $crisis$), on institutional investors' holdings, $INST_i$, and an interaction term, $post\_crisis \times INST_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. In Panel B we run the same regressions with UP_i and $SALE_i$ estimated over ten days. The sample comprises 601 U.S. corporate bond offerings of underwriters obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

	Panel A 5 Days		**Panel B** 10 Days	
	(1)	(2)	(1)	(2)
Dependent variable:	UP	$SALE$	UP	$SALE$
$post\_crisis$	11.194	0.635	22.536	2.984
	(0.657)	(0.229)	(1.046)	(1.036)
$crisis$	−13.555	−5.210**	−18.227	−5.954**
	(−0.931)	(−2.047)	(−1.035)	(−2.228)
$INST$	0.272	0.124	0.337	0.169**
	(0.883)	(1.525)	(0.881)	(2.228)
$post\_crisis \times INST$	0.316	−0.022	0.359	−0.032
	(0.701)	(−0.306)	(0.621)	(−0.428)
Bond Size	12.759***	2.979**	11.999***	3.322**
	(4.324)	(2.196)	(3.088)	(2.167)
IPO	−13.376	−3.460**	−22.222	−4.734***
	(−0.560)	(−2.358)	(−0.755)	(−2.909)
Maturity	−1.212	0.135***	−1.513	0.053
	(−1.575)	(3.624)	(−1.451)	(0.744)
Coupon	9.517***	−0.315	13.201***	1.030
	(2.991)	(−0.613)	(3.247)	(1.548)
Observations	601	601	601	601
Adjusted R^2	0.135	0.058	0.105	0.081
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table 10: The role of mutual funds for underpricing and customer sales. We present results of the proportion of mutual funds holdings relative to all institutional investors, $MUTINST$. In Panel A, we run the following regression:

$$UP_i = post\_crisis + crisis + \beta_1 MUTINST_i + \beta_2(post\_crisis \times MUTINST_i) \\ + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

We regress UP_i and $SALE_i$ of bond i on dummies ($post\_crisis$ and $crisis$), on mutual funds' holdings, $MUTINST_i$, and an interaction term, $post\_crisis \times MUTINST_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. In Panel B we run first stage regressions with $MUTINST$ and $post\_crisis \times MUTINST$ as dependent variables. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investor's holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

	Panel A Baseline Models		**Panel B** First Stages	
	(1)	(2)	(1)	(2)
Dependent variable	UP	$SALE$	$MUTINST$	$post\_crisis \times MUTINST$
$post\_crisis$	47.361***	1.893*	13.567***	44.042***
	(9.827)	(1.926)	(3.905)	(7.572)
$crisis$	37.529***	−0.533	9.372***	4.749***
	(6.762)	(−0.688)	(8.610)	(3.387)
$MUTINST$	0.690***	−0.059***		
	(5.195)	(−3.350)		
$post\_crisis \times MUTINST$	−0.361***	0.072***		
	(−2.713)	(4.135)		
IV_{MUT}			−3.845	3.078
			(−1.203)	(0.540)
$post\_crisis \times IV_{MUT}$			−0.518	−8.610
			(−0.080)	(−0.784)
Observations	5,172	5,172	5,172	5,172
Adjusted R^2	0.235	0.104	0.692	0.732
First Stage F-stat	-	-	1.447	0.615
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

A Appendix

Proofs

Unless otherwise stated, we solve all equilibria under the following assumptions:

i. Inventory capacity:

i.i. $K - S < \bar{Q}$

i.ii. $\frac{K-2S}{2} < \bar{Q} < K - 2S$

ii. $0 < q < p$

iii. $\lambda(K - S) < p\theta$

Assumption (*i.i*) describes underwriters' inventory capacity in the pre-crisis period, and implies that for none of the investors $\bar{Q}$ is triggered. Assumption (*i.ii*) describes the inventory capacity in the post-crisis period. The total amount in excess of their capacity $(K - 2S)$ exceeds $\bar{Q}$. If investors share the amount in excess of underwriters' capacity equally, then $\bar{Q}$ is not reached. Condition (*ii*) captures the relationship channel, that is, the probability of trading with the relationship investor in the secondary market, p, is greater than the probability of trading with the non-relationship investor, q. Assumption (*iii*) allows us to focus on situations in which the relationship is beneficial for underwriters as the expected intermediation spread exceeds the maximum premium required by investors.

A.1 Pre-crisis

PROPOSITION 1. *Under assumptions (i.i), (ii) and (iii), the underwriters are indifferent between splitting the issue equally among investors or giving everything to one investor.*

Proof: First, we discuss the case in which one dealer gets all the issue. She is indifferent as her profits by splitting equally among investors or allocating the bond to one of them is

$$\Pi(b, K)^{rel} = \Pi(b, K)^{unrel} = \Pi(b, K)^{split} = (\bar{p} - b)S + (n - b)(K - S) \tag{10}$$

Second, we consider the case in which one dealer gets less than her inventory and the other has the remaining part of the issue. Analogously to the first case, j is indifferent with respect to the allocation. Third, if $Q_i > S$ and $Q_j > S$, the underwriters need to jointly decide whether to give the part of the issue exceeding S to the relationship investor, to the non-relationship investor or to split it equally among the two

$$\Pi(b, Q_h)^{rel} = \Pi(b, Q_h)^{unrel} = \Pi(b, Q_h)^{split} = (\bar{p} - b)S + (n - b)(Q_h - S) \tag{11}$$

Again, the profits are the same and therefore underwriters are indifferent. □

PROPOSITION 2. *In any equilibrium in which* $\Pi(b, Q_h) \geq 0$ *we have that* $b_i^* = b_j^*$.

Proof: When $b_i \neq b_j$, one dealer gets the entire offering amount K, while the other gets nothing. Assume $b_i < b_j$ then dealer j gets the entire issue while dealer i gets nothing. This situation is possible only if $\Pi(b_j, Q_j) > 0$, since if $\Pi(b_j, Q_j) = 0$ then dealer j would be indifferent between getting the issue or not. Therefore, we must have

$$\Pi(b_j, K) = (\bar{p} - b_j)S + (n - b_j)(K - S) > 0 \tag{12}$$

If dealer i bids $b_j + \epsilon$, with $\epsilon > 0$, the profit would be

$$\Pi(b_j + \epsilon, K) = (\bar{p} - b_j)S + (n - b_j)(K - S) - \epsilon K \tag{13}$$

which is > 0 if ϵ is sufficiently small. Therefore, i would better off bidding a higher price and, consequently, we do not have an equilibrium. Assume as before $b_i < b_j$, but this time j gets zero profits in equilibrium, i.e. $\Pi(b_j, K) = 0$. If j bids $b_j - \epsilon > b_i$, the profit is

$$\Pi(b_j - \epsilon, K) = (\bar{p} - b_j)S + (n - b_j)(K - S) + \epsilon K > \Pi(b_j, K) = 0 \tag{14}$$

Even in this case there is no equilibrium as dealer j is better off by bidding $b_j - \epsilon$. □

PROPOSITION 3. *There is a unique zero-profit equilibrium, where $Q_i = Q_j = \frac{K}{2}$, and the equilibrium prices are given by $b_j^* = b_i^* = n + \hat{\Delta}$ with $\hat{\Delta} = \frac{2S[\bar{p}-n]}{K}$.*

Proof: The allocation is feasible since $Q_i + Q_j = \frac{K}{2} + \frac{K}{2} = K$ and $\hat{\Delta}$ comes from

$$0 = \Pi\left(n + \hat{\Delta}, \frac{K}{2}\right) = S\left[\bar{p} - n - \hat{\Delta}\right] + \left(\frac{K}{2} - S\right)\left(n - n - \hat{\Delta}\right) \tag{15}$$

No dealer can increase profits by bidding less than $n+\hat{\Delta}$, as she would receive no securities. If she bids ϵ more then we have

$$\Pi\left(n + \hat{\Delta} + \epsilon, K\right) = S\left[\bar{p} - n - \hat{\Delta} - \epsilon\right] + (K - S)\left(n - n - \hat{\Delta} - \epsilon\right) = 0 - \hat{\Delta}\frac{K}{2} - K\epsilon < 0 \tag{16}$$

Increasing the bid would lead to negative profits. We have shown that $\{b_i^*, b_j^*, Q_i^*, Q_j^*\} = \{\frac{K}{2}, \frac{K}{2}, n + \hat{\Delta}, n + \hat{\Delta}\}$ is an equilibrium. It remains to prove that it is unique. From PROPOSITION 1, we must look for equilibria where $b_j = b_i$. Let us start from the case where one dealer (say dealer i) gets less than her inventory capacity, i.e. $0 < Q_i < S$, and earns zero profits. In this case, the profits for i would be

$$\Pi\left(n + \hat{\Delta}, Q_i\right) = Q_i\left[\bar{p} - n - \hat{\Delta}\right] = 0 \tag{17}$$

which means that $\bar{p} - n - \hat{\Delta} = 0$. The profits of dealer j, for $S < Q_j = K - Q_i$, would be

$$\Pi\left(n + \hat{\Delta}, Q_j\right) = S\left[\bar{p} - n - \hat{\Delta}\right] + \left(n - n - \hat{\Delta}\right)(Q_j - S) = -\hat{\Delta}(Q_j - S) < 0 \qquad (18)$$

This cannot be an equilibrium since dealer j earns negative profits. Assume that $Q_i, Q_j > S$. In order to have a zero profit equilibrium we must have

$$S(\bar{p} - b) + [n - b](Q_i - S) = S(\bar{p} - b) + [n - b](Q_j - S) = 0 \qquad (19)$$

This is only possible if $Q_i = Q_j$. We still need to show that there are no alternative prices other than $n + \hat{\Delta}$ when the dealers split the issue. The price that gives zero profits when $Q_i = Q_j = \frac{K}{2}$ is obtained through the equation

$$\Pi\left(b, \frac{K}{2}\right) = S\left(\bar{p} - b\right) + (n - b)\left(\frac{K}{2} - S\right) = 0 \qquad (20)$$

$$b = \frac{[S\bar{p} + n\left(\frac{K}{2} - S\right)]2}{K} = n + \hat{\Delta}$$

Therefore, the unique price that gives zero profits when $Q_i = Q_j = \frac{K}{2}$ is $n + \hat{\Delta}$. □

PROPOSITION 4. *The institutional price n is an equilibrium price. At this equilibrium both dealers fully utilize their inventory capacity S, i.e. $Q_i > S, Q_j > S$.*

Proof: The profit function for $Q_h > S$ gives

$$\Pi\left(n, Q_h\right) = S\left(\bar{p} - n\right) + [n - n]\left(Q_h - S\right) = S\left(\bar{p} - n\right) > 0 \qquad (21)$$

The profit is positive and no dealer would bid less. Suppose i bids ϵ more. The profit is

$$\Pi\left(n + \epsilon, K\right) = S\left(\bar{p} - n - \epsilon\right) + [n - n - \epsilon]\left(K - S\right) = S\left(\bar{p} - n\right) - \epsilon K < \Pi\left(n, Q_i\right) \qquad (22)$$

Hence, there is no incentive to change, and i has no incentive to bid less and get no securities. We need to show that there is no equilibrium with $b = n$ and $Q_i < S$. The dealer would get $\Pi(n, Q_h) = Q_i[\bar{p} - n] > 0$, which gives no incentives to bid less. If the dealer bids ϵ more, the profit would be $\Pi(n + \epsilon, K) = S(\bar{p} - n) - \epsilon K$. The difference between the two profits is $(S - Q_i)(\bar{p} - n) - \epsilon K > 0$ for ϵ small enough. The dealer has therefore an incentive to deviate, meaning there is no equilibrium at $b = n$ and $Q_i < S$. $\square$

PROPOSITION 5. *Any price $b = n + \Delta$, where $0 \leq \Delta \leq \hat{\Delta}$, $Q_i + Q_j = K$ and*

$$\max\left\{K - \frac{S(\bar{p} - n)}{\Delta}, S\right\} \leq Q_h \leq \max\left\{\frac{S(\bar{p} - n)}{\Delta}, K - S\right\} \tag{23}$$

is an equilibrium.

Proof: If $\Delta \to 0$ we would have $S \leq Q_h \leq K - S$, which is the equilibrium described by PROPOSITION 4. If instead $\Delta \to \hat{\Delta}$, we would have $\frac{K}{2} \leq Q_h \leq \frac{K}{2}$ and fall in the equilibrium of PROPOSITION 3. Consider now any price $n + \Delta$ and assume $Q_j = K - Q_i$. We know already from the inequality in PROPOSITION 4 that $Q_i \geq S$ and $Q_j \geq S$. The profit of dealer i is given by:

$$\Pi(n + \Delta, Q_i) = (\bar{p} - n)S - \Delta Q_i \geq (\bar{p} - n)S - \frac{\Delta[(\bar{p} - n)S]}{\Delta} = 0 \tag{24}$$

Where the last inequality follows from $Q_h \leq \max\left\{\frac{S(\bar{p}-n)}{\Delta}, K - S\right\}$. Therefore, i has a positive profit and no incentive to lower the bid. Suppose she bids ϵ more

$$\Pi(n + \Delta + \epsilon, K) = (\bar{p} - n)S - \Delta K - \epsilon K < \Pi(n + \Delta, Q_i) \tag{25}$$

Similar arguments apply for dealer j, and therefore we are in an equilibrium. $\square$

A.2 Post-crisis

PROPOSITION 6. *Under assumptions (i.ii), (ii) and (iii), the underwriters allocate the part of the issue in excess of their inventories to the relationship investor.*

Proof: First, we examine the case in which one dealer gets all the issue. The profit she can get by splitting equally among investors or allocating the issue in one of them is

$$\Pi(b,K)^{split} = (\bar{p}-b)S + (n-b)(K-S) \tag{26}$$

$$\Pi(b,K)^{rel} = (\bar{p}-b)S + (n-\lambda-b)(K-S) + p\theta \tag{27}$$

$$\Pi(b,K)^{unrel} = (\bar{p}-b)S + (n-\lambda-b)(K-S) + q\theta \tag{28}$$

By assumption, we have $\Pi(b,K)^{rel} > \Pi(b,K)^{unrel}$ and $\Pi(b,K)^{rel} - \Pi(b,K)^{split} = p\theta - \lambda(K-S) > 0$. The underwriter always allocates the part in excess of S to the relationship investor. Second, we consider the case in which one dealer gets less than her inventory and the other has the remaining part of the issue. That is, w.l.o.g., $Q_i < S$ and $Q_j - S > \bar{Q}$. Analogously to the first case, j gives all to the relationship investor and Q_i gives only a part of her inventory in the secondary market. Third when $Q_i > S$ and $Q_j > S$ the underwriters need to jointly decide how to allocate what exceeds S. The profits are

$$\Pi(b,Q_h)^{rel} = (\bar{p}-b)S + (n-\lambda-b)(Q_h-S) + p\theta \tag{29}$$

$$\Pi(b,Q_h)^{unrel} = (\bar{p}-b)S + (n-\lambda-b)(Q_h-S) + q\theta \tag{30}$$

$$\Pi(b,Q_h)^{split} = (\bar{p}-b)S + (n-b)(Q_h-S) \tag{31}$$

It follows by (ii) and (iii) that underwriters give everything to the relationship investor.
□

Corollary 6.1. *Assume that there is no relationship channel, i.e.* $p = q > 0$. *If* $q\theta <$

$\lambda(\frac{K}{2} - S)$, *then underwriters always split the issue among the investors.*

Proof: Underwriters can either split the issue or place it with one of the investors. First, we examine the case in which one dealer gets all the issue. The profits are

$$\Pi(b, K)^{split} = (\bar{p} - b)S + (n - b)(K - S) \tag{32}$$

$$\Pi(b, K)^{conc} = (\bar{p} - b)S + (n - \lambda - b)(K - S) + q\theta \tag{33}$$

where $\Pi(b, K)^{split} - \Pi(b, K)^{conc} = \lambda(K - S) - q\theta$ and if $\lambda(K - S) > q\theta$, then the underwriter splits the bond. Second, we consider $Q_i < S$ and $Q_j - S > \bar{Q}$. As in the first case, if $\lambda(Q_j - S) > \lambda(\frac{K}{2} - S) > q\theta$, the underwriter splits the issue among investors. Third, if $Q_i > S$ and $Q_j > S$, the underwriters need to decide how to allocate the part exceeding S

$$\Pi(b, Q_h)^{split} = (\bar{p} - b)S + (n - b)(Q_h - S) \tag{34}$$

$$\Pi(b, Q_h)^{conc} = (\bar{p} - b)S + (n - \lambda - b)(Q_h - S) + q\theta \tag{35}$$

For $\lambda(min(Q_i, Q_j) - S) > q\theta$, they split the issue among the investors. We need to rule out the "conflicting" case in which $\lambda(Q_i - S) < q\theta < \lambda(Q_j - S)$. In this situation we have

$$\Pi_h(b, Q_h)^{split} = (\bar{p} - b)S + (n - b)(Q_h - S) \tag{36}$$

$$\Pi_h(b, Q_h)^{conc} = (\bar{p} - b)S + (n - \lambda - b)(Q_h - S) \tag{37}$$

$$\Pi_i(b, Q_h)^{conc} > \Pi_i(b, Q_h)^{split} \tag{38}$$

$$\Pi_j(b, Q_j)^{conc} < \Pi_j(b, Q_j)^{split} \tag{39}$$

Clearly, underwriters would have opposite incentives on how to allocate the bond at issuance among institutional investors. However, considering that in our model they compete in the price space and not on quantities, this case can be reasonably ruled out in equilibrium. In case both underwriters get some part of the issue, they will split it in a way that does not give rise to such conflict. That is, they either get the same quantity ($\frac{K}{2} = Q_j = Q_i$) or they divide the issue in a way that $\lambda(min(Q_i, Q_j) - S) > q\theta$. □

PROPOSITION 7. *In any equilibrium in which* $\Pi(b, Q_h) \geq 0$ *we have that* $b_i^* = b_j^*$.

Proof: When $b_i \neq b_j$, one dealer gets the entire offering amount K, while the other gets nothing. Assume $b_i < b_j$ then dealer j gets the entire issue while dealer i gets nothing. This situation is possible only if $\Pi(b_j, Q_j) > 0$, since if $\Pi(b_j, Q_j) = 0$ then dealer j would be indifferent between getting the issue or not. Therefore, we must have

$$\Pi(b_j, K) = (\bar{p} - b_j)S + (n - \lambda - b_j)(K - S) + p\theta > 0 \tag{40}$$

If dealer i bids $b_j + \epsilon$, with $\epsilon > 0$, the profit would be

$$\Pi(b_j + \epsilon, K) = (\bar{p} - b_j)S + (n - \lambda - b_j)(K - S) + p\theta - \epsilon K \tag{41}$$

which is greater than zero if ϵ is small. Therefore, i would better off bidding a higher price and thus there is no equilibrium. Assume as before $b_i < b_j$, but this time j gets zero profits in equilibrium, i.e. $\Pi(b_j, K) = 0$. If j bids $b_j - \epsilon > b_i$, the profit would be

$$\Pi(b_j - \epsilon, K) = (\bar{p} - b_j)S + (n - \lambda - b_j)(K - S) + p\theta + \epsilon K > \Pi(b_j, K) = 0 \tag{42}$$

Even in this case there is no equilibrium as dealer j is better off by bidding $b_j - \epsilon$. □

PROPOSITION 8. *There are two zero-profit equilibria and, in both, the equilibrium prices are given by* $b_j^* = b_i^* = n - \lambda + \hat{\Delta}$ *and* $\hat{\Delta} = \frac{2[S(\bar{p} - n + \lambda) + p\theta]}{K}$. *In the first equilibrium,* $Q_i = Q_j = \frac{K}{2}$. *In the second equilibrium* $Q_i < S$ *and* $\hat{\Delta}(Q_j - S) = p\theta$.

Proof: The allocation is feasible since $Q_i + Q_j = \frac{K}{2} + \frac{K}{2} = K$. At this allocation, dealers' profits will be zero if each of them bids $n - \lambda + \hat{\Delta}$, where $\hat{\Delta}$ comes from

$$0 = \Pi\left(n - \lambda + \hat{\Delta}, \frac{K}{2}\right) = S\left[\bar{p} - n + \lambda - \hat{\Delta}\right] + \left(\frac{K}{2} - S\right)\left(n - \lambda - n + \lambda - \hat{\Delta}\right) + p\theta \quad (43)$$

No dealer can increase profits by bidding less than $n - \lambda + \hat{\Delta}$, as she would receive no securities. If she bids ϵ more then

$$\Pi\left(n - \lambda + \hat{\Delta} + \epsilon, K\right) = S\left[\bar{p} - n + \lambda\right] + p\theta - \hat{\Delta}K - \epsilon K < \Pi\left(n - \lambda + \hat{\Delta}, \frac{K}{2}\right) = 0 \quad (44)$$

Increasing the bid would lead to negative profits, and the underwriter has no incentive to do it. We have shown that $\{b_i^*, b_j^*, Q_i^*, Q_j^*\} = \{\frac{K}{2}, \frac{K}{2}, n - \lambda + \hat{\Delta}, n - \lambda + \hat{\Delta}\}$ is an equilibrium. It remains to prove that it is unique. From PROPOSITION 6, we must look for equilibria where $b_j = b_i$. We need to show that there is no zero profit equilibrium when $Q_i \neq Q_j$. Assume $0 < Q_i < S$ and i earns zero profits. We would have

$$\Pi\left(n - \lambda + \hat{\Delta}, Q_i\right) = Q_i\left[\bar{p} - n + \lambda - \hat{\Delta}\right] = 0 \quad (45)$$

$$\Pi\left(n - \lambda + \hat{\Delta}, Q_j\right) = 0 - \hat{\Delta}(Q_j - S) + p\theta \quad (46)$$

If $p\theta < \hat{\Delta}(Q_j - S)$ there is no equilibrium since no dealer would accept negative profits. If $p\theta > \hat{\Delta}(Q_j - S)$ the zero profit equilibrium does not hold, since one dealer has positive profits. If $\hat{\Delta}(Q_j - S) = p\theta$ then we have another zero profit equilibrium because dealers have no incentive to deviate from this allocation. Assume one dealer bids ϵ more and gets all the issue. The profit would be

$$\Pi\left(n - \lambda + \hat{\Delta} + \epsilon, \frac{K}{2}\right) = \hat{\Delta}(Q_j - S) - \hat{\Delta}(K - S) - \epsilon K < 0 \quad (47)$$

Therefore, there is no incentive for i or j to bid more. No dealer would bid less and keep profits at zero. It is worth to note that this equilibrium is quite "unstable" since it is based on the condition that $\hat{\Delta}(Q_j - S) = p\theta$, which is economically unlikely to hold. Assume now $Q_i, Q_j > S$. In order to have a zero profit equilibrium we must have

$$0 = S(\bar{p} - n + \lambda) - \hat{\Delta}Q_h + p\theta \tag{48}$$

This is only possible if $Q_i = Q_j$. We still need to show that there are no alternative prices other than $n - \lambda + \hat{\Delta}$ when the dealers split the issue. The price that gives zero profits when $Q_i = Q_j = \frac{K}{2}$ is obtained through the equation

$$\Pi\left(b, \frac{K}{2}\right) = S\left(\bar{p} - b\right) + (n - \lambda - b)\left(\frac{K}{2} - S\right) + p\theta = 0 \tag{49}$$
$$b = \frac{2[S(\bar{p} - n + \lambda) + p\theta]}{K} = \hat{\Delta}$$

Therefore, the unique price that gives zero profits when $Q_i = Q_j = \frac{K}{2}$ is $n - \lambda + \hat{\Delta}$. □

PROPOSITION 9. *The lowest institutional price $n - \lambda$ is an equilibrium price. In this equilibrium both dealers obtain more than their inventory S.*

Proof: The profit for each dealer is:

$$\Pi(n - \lambda, Q_h) = (\bar{p} - n + \lambda)S + p\theta \tag{50}$$

If any dealer bids ϵ more, the profit becomes

$$\Pi(n - \lambda + \epsilon, K) = (\bar{p} - n + \lambda)S + p\theta - \epsilon K < (\bar{p} - n + \lambda)S + p\theta = \Pi(n - \lambda, Q_h) \tag{51}$$

The profit is lower and therefore there is no incentive to bid more. No dealer wants to bid less and get zero. We still need to show that there is no equilibrium with $b = n - \lambda$ and $Q_i < S$. In this case the dealer would get $\Pi(n - \lambda, Q_i) = Q_i[\bar{p} - n + \lambda] > 0$, which provides no incentives to bid less. If the dealer bids ϵ more, the profit would become $\Pi(n - \lambda + \epsilon, K) = S(\bar{p} - n + \lambda) + p\theta - \epsilon K$. The difference between the two profits gives $(S - Q_i)(\bar{p} - n + \lambda) + p\theta - \epsilon K > 0$ for ϵ small enough. The dealer has therefore an incentive to deviate, meaning there is no equilibrium at $b = n - \lambda$ and $Q_i < S$. □

Corollary 9.1. *Assume that there is no relationship channel, i.e. $p = q > 0$. If $q\theta < \lambda(\frac{K}{2} - S)$, n is an equilibrium price. In this equilibrium both dealers receive more than S and $q\theta < (min(Q_i, Q_j) - S)$.*

Proof: We know already from Corollary 6.1 that if $q\theta < \lambda(\frac{K}{2} - S)$ the underwriters would always split among the institutional investors the amount in excess of their inventories. The profit of each dealer is

$$\Pi(n, Q_h) = (\bar{p} - n)S + (n - n)(Q_h - S) = (\bar{p} - n)S \tag{52}$$

If any dealer bids ϵ more, the profit becomes

$$\Pi(n + \epsilon, K) = (\bar{p} - n)S - \epsilon K < \Pi(n, K) \tag{53}$$

Hence, there is no incentive to bid more. No dealer wants to bid less and get zero. We still need to show that there is no equilibrium with $b = n$ and $Q_i < S$. In this case the dealer would get $\Pi(n, Q_h) = Q_h[\bar{p} - n] > 0$, which provides no incentives to bid less and get zero. If the dealer bids ϵ more, the profit is $\Pi(n + \epsilon, K) = S(\bar{p} - n) - \epsilon K$. The difference gives $(S - Q_i)(\bar{p} - n) - \epsilon K > 0$ for ϵ small enough. The dealer has an incentive to deviate, meaning there is no equilibrium at $b = n$ and $Q_i < S$. □

PROPOSITION 10. *Any price* $b = n - \lambda + \Delta$*, where* $0 \leq \Delta \leq \hat{\Delta}$*,* $Q_i + Q_j = K$ *and*

$$\max\left\{K - \frac{S(\bar{p} - n + \lambda) + p\theta}{\Delta}, S\right\} \leq Q_h \leq \max\left\{\frac{S(\bar{p} - n + \lambda) + p\theta}{\Delta}, K - S\right\} \tag{54}$$

is an equilibrium.

Proof: Let's first check the lowest and highest value that Δ can assume. If $\Delta \to 0$ we have $b = n - \lambda$ and $S \leq Q_h \leq K - S$, which means that we are in the equilibrium described by PROPOSITION 9. If instead $\Delta \to \hat{\Delta}$, we have $b = n - \lambda + \hat{\Delta}$ and $\frac{K}{2} \leq Q_h \leq \frac{K}{2}$. Therefore, we are in the equilibrium of PROPOSITION 8. Consider now any price $n - \lambda + \Delta$ and assume $Q_j = K - Q_i$. We know already from the inequality in PROPOSITION 10 that $Q_i \geq S$ and $Q_j \geq S$. The profit of dealer i is given by

$$\Pi(n - \lambda + \Delta, Q_i) = (\bar{p} - n + \lambda)S - \Delta Q_i + p\theta \geq (\bar{p} - n + \lambda)S - \frac{\Delta[(\bar{p} - n + \lambda)S + p\theta]}{\Delta} = 0 \tag{55}$$

Where the last inequality follows from $Q_h \leq \max\left\{\frac{S(\bar{p} - n + \lambda) + p\theta}{\Delta}, K - S\right\}$. Therefore, dealer i has no incentive to lower the bid to receive 0. Suppose she bids ϵ more:

$$\Pi(n - \lambda + \Delta + \epsilon, K) = (\bar{p} - n + \lambda)S - \Delta K + p\theta - \epsilon K < \Pi(n - \lambda + \Delta, Q_i) \tag{56}$$

Similar arguments apply for dealer j, and therefore we are in an equilibrium. □

Internet Appendix

Internet Appendix for

Inventory Capacity and Corporate Bond Offerings

Table IA1: First-stage regressions, IV based on ranking. We present results of the following first-stage regressions:

$$\begin{aligned} INST_i =& post\_crisis + crisis + \theta_1 IV_i + \theta_2(post\_crisis \times IV_i) \\ &+ \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \\ post\_crisis \times INST_i =& post\_crisis + crisis + \theta_3 IV_i + \theta_4(post\_crisis \times IV_i) \\ &+ \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i \end{aligned}$$

We regress $INST_i$ and $post\_crisis \times INST_i$ of bond i on dummies ($post\_crisis$ and $crisis$), on our instrumental variable, IV_i, and an interaction term, $post\_crisis \times IV_i$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. IV_i is based on sorting, in each period (pre-crisis, crisis and post-crisis), the concentration of past institutional holdings of underwriters' own bonds into quintile bins (lowest to highest). The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

	(1)	(2)
Dependent variable:	$INST$	$post\_crisis \times INST$
$post\_crisis$	6.561***	42.777***
	(5.127)	(43.065)
$crisis$	−2.639***	−0.536
	(−2.974)	(−1.208)
IV	0.940***	−0.275**
	(3.734)	(−2.556)
$post\_crisis \times IV$	−0.175	1.246***
	(−0.470)	(4.501)
Observations	5,172	5,172
Adjusted R^2	0.220	0.803
First stage F-stat	13.943	20.258
Controls	Yes	Yes
Rating FE	Yes	Yes
Industry FE	Yes	Yes
Syndicate Structure FE	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes

Table IA2: Bond characteristics for high and low values of *IV*. We provide descriptive statistics for bond characteristics for high values (highest quintile) and low values (lowest quintile) of IV. We show the means and medians for the instrumental variable, IV, amount issued, maturity, coupon, rating, and for syndicate structure. We assign integer numbers to ratings (i.e., AAA=1, AA+=2, ..., D=22). The sample comprises U.S. corporate bond offerings obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX.

		High IV		Low IV	
Variable	Unit	Mean	Median	Mean	Median
IV	[%]	22.355	21.500	9.415	9.760
Amount Issued	[millions]	501.924	400.000	549.042	425.000
Maturity	[years]	12.250	10.022	11.669	10.014
Coupon	[%]	5.653	5.500	5.907	5.750
Rating	[integer]	9.580	9.000	9.548	9.000
Syndicate Structure	[integer]	2.455	2.000	2.110	2.000

Table IA3: Second-stage regressions, *IV* based on ranking. We present results of the following second-stage regression:

$$UP_i = post\_crisis + crisis + \beta_1 \hat{INST}_i + \beta_2 (\widehat{post\_crisis \times INST_i}) + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

In Panel A we regress UP_i, estimated over five days, of bond i on dummies ($post\_crisis$ and $crisis$), on the instrumented institutional investors' holdings, $\hat{INST}_i$, and an instrumented interaction term, $\widehat{post\_crisis \times INST_i}$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. Column (1) shows the OLS-estimates of Table 4 while column (2) shows the 2SLS-estimates. In Panel B we run the regression with $SALE_i$ as the dependent variable. We present results for IV based on quintile bins (see Table IA1 for first-stage regression). The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level, and are adjusted for the 2SLS-bias in the second-stage regressions.

	Panel A		**Panel B**	
	UP		$SALE$	
	(1)	(2)	(1)	(2)
	OLS	2SLS	OLS	2SLS
$post\_crisis$	66.498***	−84.921	3.641***	−25.924**
	(7.178)	(−1.260)	(2.979)	(−2.038)
$crisis$	43.168***	40.472***	−0.768	−0.332
	(7.859)	(5.511)	(−1.014)	(−0.308)
$INST$	0.161	−1.481	0.022	0.089
	(1.266)	(−0.991)	(0.937)	(0.293)
$post\_crisis \times INST$	−0.528***	2.950*	0.003	0.632**
	(−3.020)	(1.919)	(0.103)	(2.146)
Observations	5,172	5,172	5,172	5,172
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table IA4: Second-stage regressions, alternative definitions of *IV*. We present results of the following second-stage regression:

$$UP_i = post\_crisis + crisis + \beta_1 \hat{INST}_i + \beta_2 (\widehat{post\_crisis \times INST_i}) + \gamma' X_i + \alpha_{rat} + \alpha_{ind} + \alpha_{sys} + \epsilon_i$$

In Panel A we regress UP_i, estimated over five days, of bond i on dummies ($post\_crisis$ and $crisis$), on the instrumented institutional investors' holdings, $\hat{INST}_i$, and an instrumented interaction term, $\widehat{post\_crisis \times INST_i}$, as well as a set of controls, X_i, and rating, α_{rat} (based on 21 notches), industry, α_{ind} (based on 4-digit SIC) and syndicate structure, α_{sys} (number of lead underwriters), fixed-effects. Column (1) shows the OLS-estimates of Table 4 while column (2) shows 2SLS-estimates. In Panel B we run the regression with $SALE_i$ as the dependent variable. We present results for IV based on alternative definitions of the top investors in underwriters' own bonds. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level, and are adjusted for the 2SLS-bias in the second-stage regressions.

	Panel A		**Panel B**	
	UP		$SALE$	
	(1)	(2)	(1)	(2)
	OLS	2SLS	OLS	2SLS
IV Based on Top 10% Investors				
$post\_crisis$	66.498***	−142.527**	3.641***	−21.968**
	(7.178)	(−2.471)	(2.979)	(−2.015)
$crisis$	43.168***	39.487***	−0.768	−0.850
	(7.859)	(5.531)	(−1.014)	(−0.821)
$INST$	0.161	−2.090*	0.022	−0.105
	(1.266)	(−1.709)	(0.937)	(−0.367)
$post\_crisis \times INST$	−0.528***	4.271***	0.003	0.572**
	(−3.020)	(3.245)	(0.103)	(2.191)
IV Based on Top 40% Investors				
$post\_crisis$	66.498***	−122.286**	3.641***	−19.124*
	(7.178)	(−2.188)	(2.979)	(−1.877)
$crisis$	43.168***	40.811***	−0.768	−0.784
	(7.859)	(5.910)	(−1.014)	(−0.769)
$INST$	0.161	−1.482	0.022	−0.068
	(1.266)	(−1.295)	(0.937)	(−0.246)
$post\_crisis \times INST$	−0.528***	3.756***	0.003	0.505**
	(−3.020)	(2.982)	(0.103)	(2.079)
Observations	5,172	5,172	5,172	5,172
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Syndicate Structure FE	Yes	Yes	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table IA5: First-stage regressions, robustness of *IV*. We present results of the first-stage regressions:

$$INST_i = crisis + \theta_1 IV_i + \theta_2(post\_crisis \times IV_i) + \gamma_1' X_i + \gamma_2'(post\_crisis \times X_i) + \alpha_{post\_crisis \times rat} + \alpha_{post\_crisis \times ind} + \alpha_{post\_crisis \times sys} + \epsilon_i$$

$$post\_crisis \times INST_i = crisis + \theta_1 IV_i + \theta_2(post\_crisis \times IV_i) + \gamma_1' X_i + \gamma_2'(post\_crisis \times X_i) + \alpha_{post\_crisis \times rat} + \alpha_{post\_crisis \times ind} + \alpha_{post\_crisis \times sys} + \epsilon_i$$

In Panel A we present results without time-varying control variables (see Table 5). In Panel B we regress $INST_i$ and $post\_crisis \times INST_i$ of bond i on the crisis-dummy, on our instrumental variable, IV_i, and an interaction term, $post\_crisis \times IV_i$, as well as a set of controls, X_i, and their interactions, $post\_crisis \times X_i$, and rating-time, $\alpha_{post\_crisis \times rat}$ (based on 21 notches), industry-time, $\alpha_{post\_crisis \times ind}$ (based on 4-digit SIC) and syndicate structure-time, $\alpha_{post\_crisis \times sys}$ (number of lead underwriters), fixed-effects. IV_i is based on the concentration of past institutional holdings of underwriters' own bonds. The sample comprises 5,172 U.S. corporate bond offerings of non-financial firms obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX. The t-statistics in parentheses are based on standard errors that are clustered at the syndicate-period level.

	Panel A Standard First Stage		**Panel B** Robustness First Stage	
	(1)	(2)	(1)	(2)
Dependent variable	$INST$	$post\_crisis \times INST$	$INST$	$post\_crisis \times INST$
IV	0.284***	−0.069**	0.283***	0.001
	(4.507)	(−2.476)	(4.491)	(0.001)
$post\_crisis \times IV$	0.053	0.491***	0.082	0.365***
	(0.489)	(5.470)	(0.754)	(4.080)
Observations	5,172	5,172	5,172	5,172
Adjusted R^2	0.223	0.804	0.216	0.801
Controls	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	No	No
Industry FE	Yes	Yes	No	No
Syndicate Structure FE	Yes	Yes	No	No
$post_crisis \times$Controls	No	No	Yes	Yes
$post_crisis \times$Rating FE	No	No	Yes	Yes
$post_crisis \times$Industry FE	No	No	Yes	Yes
$post_crisis \times$Syndicate Structure FE	No	No	Yes	Yes
SE Clustering: Syndicate-Period	Yes	Yes	Yes	Yes

Table IA6: Summary statistics of underwriters' own bonds. We summarize descriptive statistics for underpricing, UP, customer sales volume, $SALE$, the fraction of a bond's offering amount held by institutional investors at the end of the issuance quarter, $INST$, the fraction of a bond's offering amount held by mutual funds at the end of the issuance quarter, MUT, the instrumental variable, IV, amount issued, maturity, coupon, rating, and for syndicate structure. UP is defined as the average return of a newly issued bond over five days relative to the bonds' offering price in excess of the market return over the corresponding days. $SALE$ is defined as the cumulative customer sales volume scaled by amount issued within five days after issuance. We assign integer numbers to the ratings (i.e., AAA=1, AA+=2, ..., D=22). We report across all bonds the means, standard deviations, and the 25%, 50%, and 75% quantiles. The sample comprises 601 U.S. corporate bond offerings of underwriters obtained from Mergent FISD and transaction data from TRACE for the period from January 2003 to December 2013. We retrieve information on investors' holdings of corporate bonds from Lippers eMAXX.

Variable	Unit	Mean	Stdv	q25	q50	q75
UP	[bps]	17.983	61.532	−7.141	12.949	39.837
$SALE$	[%]	10.513	14.921	3.067	7.500	13.335
$INST$	[%]	28.187	16.201	16.937	25.955	35.648
MUT	[%]	9.031	7.972	2.440	6.720	14.482
IV	[%]	14.832	6.313	10.219	14.888	18.614
Amount issued	[millions]	1342.720	952.128	750.000	1000.000	2000.000
Maturity	[years]	8.098	6.550	5.011	5.047	10.027
Coupon	[%]	4.201	1.624	2.950	4.500	5.450
Rating	[integer]	4.972	1.738	4.000	5.000	6.000
Syndicate Structure	[integer]	1.268	0.627	1.000	1.000	1.000