Call Me Maybe: Anomalies in Callable Bond Prices

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This draft: July 2023[c]

Abstract

In a sample of discretely callable corporate bonds, we find excess returns of approximately 40 b.p. realized on the release of the issuer's decision to call or not to call. The bonds that should have been called (in-the-money bonds) but are not called contribute the most to the bond price jump. We attribute the jump to the revaluation of an embedded bond call option due to a missed exercise opportunity. Investors sell callable bonds prior to the release of the issuer's decision and later buy back not-called, in-the-money bonds, leaving the price jump in bond dealers' pockets.

Keywords: Callable bonds, call dates, option, exercise, moneyness, trading volume

JEL Classification: G12

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[c]We thank seminar participants at VU Amsterdam and Morgan Stanley for insightful comments and feedback. All remaining errors are our own. We have no conflicts of interest.

Introduction

Bonds with fixed coupon payments appear to be straightforward financial instruments. Discounting a stream of known cashflows, one obtains the bond price. Applying this concept in practice is more involved than it might sound. For instance, the bond issuer may declare a default. Additionally, the issuer may decide to call the bond before maturity if she has the right to do so. The latter feature, known as bond callability, substantially complicates bond pricing. From an investor's point of view, a callable bond purchase is simultaneously a sale of a call option to the bond issuer. To render things even more complicated, such a call option is written not on the callable bond itself but on its non-callable counterpart, which likely does not even exist. Such complex transactions in fact constitute the majority of corporate bond trading. Approximately two-thirds of secondary market transactions involving U.S. corporate bonds in the last twenty years are made with callable bonds. A better understanding of callable bond pricing is thus of major importance for investors, dealers, and market regulators.

This paper studies callable bond prices around dates when uncertainty about call decisions is resolved. A subset of callable corporate bonds, known as 'retail notes', has discrete call schedules predetermined at the time of bond issuance. If the issuer calls the bond, it must notify the bondholders about the call, typically no later than thirty days prior to a set call date. If the issuer does not call the bond at the nearest call date, there is no call notice at the thirty-day deadline.[1] In either case, the uncertainty is resolved no later than the notice deadline, which is a calendar date known since issuance. We run an event study on callable bond prices and trading volumes around such exogenous notice deadline dates.

We find large and positive bond returns realized after the passage of the call notice deadline. The average bond price appreciation on the resolution of call uncertainty amounts to approximately 90 b.p. We attribute two-thirds (60 b.p.) of the effect to changes in the general level of interest rates in the economy within the event window and one-third (30 b.p.) to the revaluation of an embedded call option. van Binsbergen and Schwert (2022) find that, on average, only approximately 5 to 10 b.p. of monthly corporate bond returns are unexplained by changes in the general level of interest rates. We find that around bond call notice dates, this unexplained component is several times larger, and we analyze why that is the case.

[1]However, the issuer still has the right to call the bond at one of the later call dates. The embedded call option is thus of the Bermudan kind.

Bonds differ in the likelihood of an early call. If the issuer can retire an existing bond and replace it with the new one at a lower cost, she should do so. Denote as 'in-the-money' (ITM) such callable bonds that can be profitably retired and replaced. Similarly, out-of-the-money (OTM) bonds are those that cannot be refinanced at better terms. The arrival of a call notice for an ITM bond should be of less surprise to investors than no such notice. Analogously, the call of an OTM bond is more of a surprise than an OTM no-call. Do we observe higher notice returns when there is a surprising resolution of call uncertainty? Yes, we do.

We built a practical measure of call option moneyness that does not depend on the callable bond price and uses the prices of similar non-callable bonds instead. Categorizing bonds by moneyness, we find that a substantial share of ITM bonds is not called timely, even after accounting for call and re-issuance costs. ITM no-calls turn out to be the main driver of bond returns around call notice deadline dates. In such instances, bond prices appreciate by 50-60 b.p. above and beyond what is explained by changes in the general level of interest rates. Accounting for confounding stock market effects and the price impact of investors purchasing the bonds post-notice, the effect drops to 30-40 b.p., which we attribute to the revaluation of an embedded bond call option following an unexpected no-exercise decision. In line with this explanation, the observed no-call price jump is higher for short-term than for long-term ITM bonds. We also calibrate a parsimonious option pricing model to demonstrate that one could expect a similar variation in the bond price on a missed call date in a classic no-arbitrage pricing setting.

The left panel of Figure 1 shows an average callable bond price jump that we observe around missed call opportunities in the data. As discussed, after an initial appreciation of approximately 50 b.p., prices revert slightly to settle at a level approximately 40 b.p. higher than pre-event. Bondholders benefit from such a price appreciation. We do not observe the structure of callable bond ownership, but we know the amount of net purchases by bond investors from dealers. It turns out that just before scheduled call notice days, the investors are net sellers of callable bonds (all of them, not only ITM but also OTM). Therefore, dealers' callable bond inventory increases pre-notice. Following the absence of a call notice, investors buy back ITM bonds from dealers – but at prices that are now 40-50 b.p. higher (controlling for a possible bid-ask bounce effect), and bond dealers pocket the difference. The right panel of Figure 1 summarizes these trading volume imbalances around call notice dates.

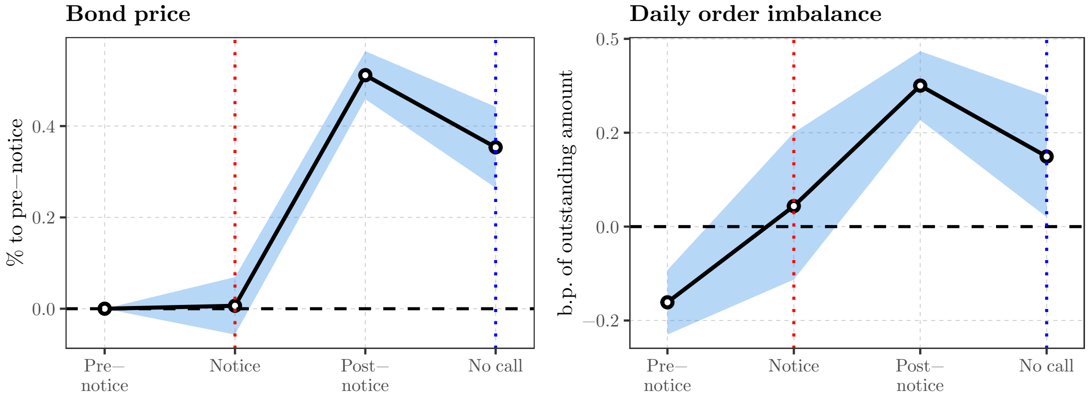

Figure 1: Bond price and average net daily volume for in-the-money bonds that were not called by the issuers. The left figure plots the dynamic of the average bond transaction price (excluding accrued interest), as % change to the pre-notice period (see below). The right figure plots the average daily net volume, defined as purchases by investors from dealers minus sales by investors to dealers, in b.p. of the bond outstanding amount. An 'in-the-money' bond is a bond that the issuer could have called and replaced, at better terms, with an otherwise identical non-callable bond. Here, the sample is in-the-money bonds that were *not* called by the issuers. On the x-axis, 'notice' is the period of seven calendar days ending with the latest possible bond call announcement date (the latest date when the uncertainty about the nearest possible bond call is resolved). 'Pre-notice' and 'post-notice' are thirty calendar days before and after the 'notice' period. 'No call' is seven days around the date when the call should have been exercised if the bond had been called. The shaded area is two standard deviations around the cross-sectional mean. The sample period is 2010–2019.

Can an investor exploit bond price jumps around scheduled call notice dates? We believe that this largely depends on the ability to optimize bond trading costs. Our sample of discretely callable corporate bonds consists of retail notes with smaller outstanding amounts than institutional bond issues. It is more expensive to trade bonds with smaller than larger outstanding amounts. The estimates available in the literature suggest that a round-trip cost of trading a typical bond in our sample is above 100 b.p. (Bessembinder, Jacobsen, Maxwell, and Venkataraman 2018), which fully offsets the no-call price jump. This suggests, again, that dealers holding callable bonds in inventory are the main beneficiaries of such price jumps.

By identifying jumps in callable bond prices at call information events, our paper contributes to the literature that studies the value of embedded bond call options. King (2002) evaluates embedded option values by constructing non-callable bond portfolios that exactly match traded callable bonds in coupon rates and maturity. The paper describes the cross-sectional distribution of the option premium and shows that the embedded bond call option is, on average, worthless up to one year before the first possible call date. The firms that call aggressively also have a higher option premium. Becker, Campello, Thell, and Yan (2023), in the first part of their paper, evaluate bond call option premia on a more recent sample to find an average premium of approximately 2-2.5%, which is close to King (2002). Our paper extends these results by showing how the call premium changes over time upon the release of new public information about future calls.

Our results depend strongly on ex ante call likelihood, which links our paper to the literature on why and how bond issuers call their bonds. Mauer (1993) shows that, because of transaction costs, it may not be optimal for a firm to call a bond as soon as the embedded call option is ITM. King and Mauer (2014) examine why firms call their bonds and show that only 23% of the calls are to refund at a lower cost. Calls that allow the removal of restrictive covenants are twice as common. King and Mauer (2014) also investigate the delay between when it becomes optimal to call and when the bond is called. Such a delay (which is a suboptimal no-exercise leading to a price jump in our study) is more likely under higher refinancing costs, higher interest rate volatility, a steeper term structure of interest rates, and less liquidity on the issuer's balance sheet, according to King and Mauer (2014). In a related work, Chen, Cohen, and Liu (2022) show that municipal bonds are not exercised optimally, leading to high costs for municipalities. In that paper, the suboptimal no-exercise is due to a lack of issuer attention. Examining callable bonds that should be called but are not called timely, Chen *et al.* (2022) show that this occurs more often at fiscal year-ends, which are known to be hectic times with a lack of available human resources. Our paper contributes by quantifying the option value destroyed upon suboptimal no-exercise by large corporate issuers.

One can also view the documented cost of not exercising an embedded bond call option as insufficient to outweigh a publicly unobserved benefit to the issuer from having callable debt on the balance sheet. This links our work to a broader literature on why firms issue callable debt in the first place. Crabbe and Helwege (1994) examine multiple agency-theoretical reasons for why firms issue callable bonds but find little supporting evidence for either. More recently, Chen, Mao, and Wang (2010) argue that firms might issue callable bonds when management believes that future investment risks are high. They empirically confirm their theoretical assumptions. Becker *et al.* (2023) and Flor, Petersen, and Schandlbauer (2023) both link the issuance of callable bonds to the debt overhang problem but disagree on whether callable debt alleviates or exacerbates the problem. Finally, Ma, Streitz, and Tourre (2023) develop an elegant model to distinguish the role played by interest rate risk and rollover risk in the decision to issue callable versus non-callable bonds. They apply the model to high-yield callable bonds to find supporting evidence for callable debt being used as an instrument to manage rollover risk. Most of the above literature links callable debt issuance and management to agency conflicts within a firm. Our paper shows that the marginal investor in callable bonds likely has a simpler view of the world: an ITM callable bond should be called, and if it is not, the prices adjust accordingly, even if the issuer keeps receiving agency benefits of callable debt.

Our study also sheds light on the risks associated with investments in retail notes, which are a popular investment instrument among high net-worth individuals, family offices, corporate treasuries, and smaller discretionary bond mutual funds. In 2019, the Fixed Income Market Structure Advisory Committee (FIMSAC) established by the SEC called to *'...educate retail investors on the uses, characteristics, and risks of retail notes. The initiative should identify the embedded issuer call option and survivor put options that are typical in these notes along with other options that may have an impact on the pricing of these notes.'* U.S. SEC (2019). Our paper addresses this call.

The paper is organized as follows. Section 1 discusses the sample, establishes the timeline of events preceding possible bond calls, defines event returns and bond moneyness, and presents the summary statistics. Section 2 focuses on the cross-section of event returns. Section 3 studies bond moneyness and its relationship with call probability and links moneyness, (no-)calls, and event returns – both in the data and in a calibrated option pricing model. Section 4 elaborates on the trading volume patterns in the event window. Section 5 discusses the implications for callable bond portfolio investments, and Section 6 concludes the paper.

1 Sample, notice events, and return measurement

1.1 Sample

The majority of corporate bonds traded in the U.S. are callable. In TRACE (the dataset of all corporate bond transactions administered by FINRA since 2004), approximately 70% of transactions are with callable bonds (also referred to as 'callables' below). The callable bond issuer has the right to call the bond before maturity. The terms of such a call vary across bonds. The key characteristics of the call feature are when (how often) and at what price the bond can be called. With respect to the call price, a callable bond typically falls into one of two categories. The first category of bonds pays back the discounted sum of all remaining cash flows. The spread to the Treasury curve used to determine the discount rates is typically fixed at the time of bond issuance. Such bonds are called 'make-whole' callable bonds, and they comprise approximately 75% of the callable TRACE subset. Bonds of the second category, when called, pay back a fixed price. Such a call price (or a schedule of call prices) is also fixed at issuance. These bonds, which we call 'non-make-whole' callables, constitute the rest of the subset of callable TRACE bonds. Make-whole bonds are predominantly continuously callable, meaning they can be called at any date (possibly after an initial protection period of several years). Conversely, most non-make-whole bonds are only callable at fixed dates predetermined at issuance. Such discreteness of the set of possible call dates is particularly useful for the analysis of the resolution of uncertainty surrounding call decisions. Thus, in this paper, our sample consists of non-make-whole, discretely callable bonds. It accounts for approximately 20% of all callable bonds in TRACE.[2]

Almost all non-make-whole, discretely callable corporate bonds in TRACE are of a specific type called 'retail notes'. A retail note is a corporate debt security that, at initial offering, can be purchased directly from the issuer and in smaller lots than in a typical 'institutional' bond offering.[3] The term 'retail' might be misleading because, anecdotally, the notes are also popular among discretionary institutional investors and corporate treasuries. In the secondary corporate bond market, retail notes trade in the same dealer-intermediated over-the-counter (OTC) market as institutional bonds. To preserve the homogeneity of our sample, we remove a handful of non-make-whole, discretely callable bonds that are not retail notes. Our final sample consists exclusively of retail notes. As is common in the corporate bond literature, we only retain fixed-coupon, USD-denominated,

[2]Some elements of our analysis also apply to make-whole callables. In particular, the calculation of the moneyness of the embedded option differs only slightly between non-make-whole and make-whole callables. However, the event study methodology presented in Section 1.2 does not straightforwardly extend to make-whole bonds. Nonetheless, we believe that the economic mechanisms discussed in the paper are equally relevant for make-whole callables.

[3]Brokers usually act as sales agents for the issuers at initial retail note offerings. Unlike in the traditional underwriting process, brokers receive commissions but do not hold notes in their inventory. Additionally, retail notes can be redeemed at par by the survivors of a deceased investor. We believe that these characteristics of retail notes are not critical for the external validity of our exercise.

not asset-backed, and non-convertible bonds in the sample. We clean raw TRACE data as in Dick-Nielsen (2014).

An important feature of a call option embedded in retail notes is that, at issuance, it has multiple possible exercise dates; in other words, the call option is Bermudan. If the issuer does not call the bond at the nearest call date, she can still call the bond at one of the later exercise dates (unless it is the last of the scheduled exercise opportunities). If the intervals between scheduled call dates were zero, a Bermudan option would be identical to an American option. In our sample, the majority of bonds are callable semi-annually. We also have a few bonds callable quarterly or annually. We remove from the sample a handful of bonds callable at a monthly (or shorter) frequency to preserve the interpretability of our event study, which we now describe.

1.2 Event timeline

All bonds in our sample have a calendar of possible call dates and call prices, which are known at issuance. If the issuer decides to call the bond, she must issue a call notice at least 30 days prior to the scheduled call date.[4] Therefore, either a release of the call notice or a passage of the 30-day notice deadline (without notice being released) resolves the uncertainty about the nearest possible call. Assuming that bond issuers do not release call notices earlier than a week before the notice deadlines,[5] we define a period of 7 calendar days prior to (and including) the notice deadline as the instance when the new information about the value of the embedded call option becomes public. This is an information event around which we conduct an event study.

Figure 2 presents the timeline of the event study. Our main focus is the comparison of post- to pre-notice bond prices. We define the pre-notice period as 28 calendar days ending 7 days before the scheduled call notice deadline. The post-notice period is 28 calendar days following the notice deadline. In the post-notice period, it is publicly known whether the bond will be called at the nearest call date (which is date 0 in Figure 2). In the pre-notice period, such information is not publicly available. The difference between pre- and post-notice bond prices is the event return, which is the main focus of this paper.

[4] Alternative call notice periods, longer or shorter than 30 calendar days, are possible, but that does not occur in our sample. The call notice period, as registered in the prospectus, is available in the Mergent FISD dataset, which we use for bond characteristics.

[5] There is no dataset with a historical record of call notice release dates. We manually checked the release dates in a few recent bond calls on Bloomberg and did not find any evidence of call notice releases earlier than 7 days prior to the deadlines.

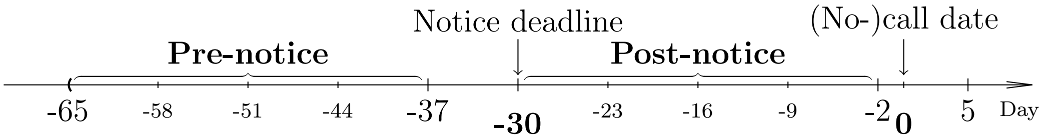

Figure 2: Event timeline in calendar days. Day 0 is the possible bond call date. It is known at the time when the bond is issued. Day -30 is the deadline for a call notice. We define 'pre-notice' period as 28 calendar days ending one week before the latest possible call notice, corresponding to days between 64 and 37 on the event timeline (inclusive). 'Post-notice' period is another 28 calendar days between -29 and -2 on the event timeline.

As previously mentioned, we exclude from consideration bonds that are callable monthly: for such bonds, event periods overlap, which creates a mechanical dependence between notice returns in the cross-section of bond events. Therefore, the set of notice events consists of non-overlapping bond-event observations.

1.3 Return measurement

We define total bond return, R_i, around a (no-)call notice event i as

$$R_i = \frac{\bar{P}_i^{\text{post}} - \bar{P}_i^{\text{pre}}}{\bar{P}_i^{\text{pre}}},$$

where $\bar{P}_i^{\text{pre}}$ and $\bar{P}_i^{\text{post}}$ are simple averages of volume-weighted daily invoice prices in the pre- and post-notice periods, respectively, as defined in Figure 2.[6] We observe $\bar{P}_i^{\text{pre}}$ and $\bar{P}_i^{\text{post}}$ if there is at least one TRACE-reported transaction in the respective period. In our sample, there are no bonds that pay coupons in a 90-day period prior to the nearest call date (date 0 in Figure 2); hence, R_i represents a total return to an investor buying at $\bar{P}_i^{\text{pre}}$ and selling at $\bar{P}_i^{\text{post}}$.

Following Gilchrist and Zakrajšek (2012) and van Binsbergen and Schwert (2022) in bond return measurement, we distinguish corporate bond returns that are due to the changes in the term structure of risk-free rates and those that are due to changes in credit spreads. We define the spread component of the notice return or, simply, the 'spread return' RS_i as

$$RS_i = R_i - RF_i,$$

[6] The invoice price is the 'dirty' price of the bond: it is the sum of the transaction price and the accrued interest. This is the price a buyer needs to pay to acquire a bond.

where RF_i is the total event return on a synthetic risk-free bond $\mathcal{B}_i$:

$$RF_i = \frac{\bar{P}_i^{\mathcal{B},\text{post}} - \bar{P}_i^{\mathcal{B},\text{pre}}}{\bar{P}_i^{\mathcal{B},\text{pre}}}.$$

Bond $\mathcal{B}_i$ has the exact same size and schedule of coupons and principal repayments as the bond under consideration in event i, but its daily price is calculated as the sum of scheduled cash flows discounted at the Treasury yield curve. We retrieve the history of Treasury yield curves estimated as in Gürkaynak *et al.* (2007) from the Federal Reserve website. For the purpose of this paper, RS_i is a better measure of event returns than R_i because the former captures bond returns beyond a macroeconomic-driven revaluation.

To further separate the component of RS_i that is specific to event i, we consider several types of benchmark spread returns. Bessembinder *et al.* (2008) argue that matching-portfolio models are superior to factor models in statistically detecting abnormal bond returns; we follow their findings. The part of the spread return above a *broad benchmark*, XRS_i^b, is

$$XRS_i^b = RS_i - \sum_j \omega_{i,j} RS_{i,j}^b,$$

where $RS_{i,j}^b$ is the return of bond j in the benchmark portfolio in event i and $\omega_{i,j}$ is the ratio of bond j outstanding amount to the sum of outstanding amounts of all benchmark portfolio bonds in the pre-notice period. Bond j is included in the benchmark portfolio if:

– it is a non-callable TRACE-reported corporate bond;

– it has the same credit rating as the callable bond under consideration (matching is on letter ratings here, AAA, AA, etc., with the three bottom non-default categories, CCC to C, merged into one);

– it belongs to the same maturity bin as the callable bond, with maturity bins (7 in total) exogenously defined by breakpoints 1Y, 3Y, 5Y, 7Y, 10Y, 15Y, and 30Y;

– it belongs to the same coupon-rate bin as the callable bond, with coupon bins (8 in total) exogenously defined by breakpoints 2%, 3%, ..., 8%, 10%.

That is, the benchmark portfolio is a size-weighted portfolio of rating-maturity-coupon-matched bonds. The weighted sum $\sum_j \omega_{i,j} RS_{i,j}^b$ is the spread return on this portfolio in event i. In what follows, we will also use the size-weighted average of bond yields in the broad benchmark:

$$\bar{y}_i^b = \sum_j \omega_{i,j} \bar{y}_{i,j}^b, \tag{1}$$

where $\bar{y}_{i,j}^b$ is the average pre-notice yield to maturity of bond j included in the broad benchmark portfolio in event i.[7]

The part of the spread return above the *narrow benchmark*, XRS_i^n, is

$$XRS_i^n = RS_i - RS_i^n,$$

where RS_i^n is the spread return of a matched non-callable bond of the same issuer in event i. This narrow benchmark is only available for approximately half of the events in our sample. Here, the matching is purely based on duration: both the callable and the non-callable bond of the same issuer must be in the same decile of the cross-sectional duration distribution.

For econometric reasons, in several empirical tests in this paper, we also consider duration-scaled bond returns. These are event returns R_i, RS_i, XRS_i^b, and XRS_i^n divided by bond duration D_i. We denote such duration-scaled bond returns with lowercase letters r_i, rs_i, xrs_i^b, and xrs_i^n, respectively. We present all of the paper's results first and foremost in terms of the spread return RS_i and use alternative return measures to highlight additional economic or econometric aspects of our argument.

1.4 Embedded option moneyness

Callable bonds differ in the moneyness of embedded call options. Consider a bond callable at the par value of 100. Imagine that an otherwise identical non-callable bond of the same issuer trades simultaneously at the price of 103 and there is sufficient demand for new offerings at this price. In a frictionless world, a rational bond issuer should call the bond at 100 and issue a non-callable bond, raising 103 instead of 100 and realizing a gain of 3%. The call price of 100 is a strike price, and the difference between the price of the non-callable bond and the strike can be interpreted as the intrinsic value of the call option

[7] In unreported results, we also performed duration-matching to a broad bond portfolio that delivers quantitatively and qualitatively similar results on event returns. We prefer matching on coupon, rating, and maturity because it delivers the benchmark yield (1) that is a better measure of the cost of borrowing, in our opinion.

embedded in the callable bond. In the example above, the intrinsic value is positive, and the embedded call option is ITM. The issuer should exercise it.

We measure the moneyness for each callable bond in our sample, as in the example above, by comparing its price with the price of an otherwise identical non-callable bond. Generally, the latter does not exist in practice, so we construct a synthetic non-callable bond by discounting the promised (callable) cash flows at benchmark non-callable yields. Consider a (no-)call notice event i, and denote by $\{CF_{i,\tau}\}$ the set of promised cash flows of the callable bond (up until maturity and including the principal repayment) with τ being the payment times. An observed yield of the matched non-callable bond portfolio is $\bar{y}_i^b$, which is defined in (1). Then, the price of the synthetic non-callable bond of interest is

$$P_i^{NC}\left(\bar{y}_i^b\right) = \sum_{\tau} e^{-\tau \bar{y}_i^b} CF_{i,\tau}.$$

This is the amount of money the issuer can raise by issuing, at the yield of $\bar{y}_i^b$, a non-callable bond with the same promised cash flows as the callable bond. Denote a known call price at the nearest call date P_i^{call}. Then, pre-notice, the intrinsic value of the call option embedded in such a callable bond is:

$$\bar{IV}_i^{\text{pre}} = \frac{P_i^{NC}\left(\bar{y}_i^b\right) - P_i^{\text{call}}}{P_i^{\text{call}}} \times 100\%, \tag{2}$$

measured in percentages of the call price.[8] Note that $\bar{IV}_i^{\text{pre}}$ does not depend on the callable bond yield and only includes the information about the callable bond that is known at its issuance: the coupon structure, maturity, call dates, and call prices. If $\bar{y}_i^b$ does not change, neither does the intrinsic value of the callable bond, even if the yield of the callable bond fluctuates.[9]

In principle, an intrinsic value above 0% means that the embedded option is in the money, and the issuer must call it. However, there is a cost of calling an issue and placing a new non-callable bond instead. This cost is difficult to estimate for individual bonds. Al-

[8] Ma *et al.* (2023) consider a similar measure of moneyness that uses CDS spreads instead of non-callable yields to proxy for the cost of non-callable borrowing.

[9] Callable bond yields and hence prices change with the perceived call risk, which makes them a poor indicator of the bond's moneyness. Intuitively, a bond that is likely to be called must be priced as a short-term, not a long-term, bond. In many cases, that means being traded close to the call price (assume par), but how close depends on multiple factors (steepness of the term structure, call probability, and bond maturity, for example). A bond traded at 99 does not need to be OTM. Likewise, a bond traded at 101 is not necessarily ATM/ITM.

tinkihc and Hansen (2000) estimate the average debt underwriting cost to be approximately 0.5–1.5% (depending on the borrower's credit quality). There is also possibly estimation error in the intrinsic value (2). For these reasons, we call ITM embedded options that have a pre-event intrinsic value $I\bar{V}_i^{\text{pre}}$ above 4%. We call the bonds with $I\bar{V}_i^{\text{pre}} \in [0\%; 4\%]$ 'at-the-money' (ATM). Bonds with an intrinsic value of the option below 0% are OTM. The choice of the 4% moneyness threshold does not drive the paper's results: we obtain similar results (unreported) with several percentage points higher or lower thresholds. An added benefit of this choice of a rather conservative threshold is that it balances the size of OTM-ATM-ITM bins well.

1.5 Summary statistics

Table 1 summarizes the sample. We observe more than 11,000 bond-events spread across the years 2005–2019.[10] A representative event is a no-call notice of a 5.5%-coupon bond that matures in approximately nine years and was issued five years ago. It is a BBB(+)-rated bond traded at a yield spread of 7% with 7.5 years duration. The average outstanding amount of the bond is close to $20 mn. The bond is OTM and is likely not called in the sample period (11% of the events in the sample are call notices – the rest are no-calls). Most bonds in the sample are issued by large and profitable public firms (with $90 bln market capitalization and 6% profit margin, on average). Table 12 in the Appendix lists the top issuers in our sample; large industrial and financial corporations dominate in the list.

Panel (B) of Table 1 demonstrates how callable bonds differ from benchmark non-callable bond portfolios. The average difference between the callable bond and the matched non-callable portfolio in maturity, age, and duration is less than nine months. The coupon rate only differs by eight b.p., on average. Benchmark portfolios consist of bonds with much larger outstanding amounts (they are, primarily, institutional-sized bond issues). The average difference in the yield spread between the callable bond and the matched non-callable bond portfolio is approximately 90 b.p. Remarkably, approximately 15% of sampled callable bonds have lower yields than matched non-callable bonds pre-notice (this also applies to non-callable bonds of the same issuer, as reported in Panel (C) of Table 1). One can interpret this as a negative value of the embedded call option. The proportion of

[10]The sample of (no-)call events is not evenly spread across years from 2005 to 2019. Figure 6 in the Appendix shows fewer callable retail notes outstanding in more recent sample years.

negative-value call options in our sample is then similar to that reported in King (2002). Note, however, that our measure of call option moneyness (2) is different and does not depend on the yield of a callable bond itself.

Panel (C) of Table 1 compares callable bonds with matched non-callable bonds of the same issuer. We find a same-issuer match for only half of the callables in our sample bonds. Most matches are very close: approximately 90% of the matched sample are within a one-year maturity and duration difference. The latter ensures that XRS_i^n is a reliable measure of excess callable bond returns. The same caveat as for the broad benchmark basket applies here: matched non-callable bonds are primarily institutional-sized issues with large outstanding amounts. Bonds with larger outstanding amounts tend to be more liquid (Bao *et al.*, 2011), which translates into higher returns (Bai *et al.*, 2019). We discuss in Section 5 that exposure to liquidity risk does not explain callable bond notice returns.

Panel (D) of Table 1 lists several trading activity characteristics of sample callable bonds. The average dealer-to-client trading volume per *calendar* business day is approximately 9 b.p. of the outstanding amount, which translates to a total of 1.8% of the outstanding amount traded in the pre-notice period. This volume is relatively balanced. The median net volume (client purchases from dealers in excess of client sales to dealers) is zero, and the mean is slightly (but significantly) negative at -0.14 b.p. of the outstanding amount (per trading day). This indicates that the total dealer inventory of retail notes increases pre-notice. The bonds in our sample only trade, on average, three out of ten business days, which is similar to other bonds in TRACE (Dick-Nielsen *et al.* 2012 report a TRACE average of zero-trading days of 60%; in the Harris (2015) sample, it is closer to 70%).

2 Bond returns around (no-)call notice dates

Next, we investigate the pricing of callable bonds around (no-)call notice announcements. Table 2 presents summary statistics of different return metrics in our sample of callable bonds. The total bond return based on average transaction prices 28 days post- relative to pre-notice, R_i, is at 94 b.p., on average. This is some 40 b.p. higher than the average total monthly bond return in a broad basket of bonds in a comparable sample period (Bai *et al.* 2019).

	Mean	S.D.	5th	25th	Med.	75th	95th	N.Obs.
(A) Callable bonds characteristics								
Maturity, years	9.26	5.60	1.67	5.21	8.26	12.06	20.43	11277
Size, mn $	17	20	3	6	10	21	50	11277
Age, years	4.95	2.31	1.42	2.94	4.93	6.47	8.99	11277
Coupon rate, %	5.55	1.02	3.40	5.12	5.55	6.15	7.05	11277
Rating	8.08	4.33	3.00	5.00	7.00	10.00	16.00	11277
Duration, years	7.43	3.92	1.63	4.50	6.96	9.56	14.72	11277
Yield spread, %	7.34	4.78	3.70	5.43	6.00	7.41	14.14	11277
Moneyness, %	-4.50	11.29	-26.89	-7.94	-2.38	2.47	9.05	11277
Called (dummy)	0.11	0.32	0.00	0.00	0.00	0.00	1.00	11277
(B) Difference to duration- and rating-matched portfoio								
ΔMaturity, years	-0.73	2.68	-7.03	-0.93	-0.04	0.59	1.77	11277
ΔSize, mn $	-1036	864	-2813	-1447	-871	-378	-32	11277
ΔAge, years	0.47	3.74	-6.26	-0.97	0.76	2.94	5.65	11277
ΔCoupon rate, %	-0.08	0.34	-0.61	-0.34	-0.09	0.17	0.45	11277
ΔDuration, years	-0.42	1.70	-4.27	-0.71	-0.02	0.48	1.35	11277
ΔYield spread, %	0.91	3.09	-1.65	0.13	0.59	1.35	4.33	11277
(C) Difference to same-issuer matched non-callables								
ΔMaturity, years	0.08	0.86	-1.09	-0.12	0.01	0.27	1.29	5914
ΔSize, mn $	-522	718	-1986	-746	-244	-10	15	5914
ΔAge, years	1.36	5.63	-15.20	-0.18	2.30	5.05	7.05	5914
ΔCoupon rate, %	-0.34	1.43	-3.77	-0.55	0.00	0.45	1.25	5914
ΔDuration, years	0.06	0.58	-0.88	-0.16	0.02	0.27	0.97	5914
ΔYield spread, %	1.03	2.16	-0.73	0.10	0.59	1.35	4.00	5914
(D) Issuer characteristics								
Market cap., bn $	90.74	85.43	2.92	23.56	55.93	161.33	218.85	9374
Book leverage, %	43.29	21.94	5.84	29.25	41.50	63.22	73.81	9374
Profit margin, %	5.57	10.60	-10.03	1.44	6.87	9.81	18.27	9374
Equity return, %	0.29	12.91	-18.53	-5.90	0.32	5.93	19.96	9384
(E) Trading characteristics								
Daily vlm, b.p. of size	8.91	19.09	1.00	2.79	5.11	9.37	25.39	11277
Trade size, b.p. of size	5.27	7.80	0.65	1.79	3.28	6.02	15.33	11277
Net volume, b.p. of size	-0.14	2.74	-3.89	-0.71	0.00	0.36	3.43	11277
No-trading days, %	70.47	20.87	26.32	60.00	77.78	85.00	94.74	11277

Table 1: Pre-notice summary statistics. The unit observation is a bond-event. The definition of the pre-notice period is in Figure 2). In Panel (A), maturity is the bond maturity at issuance. Size is the amount outstanding. Age is the time since issuance. The coupon rate is per annum. Rating is on a conventional numerical scale (1 is AAA, 2 is AA+, . . . , 21 is C). Duration is the cash-flow-weighted average of scheduled payment times. The yield spread is relative to a synthetic risk-free bond with the same cash flows but discounted at Treasury rates. Moneyness is a theoretical gain to the issuer from calling a bond and replacing it with an otherwise identical non-callable bond (the details are in Section 1.4). Panel (B) presents the difference between callable retail notes and coupon-, maturity- and rating-matched non-callable bonds. Similarly, Panel (C) present the difference to matched non-callable bonds of the same issuer (not every callable bond in the sample has a match). In Panel (D), issuer characteristics are from CRSP/Compustat. Book leverage is the ratio of current and long-term liabilities to total assets. Profit margin is net income divided by sales. Equity return is the percentage change in the average price of the common stock post-notice to pre-notice. Table 12 in the Appendix lists the top issuers in the sample. In Panel (E), the trading activity is dealer-to-client only (inter-dealer trades are excluded). The average daily volume is per *calendar* business day (i.e., including no-trading days) and is measured in basis points of the outstanding amount. Trade size is for individual dealer-to-client transactions. Net volume is client purchases from dealers in excess of client sales to dealers, per calendar business day. No-trading days are the days with no dealer-to-client volume. The sample period is 2005–2019.

Total bond returns include both the accrued interest and the price appreciation. The latter can be, in principle, driven by changes in both the economy-wide term structure of risk-free interest rates and a bond-specific term structure of yield spreads. The return metric that singles out the spread component of return, RS_i, stands at a lower average level of 31 b.p. (the median is 47 b.p.), but it is highly statistically significant. To put this number into perspective, van Binsbergen and Schwert (2022) find that a similarly calculated average spread return of a broad basket of BBB-rated bonds stands at 5 b.p. in a sample that starts in the mid-1980s and extends to the present.

	Mean	Med.	S.D.	Min	5th	25th	75th	95th	Max	N.Obs.
(A) Bond return, %										
R	0.94	0.93	6.54	-35.26	-6.34	-0.15	2.34	8.41	34.74	11277
RS	0.31	0.47	6.97	-36.12	-8.52	-1.37	2.34	8.03	35.20	11277
XRS^b	0.44	0.53	6.20	-34.02	-6.69	-1.02	2.20	7.68	33.38	11277
XRS^n	0.41	0.24	5.48	-21.21	-6.45	-1.66	2.21	7.56	27.45	5914
(B) Duration-adjusted bond return, %										
r	0.20	0.13	1.22	-5.62	-1.04	-0.02	0.39	1.66	6.73	11277
rs	0.11	0.08	1.26	-5.89	-1.33	-0.20	0.37	1.64	6.73	11277
xrs^b	0.09	0.08	1.13	-5.32	-1.28	-0.15	0.35	1.40	5.75	11277
xrs^n	0.11	0.04	1.28	-4.54	-1.44	-0.27	0.37	1.71	6.60	5914

Table 2: Cross-section of notice returns. Panel (A) presents the cross-section of bond returns around call notice dates. Panel (B) presents the same returns but divided by bond duration. The notice return R is the percentage change (not annualized) in the average invoice price of the bond from pre-notice to post-notice. The spread component of the notice return, or simply the 'spread return', RS is R minus the notice return of a synthetic risk-free bond with the same scheduled cash flows). XRS^b is the spread return in excess of the size-weighted spread return of the basket of coupon-, maturity- and rating-matched non-callable bonds. XRS^n is the spread return in excess of the spread return of a maturity-matched bond of the same issuer. In Panel (B), every variable v is V/D, where D is the pre-event duration (in years) for individual bonds. The sample period is 2005–2019. The sample size for each year can be found in Figure 6 of the Appendix.

Bond returns have been lower in recent decades than in the 1980s and the 1990s. To compare notice spread returns with a contemporary benchmark, we calculate spread returns in excess of (size-weighted) spread returns of non-callable benchmark portfolios in our event window. Table 2 shows that the average of both excess return measures, XRS_i^b (broad portfolio) and XRS_i^n (same-issuer portfolio), is 44 and 41 b.p., respectively. Panel (B) of Table 2 suggests that, in yield terms, the average excess returns are approximately 10 b.p. Overall, we document that callable bonds exhibit a strong and positive return in the event window. The excess spread return of approximately 40 b.p. around scheduled call notice dates is a novel empirical fact. The remainder of the paper explains the reasons for this seemingly large and puzzling number.

	R	RS	XRS^b	XRS^n	r	rs	xrs^b	xrs^n
Intercept	1.08***	0.39**	0.66***	0.25***	0.21***	0.13**	0.13***	0.06***
	(0.13)	(0.18)	(0.07)	(0.06)	(0.05)	(0.06)	(0.03)	(0.01)
GFC	−0.20	−0.10	−0.66	0.50	0.05	0.03	−0.10	0.17
	(0.63)	(0.66)	(0.48)	(0.50)	(0.14)	(0.14)	(0.09)	(0.12)
Pre-GFC	−0.44***	−0.27**	−0.31**	0.16	−0.10*	−0.11**	−0.08**	0.03
	(0.11)	(0.11)	(0.12)	(0.13)	(0.05)	(0.05)	(0.03)	(0.04)
Observations	11,277	11,277	11,277	5,914	11,277	11,277	11,277	5,914

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3: Average notice returns pre-, during, and after the GFC. The regression model is $Y_i = \beta_0 + \beta_1 \mathbf{1}_i^{\text{GFC}} + \beta_2 \mathbf{1}_i^{\text{Pre-GFC}} + \epsilon_i$, where Y is one of the notice return measures, $\mathbf{1}^{\text{GFC}}$ is the dummy variable that takes the value of 1 if event i is in 2008 or 2009, $\mathbf{1}^{\text{Pre-GFC}}$ is the dummy variable that takes the value of 1 if event i is prior to 2008. The intercept $\hat{\beta}_0$ is the average post-GFC notice return. The loading on the GFC dummy $\hat{\beta}_1$ is the difference in average notice returns between GFC and post-GFC years. The loading on the pre-GFC dummy $\hat{\beta}_2$ is the difference in average notice returns between pre- and post-GFC years. Column names correspond to those in Table 2: capital letters are for notice returns, in %, while lower-case letters denote duration-adjusted returns. The sample period is 2005–2019. The standard errors (in parentheses) are clustered at the bond issuer level.

Table 3 also presents the difference in average notice returns between pre-GFC, GFC, and post-GFC periods. While the GFC period (defined here as events in 2008 and 2009) does not exhibit average returns that are significantly different from the post-GFC period, the pre-GFC period does. For instance, the average RS_i pre-GFC is only approximately one-third of the post-GFC level ($0.39 - 0.27 = 0.12$ b.p. compared to 39 b.p.). Except for excess returns relative to the narrow benchmark, all other average return metrics in Table 3 are lower pre-GFC than post-GFC. For this reason, we examine the evidence for (no-)call notice returns and their factors separately for pre- and post-GFC periods in the rest of the paper.

3 Intrinsic value of the call option and callable bond return

We have documented that callable bond returns around scheduled (no-)call notice dates are approximately 40 b.p. higher than returns on non-callable benchmarks. Treating a callable bond as a portfolio of an otherwise identical non-callable bond (long position) and a Bermudan call option written on this bond (short position), we attribute the documented 40 b.p. return to a revaluation of an embedded call option. The revaluation is due to the dissemination of an important piece of news about the call option exercise probability. In the pre-notice period, as long as there is some uncertainty about the exercise decision, the nearest-call-date exercise probability is between 0 and 1. As the (no-)call notice arrives, the probability jumps to either 0 or 1.

The size of the exercise probability jump must be a factor of realized returns. If the marginal investor believes that exercise is very unlikely and a no-call notice arrives, then the effect on the price of the embedded option is limited because the no-call is 'priced in' in the pre-notice period. Analogously, a widely expected call decision should not generate call notice returns because the call decision is priced in. On the contrary, a 'surprising' (no-)exercise decision should move the price of the embedded option. For instance, if investors expect the bond to be called at the nearest call date, but the issuer does not call it, such a no-exercise decision destroys part of the embedded Bermudan option value. As the option becomes cheaper, the bond becomes more expensive. In this section, we a) identify and characterize such surprising exercise decisions in the data and b) benchmark observed notice returns on simulated option price changes following suboptimal exercise decisions in a parsimonious option-pricing model.

3.1 Option moneyness and (no-)call decisions

We proxy for the likelihood of embedded option exercise with the intrinsic value of the embedded option as defined in (2). Recall that the intrinsic value here is a hypothetical benefit of the bond issuer from calling an outstanding callable bond and instead issuing an identical non-callable bond with the yield prevalent for similar non-callable bonds pre-notice. A negative intrinsic value means that it is unprofitable for the issuer to call the bond, the embedded option is OTM, and the exercise probability is small. As the intrinsic value increases, the call option becomes more ITM, and the exercise probability increases. In what follows, we distinguish between bonds with a small positive intrinsic value (between 0 and 4%, ATM) and a large positive intrinsic value (above 4%, ITM). The ex ante exercise probability for the ITM bonds should be greater, on average, than for the ATM bonds – and both must be greater than the call probability of the OTM bonds.[11]

[11] Option moneyness is often defined as the intrinsic value scaled by the volatility of the underlying asset. A relevant volatility measure here is duration-times-spread (DTS), a usual proxy for the part of the

	Full sample			Ex-GFC			Post-GFC		
	OTM	ATM	ITM	OTM	ATM	ITM	OTM	ATM	ITM
No. bond-events	7084	2102	2091	4677	1924	2057	2785	1712	1881
no. no-calls	6720	1761	1536	4407	1602	1504	2544	1405	1375
no. calls	364	341	555	270	322	553	241	307	506
% called	5.1	16.2	26.5	5.8	16.7	26.9	8.7	17.9	26.9

Table 4: Bond calls by the moneyness of the embedded option. The full sample is from 2005 to 2019. The 'Ex-GFC' sample excludes 2008 and 2009. The 'Post-GFC' sample is 2010–2019. 'OTM' stands for 'out-of-the-money' and includes bonds with a pre-notice average intrinsic value of the embedded call option, $\bar{IV}_i^{\text{pre}}$, below 0% (see Section 1.4 for a full definition). 'ATM' is 'at-the-money' and consists of bonds with the $\bar{IV}_i^{\text{pre}}$ between 0% and 4%. 'ITM' is 'in-the-money' and consists of bonds with $\bar{IV}_i^{\text{pre}} > 4\%$. The first three lines are event counts: the total number of bond-events, the number of events that were bond no-calls and the number of bond calls. '% called' is the ratio of calls to the sum of calls and no-calls, in %.

Table 4 presents the split into OTM-ATM-ITM bonds across different subsamples and shows in-sample call frequency by moneyness bin. In the full 2005–2019 sample, approximately 63% of the bonds are OTM, with the remaining 37% split almost equally between the ATM and the ITM bonds. The latter two categories remain of approximately equal size in ex-GFC and post-GFC subsamples. However, the fraction of OTM bonds in the post-GFC sample drops to only 43%. This is expected, given the general decrease in the level of interest rates post-crisis. Lower risk-free rates, other things being equal, lead to lower corporate borrowing costs, which increase the intrinsic value of callable bonds. As interest rates drifted to an almost zero level post-GFC, there were considerably fewer OTM bonds left in the sample. The fraction of bond-events that are bond calls (the issuer exercises the call option) increases with moneyness. In the OTM bin, only 5.1% of events are bond calls in the full 2005–2019 sample. In the post-GFC sample, the fraction of called OTM bonds grows to 8.7%. This is several times lower than the fraction of calls in the ATM category (16.2% in the full sample and 17.9% in the post-GFC sample). Expectedly, the fraction of calls is the largest in the ITM category. It is in the range from 26% to 27% across different subsamples.

bond return volatility driven by yield spread fluctuations (Ben Dor *et al.* 2007). Intuitively, high-duration, high-yield bonds should be more volatile than short-duration bonds with narrow yield spreads. Dividing the intrinsic value by the DTS does not alter the split of the sample into OTM and non-OTM bonds (unless the spread is negative, which is never the case in our sample). The only thing that changes is the split between ATM and ITM bonds. We rerun the analysis with such DTS-adjusted moneyness labels and find little difference from the results presented in the paper (unreported).

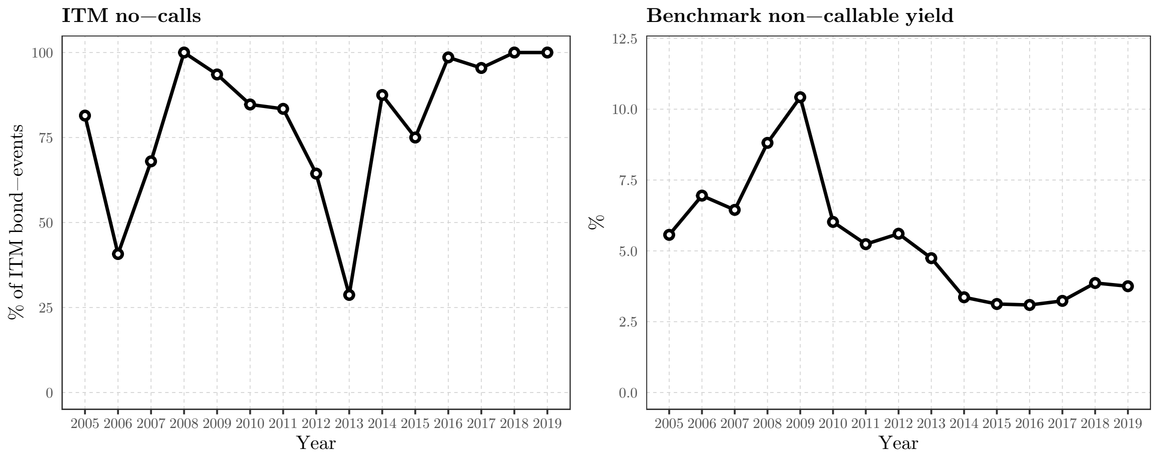

Figure 3: Not-called in-the-money bonds and corporate borrowing costs. The left panel shows ITM bond-events that did not lead to a call, as a % of all ITM bond-events, per calendar year. Bond-event i is 'ITM' if $I\bar{V}_i^{\text{pre}} > 4\%$ (see Section 1.4 for a full definition). The right panel is the per-year cross-sectional average yield to maturity of matched non-callable bonds, $\bar{y}^b$.

Having a fraction of early calls that stands at approximately 27% implies that more than 70% of ITM bond-events do not lead to a bond call at the nearest call date. This is a strikingly high number. The left panel of Figure 3 plots its evolution year-by-year. Only in 2006 and 2013 does the fraction of no-calls among ITM bond-events drop below 50%, but it nevertheless remains above 25%. Between 2014 and 2019, no-calls amount to more than 75% of the ITM bond-events (although the sample is much smaller in recent years, as Figure 6 in Appendix suggests).

There are a few explanations why the fraction of ITM no-calls is consistently high. First, even in a frictionless world, the optimality of the early exercise of a Bermudan option depends on several parameters (time to maturity, yield volatility, etc.) beyond the intrinsic value of the option. It could be that the time value of some ITM options exceeded an early exercise benefit. The right panel in Figure 3 shows that the borrowing cost for bond issuers in our sample was drifting down in the post-GFC years, suggesting that late exercises might have been more profitable (as viewed ex post). Second, an exercise-and-reissue decision might bear a lump-sum cost that renders the exercise of callable bonds with smaller outstanding amounts suboptimal. We now provide empirical evidence supporting such an explanation, which we deem particularly relevant for the sample of retail notes with small outstanding amounts.

Table 5 presents the estimates from linear probability models for the call dummy in our panel of bond-events.[12] The estimates confirm that the embedded option's intrinsic value is a statistically strong predictor of exercise probability across all considered subsamples and diverse sets of fixed effects and control variables. The economic magnitude of the effect is such that a 1 p.p. increase in the intrinsic value raises the exercise probability by 0.7–1.4 p.p. (models 5–8). Notably, the bond outstanding amount (size) also becomes a significant predictor of the call probability after controlling for issuer fixed effects. The size of the effect is such that an additional \$10 mn outstanding amount increases the exercise probability by 0.8–1% (controlling for some or all of the following: the intrinsic value of the option, the market capitalization of the bond issuer, bond rating, and maturity, as well as time and issuer fixed effects).

Why does the call probability increase with the bond outstanding amount? Assume that the issuer calls the bond and replaces it with more favorably priced debt (i.e., the issuer's capital structure remains unchanged). Such a transaction bears a cost, part of which is a set dollar amount (as opposed to a percentage of the issue size). Legal, trustee, and auditing services are costs often nonproportional to the issue size. We do not have sufficient data to evaluate such costs in our sample of bonds. Nevertheless, it must be that a set dollar cost represents a larger fraction of the outstanding amount of a small than a large bond issue. Therefore, it might be suboptimal to call smaller bond issues when a nonproportional cost is accounted for. This factor might play an important role in our sample of retail notes with relatively small outstanding amounts. The evidence presented in Table 5 is in line with such an explanation. The larger the outstanding amount is, the higher the probability that the bond is called when controlling for the moneyness of the embedded option.

Beyond the rational explanations listed above, one can consider diverse behavioral reasons why issuers do not call ITM bonds timely. For instance, Chen *et al.* (2022) document delayed calls of municipal bonds and link them with busy business periods when issuers are more likely to overlook profitable call opportunities. What matters for pricing, though, is the belief of the marginal investor about the nearest call exercise probability. The call probability is in turn related to option moneyness. Hence, we next consider how option moneyness relates to notice returns.

[12] Table 14 in Appendix presents similar evidence obtained in a panel logit model.

	Dependent variable: $\mathbf{P}_i$ [Called]							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	14.19***	13.84***						
	(2.11)	(2.33)						
Intrinsic value	0.67***	0.67***	0.78***	0.57***	0.71***	0.80***	1.03***	1.36***
	(0.12)	(0.12)	(0.21)	(0.13)	(0.15)	(0.15)	(0.26)	(0.32)
Outstanding amount		0.02	0.10***	0.09***	0.08***	0.08**	0.08**	0.10*
		(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.05)
Rating					2.16	2.26	6.90**	7.81**
					(1.67)	(1.88)	(3.04)	(3.14)
Maturity					0.19	0.09	0.01	0.07
					(0.29)	(0.30)	(0.29)	(0.34)
Market cap.						0.09		−0.36***
						(0.06)		(0.10)
Issuer FE	NO	NO	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	YES	YES	YES	YES	YES
Post-GFC only	NO	NO	NO	NO	NO	NO	YES	YES
Observations	11,277	11,277	11,277	11,277	11,277	9,374	6,378	5,504
Adjusted R^2	0.06	0.06	0.13	0.23	0.24	0.25	0.35	0.37
Note:	*p<0.1; **p<0.05; ***p<0.01							

Table 5: Linear probability model for the call dummy. The dependent variable equals 100 if the bond is called in event i and equals 0 otherwise. Models (1)–(6) are estimated on the entire sample (2005–2019), while models (7) and (8) are for post-GFC years only. 'Intrinsic value' is the intrinsic value of an embedded callable bond option relative to a broad non-callable benchmark portfolio as defined in Section 1.4, in % of the call price. 'Outstanding amount' is the bond amount outstanding, in $ mn. 'Rating' is the bond credit rating on a conventional numerical scale from 1 (AAA) to 21 (C). 'Maturity' is the remaining time to bond maturity, in years. 'Market cap.' is the equity market capitalization of the bond issuer. All right-hand-side variables are pre-notice averages as defined in Figure 2. The standard errors are clustered by the bond issuer. Analogous Logit models are in Table 14 in Appendix.

3.2 Option moneyness and notice returns

We have established that the intrinsic value of an embedded call option is a factor of the exercise probability. The more ITM the bond, the more likely it is to be called. Now we characterize event returns conditional on bond moneyness and the (no-) call decision. Our hypothesis is that the unexpected (no-)call decisions generate positive notice returns, while the expected decisions do not move bond prices. If that is the case, then we should find strong and significant average event returns for not-called ITM bonds and called OTM bonds. Conversely, OTM no-calls and ITM calls should not affect bond prices.

To estimate average event returns associated with different call outcomes conditional on option moneyness, we regress, in a cross-section of events, a return measure on respective

	Dependent variable: RS_i					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	0.34**	0.39	0.57	0.30*	0.02	1.72***
	(0.13)	(0.29)	(0.36)	(0.14)	(0.12)	(0.15)
ATM × Not-called	0.02	0.03	0.03	0.69***	−0.24	0.58**
	(0.20)	(0.23)	(0.26)	(0.07)	(0.30)	(0.21)
ITM × Not-called	0.47**	0.49**	0.63***	1.04***	0.57***	−0.70
	(0.21)	(0.21)	(0.14)	(0.25)	(0.11)	(0.49)
OTM × Called	1.20***	0.79**	0.51**	0.28	0.50	0.69***
	(0.36)	(0.31)	(0.24)	(0.18)	(0.34)	(0.09)
ATM × Called	0.01	0.02	−0.09	0.14	−0.41	0.38***
	(0.23)	(0.24)	(0.22)	(0.10)	(0.31)	(0.05)
ITM × Called	0.11	0.10	0.06	0.04	0.01	0.55
	(0.13)	(0.14)	(0.15)	(0.19)	(0.19)	(0.42)
Observations	11,277	8,658	6,378	1,236	4,088	1,054
Note:	*p<0.1; **p<0.05; ***p<0.01					

Table 6: Average notice return by option moneyness, call decision, credit quality, and bond maturity. The regression model is $RS_i = \beta_1 \mathbf{1}_i^{\text{OTM}} \times \mathbf{1}_i^{\text{Not called}} + \cdots + \beta_6 \mathbf{1}_i^{\text{ITM}} \times \mathbf{1}_i^{\text{Called}} + \epsilon_i$, where $\mathbf{1}^{\mathcal{M}}$ is the dummy that takes the value of 1 if condition $\mathcal{M}$ is satisfied and 0 otherwise. Hence, β_j is a conditional average notice spread return (in %). The 'Ex-GFC' sample excludes the years 2008 and 2009 from consideration. The 'Post-GFC' sample is from 2010 to 2019. The '<5Y' sample consists of bonds that mature in less than 5 years, '>5Y' – of bonds that mature in more than 5 years. Table 15 runs similar regressions for alternative notice return measures. The number of observations behind each estimated coefficient is in Table 13. The standard errors are clustered by the bond issuer.

dummy variables:

$$\text{Event return}_i = \beta_1 \mathbf{1}_i^{\text{OTM}} \times \mathbf{1}_i^{\text{Not called}} + \cdots + \beta_6 \mathbf{1}_i^{\text{ITM}} \times \mathbf{1}_i^{\text{Called}} + \epsilon_i. \tag{3}$$

Above, the event return is one of RS_i, XRS_i^b, or XRS_i^n and duration-adjusted versions of these return metrics. In the main specification presented in Table 6, the left-hand side variable is the spread return RS_i. The results for other return metrics are in Table 15. The estimated coefficients $\hat{\beta}_1, \ldots, \hat{\beta}_6$ are average returns conditional on moneyness and call decision. In (3), we cluster standard errors at the bond issuer because there are a few simultaneous events per issuer in the sample (overlapping events for different outstanding bonds issued by the same firm), which potentially creates a within-firm correlation of unexplained return components.

We find that in the entire 2005–2019 sample, a significantly positive event return is generated by ITM calls and OTM no-calls, in line with our hypothesis, but also by OTM no-calls. However, the significance of returns associated with OTM no-calls disappears when we exclude the GFC years 2008 and 2009 from the sample. Anecdotally, high and positive OTM no-call returns in those years are mainly observed for the bonds issued by General Motors and its subsidiaries, which were noninvestment grade at that time, and the returns were likely due to the news regarding the restructuring of the company and had little to do with call notice events per se. The column 'Post-GFC' of Table 6 further documents that only OTM calls and ITM no-calls generate significantly positive returns. The magnitude of the effect is comparable for these two categories: ITM no-calls yield a 63 b.p. bond price appreciation, while OTM calls drive prices 51 b.p. higher. Since the left-hand side variable here is RS_i, both effects are above and beyond the returns generated by changes in the term structure of the risk-free rates in the event window. Table 15c in Appendix shows that the ITM no-call notice return in excess of the return on a non-callable bond of the same issuer (XRS_i^n) is of a similar magnitude of 55 b.p. and also highly significant.

The last three columns in Table 6 further split the post-GFC sample into investment-grade and high-yield bonds and, for the former, into shorter (less than 5 years) and longer (more than 5 years) maturity.[13] For longer-term investment-grade bonds, we find that ITM no-calls are the only events with significantly positive excess returns. The magnitude is 57 b.p. per ITM event that did not lead to a bond call. For shorter-term investment-grade bonds, all no-calls are associated with significantly positive returns. However, for OTM no-calls, the effect is only marginally significant and is smaller in size than ATM/ITM no-calls. Between ATM and ITM no-calls, the effect is greater in the latter category: 104 b.p. against 69 b.p. An increase in the average no-call notice return from OTM to ATM to ITM options is consistent with the hypothesis that more surprising exercise decisions must generate stronger returns.

Observe further in Table 6 that ITM no-call returns are, on average, almost twice as high for shorter-term than for longer-term IG bonds. This might appear counterintuitive. If the underlying yields were changing by the same quantity for shorter- and longer-term bonds, the latter would exhibit stronger returns, while we observe the opposite. We argue, however, that the observed effect is in line with a difference in returns associated with the suboptimal exercises of shorter- and longer-term Bermudan options. Intuitively, a short-

[13] More granular splits would come at the cost of very small sample sizes and little statistical power to evaluate average event returns. Table 13 in the Appendix presents the sample sizes behind Table 6 splits.

term embedded Bermudan option gives the issuer fewer opportunities to call the bond than a long-term option. By not exercising the short-term option at the nearest possible call date, the issuer destroys a more significant portion of the option value than in the case where there are multiple future call dates scheduled. In Section 3.3, we calibrate a classic workhorse option-pricing model to illustrate this effect.

For high-yield bonds, the average notice returns in Table 6 are not in line with the hypothesis we are testing. We observe strong and significant returns for OTM high-yield bonds, regardless of whether they are called. The same applies to ATM high-yield bonds, although the effect is weaker than for the OTM bonds. ITM high-yield bonds generate (no-)call notice returns that are statistically indistinguishable from zero. We believe that these findings suggest that our approach to calculating the intrinsic value as in Equation (2) is not well-suited for evaluating the moneyness of high-yield bond options. There are fewer high-yield than investment-grade bond transactions in TRACE, especially in lower-rated high-yield bonds (CCC to C). A representative benchmark for such bonds does not always exist. By matching to similar-maturity, actively traded non-callable bonds within a broad range of ratings from CCC to C, we probably overestimate the moneyness of embedded options, thus labeling as ITM bonds that might be OTM. Similarly, the moneyness of higher-quality bonds within the high-yield group is probably underestimated. This might explain the no result that we obtain for high-yield bonds in our sample. Ma *et al.* (2023) investigate in greater detail the motivation of high-yield bond issuers to call bonds.

Figure 4 plots a week-by-week bond price dynamic for ATM and ITM bonds in the post-GFC period. A (no-)call notice arrives in week -5. This is when the uncertainty about a possible call in week 0 is resolved. Weeks -9 to -6 (inclusive) comprise the pre-notice period, and weeks -4 to -1 – represent the post-notice period. The return is a cumulative return relative to week -9. The plot demonstrates that the dynamics of both called and not-called ATM and ITM bonds are very similar pre-notice. The bonds that are eventually called perform slightly worse pre-notice, but the difference is modest at approximately 25 b.p. and disappears in the notice week. However, not-called bonds grow in value immediately after the no-call notice – in line with the estimates in Table 6. The difference in cumulative returns relative to called ATM and ITM bonds reaches 60 b.p. in weeks -4 to -2 and only then subsides to 30 b.p., which is still strongly significant. In Sections 4 and 5, we argue that the price patterns in Figure 4 are consistent with investors' trading patterns around (no-)call notice dates. A part of the observed notice return is the transitory price pressure

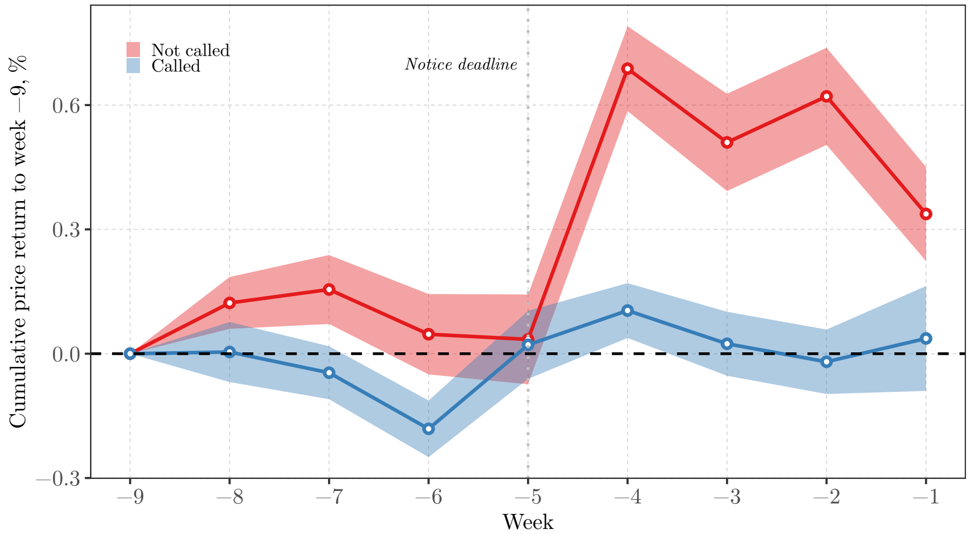

Figure 4: Bond price dynamics around call notice dates for at- and in-the-money bonds. On the y-axis is the percentage change in the average weekly bond clean price (excl. accrued interest) relative to a reference week '-9', which corresponds to the days from -64 to -58 (inclusive) on the event timeline in Figure 2. The bonds that did not trade in week -9 are excluded from consideration. Week '-5' corresponds to days -37 to -30 and ends with the call notice deadline; hence it is the 'call notice' week. The sample is from 2010 to 2019 here. The shaded areas are two standard deviations around the cross-sectional average.

of buying investors. The permanent part is, nonetheless, larger and, we believe, represents a revaluation of an embedded call option due to a missed exercise opportunity.

3.3 Callable bond price and suboptimal exercise policy: a simulation

The question is, by how much would a callable bond price jump if the bond were not called? Although we are aware of the most advanced models such as Jarrow *et al.* (2010), where the authors model the term structure of risk-free assets with two factors, with one factor being the credit spread, and one more factor for the early exercise we instead rely on a very simple setting since our goal is just to obtain an order of magnitude of the price variation upon non-exercise. In our model, the fundamental uncertainty is driven by a one-factor CIR model. This source of uncertainty drives the term structure and, thus, the price of a bond. We assume that the bond can be called at each coupon payment date. The issuer faces a tradeoff between calling or leaving open the option to call. Before the potential exercise date, investors assume the worst, i.e., that the firm calls when it is rational for the firm to do so. This determines the market value of the firm. In our model, we explicitly model the optimization of the manager and do not need to rely, as in Jarrow *et al.* (2010), on some latent factor determining exercise. Furthermore, we consider a Bermudan setting with discrete times, for calling the bond, instead of an American setting where calling a bond over a window of time is required. This means that we do not need to rely on settings such as those in Ibáñez and Zapatero (2004) or Ibáñez and Paraskevopoulos (2010).

Formally, this translates into the following. The interest rate dynamic is given by the square root process, also called the CIR process, and introduced by Cox *et al.* (1985). Let r_t be the instantaneous interest rate at time t. This will be our single risk factor. We assume the following risk-neutral dynamic for r_t

$$\mathrm{d}r_t = \kappa(\theta - r_t)\mathrm{d}t + \sigma\sqrt{r_t}\mathrm{d}W_t^*.$$

In this equation, κ, $\theta > 0$, and $\sigma > 0$ are constant parameters. The parameter θ has the interpretation of being a long-term interest rate level. κ is the speed of mean reversion. A greater value of this parameter means that interest rates that deviate from the long-run mean will return faster to the long-run mean. σ represents the volatility of mean-reversion. By $\mathrm{d}W_t^*$, we denote an increment of a Brownian motion over an elementary time increment $\mathrm{d}t$.

It has been shown in Cox *et al.* (1985) that the discount factor, i.e,. the price at t of a zero-coupon bond paying 1 at T, is given by

$$\begin{aligned}
Z(t,T) &= e^{A(t,T) - r_t\,B(t,T)} \\
A(t,T) &= \frac{2\kappa\theta}{\sigma^2}\ln\left(\frac{2he^{\frac{h+\kappa}{2}(T-t)}}{(h+\kappa)\left(e^{h(T-t)}-1\right)+2h}\right) \\
B(t,T) &= \frac{2\left(e^{h(T-t)}-1\right)}{(h+\kappa)\left(e^{h(T-t)}-1\right)+2h}
\end{aligned}$$

where $h = \sqrt{\kappa^2 + 2\sigma^2}$.

The price of a non-callable plain vanilla coupon bond with semiannual coupons can then be determined as follows. Assume that the coupon payment dates are T_i for $i = 1, \cdots, N$. Let F be the face amount to be paid at maturity. Define c as the constant coupon rate.

The price of the bond can be easily obtained using the discount factors above, with

$$B(t) = \sum_{i=1}^{N} \frac{cF}{2} Z(t, T_i) + FZ(t, T_N)$$

The price of a callable coupon bond with semiannual coupons adds at coupon payment dates an additional choice for the issuer: should the bond be called ? In practice, there may be a certain initial period of time where the bond cannot be called. In any case, the price of the bond is then valued by backward induction. There are also make-whole bonds that, upon call, pay to the holder of the bond the present value of the future cash flows. In this section, we are more interested in non-make-whole bonds that pay their owner only the face value. The case where the bond pays a (small) premium above the face value in the case of exercise is similar in treatment. Thus, for simplicity, we assume here that the bond issuer needs to consider the present discounted value of the future cash flows the bond represents and the strike price, here assumed to be F.

At maturity date T_N, the bond issuer must pay F and the last coupon. The value of the callable bond is thus

$$V_c(T_N) = F + \frac{cF}{2}.$$

At any time $T_i < T_N$, the bond issuer needs, first, to pay a coupon. Then, the issuer has the choice between calling or waiting and does so based on the continuation value of the instrument.

$$V_c(T_i) = \min(F, Z(T_i, T_{i+1})V_c(T_{i+1})) + \frac{cF}{2}.$$

Intuitively, if the bond price has increased over time because of a decrease in the general level of interest rates, the present value of the future coupons and repayment of F may be higher than the par value F. In such a situation, it would be of interest for the issuer to call the option and possibly refinance at some lower cost. When the option is ITM, market participants should expect the worst, which means an early exercise. In such a case, the investors only receive F. No rational buyer should pay a price higher than F if the call is ITM. In the case when an option is not called, we call the price jump the difference between the price after the issuer has decided not to call and F.

Presently, we turn to the simulation. It turns out that simulating the CIR process is not a trivial task, especially if one seeks efficiency. We rely on the discussion in Okhrin *et al.* (2022) and retain the QE algorithm of Andersen (2008).[14] For each scenario, We simulate 10,000 trajectories. The entire simulation lasts a fraction of a second. We present our findings in Table 7. The top part of the table presents the parameters chosen. We hold the long-run level of interest rates constant at 5%. This parameter does not affect the overall picture. We have a scenario with fast mean reversion, $\kappa = 10$, and another with slow mean reversion, $\kappa = 3$. We also have scenarios with lower (7%) and higher (20%) volatility of interest rates. The case of $\kappa = 3$ and $\sigma = 7\%$ aligns with the estimates in Duffee (1999) (treating r_t as an instantaneous yield spread process).[15] Time moves forward from the issue date to the penultimate period $T_N - 0.5$ by steps of a half year. $T_1 = 0.5$ corresponds to the first coupon date. The column 'NbC' expresses the percentage of situations in which the callable bond should have been rationally called. 'Mean' is the average price jump of the bond if the issuer does not call. 'Mean (10% max)' is the average price jump within the 10% largest price jumps.

κ	10			3			10		
θ	5%			5%			5%		
σ	7%			7%			20%		
T_i	NbC (%)	Mean	Mean (10% max)	NbC (%)	Mean	Mean (10% max)	NbC (%)	Mean	Mean (10% max)
0.5	30.64	0.1334	0.58	28.05	0.2379	0.92	25.26	0.3510	1.48
1.0	32.37	0.1346	0.55	28.82	0.2482	1.01	25.75	0.3415	1.48
1.5	33.98	0.1324	0.66	30.32	0.2418	1.07	26.92	0.3536	1.49
2.0	35.85	0.1363	0.64	32.04	0.2473	1.09	28.16	0.3460	1.57
2.5	37.84	0.1334	0.55	34.36	0.2471	1.02	29.95	0.3565	1.63
3.0	39.30	0.1352	0.64	36.55	0.2450	1.01	32.71	0.3531	1.75
3.5	42.42	0.1364	0.60	39.82	0.2467	1.14	36.16	0.3688	1.53
4.0	46.87	0.1376	0.60	44.28	0.2462	1.17	41.57	0.3584	1.51
4.5	57.22	0.1517	0.42	56.09	0.2536	0.70	54.01	0.3851	1.05

Table 7: Option price jumps following missed exercise opportunities in a calibrated CIR model. This table displays for selected values of the parameters for different times to maturity statistics of the price-jumps. NbC is the percentage of the 10'000 simulations where the issuer should have rationally called the bond. Mean is the average price jump if the issuer of the callable bond decides not to call the bond. To get an idea of the upper bound of the option value we also present 'Mean (10% max)' which is the average over the 10% largest price jumps .

[14] One may find codes on how to simulate the CIR process in the following GitHub repository: https://github.com/mrockinger/CIR-Heston-Simulation.

[15] We reestimated the model of Duffee (1999) in a recent TRACE sample and found similar parameter values for a median bond. However, there is substantial variation in parameter estimates in the cross-section of bonds.

Our findings correspond to what economic intuition suggests: as time passes, interest rates drift from their starting value, and this creates more situations where the bond should be called. Decreasing κ from 10 to 3 means that the series reverts less toward the mean. As interest rates drift further from the starting value (set at the long-term rate), this increases the option value of the call and, therefore, the price jump in the case of no call. Similarly, if one increases the volatility from 7% to 20%, the option value of the call increases and the price jump upon non-exercise is higher. The sizes of price jumps in Table 7 are generally in line with the effects we observe in the data. In a slow mean reversion case with low volatility, the price jump following no-exercise is approximately 25 b.p. In the data, depending on the sample period, we find average price jumps of approximately 30 to 40 b.p. (these are spread returns, which is the relevant comparison benchmark here), which can be matched by adjusting the volatility σ upward, as the case of $\sigma = 20\%$ demonstrates. In this latter case, the price jumps in the model are approximately 35 b.p. Additionally, observe in Table 7 that the price jump for a long-maturity bond (for instance, when $T_i = 0.5$) is smaller than for the shortest maturity bond ($T_i = 4.5$), although the difference of several basis points is not as large as what we observe in the data. Nonetheless, the effect goes in the same direction: with many opportunities to call, a suboptimal no-exercise is less detrimental to the option value than in the case of only a few remaining call opportunities.

4 Trading around call notices

We have documented bond price patterns around prescheduled call notice dates and found a large and significant return associated with missed exercise opportunities of ITM bonds. The return is in line with a revaluation of a Bermudan option embedded in callable bonds. Consistent with such an explanation, we demonstrate in this section that, in the cross-section of bond events, the ITM no-call return is not fully explained by a higher demand for not-called bonds post-notice. For this, we first investigate trading volume patterns in the event window and then regress event returns on changes in investors' demand for callable bonds.

A trading volume metric that we analyze is the 'average daily net volume' or $ADNV$. We calculate the $ADNV$ for a given bond the following way. The $ADNV$ is the difference between the average daily buy and sell volumes. The average daily buy volume is the total dollar amount of all purchases by clients from dealers in a chosen event interval (pre-notice or post-notice), divided by the number of calendar business days in the interval. Similarly, the average daily sell volume is the total amount of sales by dealers to clients divided by the number of business days. On average, there are approximately 20 business days in both pre- and post-notice periods. Most of these days, there is no trading activity (see Table 1, Panel E). Hence, our measure of the $ADNV$ represents what net investors' purchases would be if the bond were traded every business day. As opposed to a total net purchase, the $ADNV$ corrects for a different number of business days in the cross-section of bond-events. To render $ADNV$ comparable across bonds, we represent it as a fraction of the outstanding bond amount. The difference between post- and pre-notice $ADNV$ measures the change in investors' demand for a bond in the post-notice period relative to the pre-notice period.

Table 8a presents the regressions of a pre-event $ADNV$ on the combination of moneyness and call outcome dummies. Here, the regression model is similar to the returns model (3), but the left-hand side is now a bond-event-specific $ADNV$:

$$ADNV_i^{\text{pre}} = \gamma_1 \mathbf{1}_i^{\text{OTM}} \times \mathbf{1}_i^{\text{Not called}} + \cdots + \gamma_6 \mathbf{1}_i^{\text{ITM}} \times \mathbf{1}_i^{\text{Called}} + \epsilon_i. \quad (4)$$

The standard errors in the above model are still clustered at the bond-issuer level. The estimates $\hat{\gamma}_1, \ldots, \hat{\gamma}_6$ measure the average net demand for callable bonds depending on the moneyness of the embedded option and whether the bonds were or were not called.

We find that investors are net sellers of callable bonds in the pre-notice period. The $ADNV$ is mostly significantly negative pre-notice, and the effects are comparable across moneyness categories (Table 8a splits each bin further into called and not-called bonds, which is not known to investors pre-event, but keep in mind that there are many more no-calls than calls in the sample). Post-GFC, which is arguably the most homogeneous economic period of our sample, the $ADNV$ varies between -0.38 and -0.11 b.p. of the outstanding amount according to the third column of Table 8a. The economic size of the effect is small: for instance, the $ADNV$ of -0.38 b.p. translates into total net investor sales of approximately 8 b.p. pre-notice. This is, by construction, an increase in total dealers' inventory pre-notice. For a bond with \$20 mn outstanding amount, this translates into a net inventory increase of approximately \$16 th per bond.

Table 8b presents the estimates from a model similar to (4), but the left-hand side variable is now a change in the $ADNV$ post-notice relative to pre-notice. It represents

	Dependent variable: $ADNV_i^{\text{pre}}$					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	−0.12***	−0.18***	−0.13	−0.34**	−0.18**	0.09
	(0.03)	(0.05)	(0.09)	(0.15)	(0.07)	(0.29)
ATM × Not-called	−0.14	−0.16*	−0.18**	−0.40**	−0.12	−0.16*
	(0.08)	(0.09)	(0.09)	(0.14)	(0.11)	(0.08)
ITM × Not-called	−0.18***	−0.19***	−0.19***	−0.33***	−0.15***	−0.20
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.74)
OTM × Called	−0.44*	−0.50*	−0.38	−1.35*	−0.56***	0.97**
	(0.23)	(0.28)	(0.30)	(0.68)	(0.14)	(0.26)
ATM × Called	−0.34*	−0.37**	−0.36*	−0.03	−0.28	−1.04***
	(0.18)	(0.17)	(0.17)	(0.20)	(0.26)	(0.16)
ITM × Called	−0.09	−0.09	−0.11	−0.17	−0.07	−0.32
	(0.07)	(0.07)	(0.08)	(0.11)	(0.09)	(0.33)
Observations	11,277	8,658	6,378	1,236	4,088	1,054
Note:	*p<0.1; **p<0.05; ***p<0.01					

(a) Pre-event average daily net volume ($ADNV$)

	Dependent variable: $\Delta ADNV_i^{\text{post-pre}}$					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	0.02	0.19	0.33**	0.88	0.30*	0.10
	(0.14)	(0.18)	(0.16)	(0.51)	(0.17)	(0.18)
ATM × Not-called	0.26*	0.29*	0.32	0.78*	0.13	0.63*
	(0.15)	(0.16)	(0.19)	(0.44)	(0.20)	(0.32)
ITM × Not-called	0.33**	0.32**	0.37***	0.66***	0.31**	−0.30
	(0.12)	(0.13)	(0.13)	(0.22)	(0.12)	(0.94)
OTM × Called	−2.17***	−2.02**	−1.18**	−0.12	−1.23**	−1.74***
	(0.62)	(0.85)	(0.56)	(2.30)	(0.59)	(0.22)
ATM × Called	−2.12***	−2.15***	−1.92***	−1.75***	−2.36***	−1.00
	(0.22)	(0.24)	(0.31)	(0.43)	(0.46)	(1.00)
ITM × Called	−2.83***	−2.79***	−2.43***	−1.72***	−2.72***	−1.60
	(0.59)	(0.59)	(0.43)	(0.44)	(0.52)	(0.85)
Observations	11,276	8,657	6,377	1,236	4,087	1,054
Note:	*p<0.1; **p<0.05; ***p<0.01					

(b) Change in the $ADNV$ post-event to pre-event

Table 8: Trading volume by option moneyness, call decision, credit quality, and maturity. The regression model is $V_i = \beta_1 \mathbf{1}_i^{\text{OTM}} \times \mathbf{1}_i^{\text{Not called}} + \cdots + \beta_6 \mathbf{1}_i^{\text{ITM}} \times \mathbf{1}_i^{\text{Called}} + \epsilon_i$, where $\mathbf{1}^{\mathcal{M}}$ is the dummy that takes the value of 1 if condition $\mathcal{M}$ is satisfied and 0 otherwise. In Panel (a), V is the average daily net volume (client purchases from dealers minus client sales to dealers), in b.p. of the outstanding amount. The average is taken across all calendar business days (incl. zero-trading days). In Panel (b), V is the change in the $ADNV$ post- to pre-event. The 'Ex-GFC' sample excludes the years 2008 and 2009 from consideration. The 'Post-GFC' sample is from 2010 to 2019. The '<5Y' sample consists of bonds that mature in less than 5 years, '>5Y' – of bonds that mature in more than 5 years. The number of observations behind each estimated coefficient is in Table 13. The standard errors are clustered by the bond issuer.

the change in net investor demand for bonds from different moneyness categories *after* the uncertainty about the nearest call decision is resolved. The estimates in Table 8b have a very clear pattern: investors are selling the bonds that were called, regardless of the pre-event moneyness and are buying back ATM and ITM bonds that were not-called, which are those that exhibit positive event returns. The change in the $ADNV$, in absolute value, is several times greater for called than for not-called bonds. For instance, in the post-GFC sample, additional investor sales of called ITM bonds to dealers amount to approximately 2.4 b.p. of the outstanding amount per business day. Recall from Table 6 that there was no price effect associated with such sales (since the call is already priced in pre-notice, the transactions are at prices very close to the call price). Consider now a change in the $ADNV$ for not-called ITM bonds post-GFC (the third column of Table 8b). Investors increase net purchases of such bonds by 0.37 b.p. of the outstanding amount per day, which is almost two times more than what they sold to dealers pre-notice. The effect is twice stronger for investment-grade bonds with less than five years to maturity, which is the category where the largest event returns were also observed. Can it be that the event returns that we observe are due to temporary price pressure from an increase in investor demand?

To answer this question, we regress event returns on the change in the $ADNV$ in the cross-section of bond events. Table 9 reports the estimates for the spread return RS_i. The first four columns of Table 9 differ in the underlying sample (all years, post-GFC years, and post-GFC ITM bonds, all or only the called bonds) but deliver a similar loading on $\Delta ADNV$ of approximately 0.03–0.05% (not significant for not-called ITM bonds). This means that a 1 b.p. of additional post-notice client purchases (per business day) moves the bond price by 3–5 b.p. This is a relatively small economic effect: in models 1 to 4 in Table 9, the intercept (which is the part of RS_i beyond the price pressure of additional client purchases) stands at 32 to 62 b.p. Columns 5 to 8 further control for the issuers' equity return in the event window. We find that the equity return has a positive and significant loading and absorbs some of the volume price pressure. That is, the good news about the issuer's publicly traded stock correlates positively with the additional demand for the issuer's bond. The equity return also considerably improves the fit of the model: the R^2 jumps after the inclusion of the equity return. Nonetheless, the intercept in Columns 5–8 of Table 9 is strongly statistically and economically significant. The part of RS_i not explained by both $\Delta ADNV_i$ and R_i^{eq} is in the range of 22–71 b.p. The high end of the range is for not-called ITM bonds. The average spread return in the 'ITM but not called' subsample, before conditioning on volume and equity return, is at 63 b.p. Table 16 in

	Dependent variable: RS_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.32***	0.39**	0.50***	0.62***	0.30***	0.22***	0.54***	0.71***
	(0.11)	(0.18)	(0.11)	(0.15)	(0.10)	(0.07)	(0.10)	(0.19)
$\Delta ADNV_i$	0.05**	0.03***	0.04**	0.04	0.02	0.03***	0.03*	0.02
	(0.02)	(0.01)	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
R_i^{eq}					0.18***	0.19***	0.15***	0.16***
					(0.02)	(0.04)	(0.02)	(0.02)
Post-GFC	NO	YES	YES	YES	NO	YES	YES	YES
Moneyness	All	All	ITM	ITM	All	All	ITM	ITM
Called?	All	All	All	No	All	All	All	No
Observations	11,276	6,377	1,880	1,375	9,383	5,503	1,797	1,341
R^2	0.002	0.002	0.01	0.003	0.13	0.24	0.19	0.21

Note: *p<0.1; **p<0.05; ***p<0.01

Table 9: Callable bond notice returns, trading volume, and issuer stock returns. The regression model is $RS_i = \beta_0 + \beta_1 \Delta ADNV_i + \beta_2 R_i^{eq} + \epsilon_i$, where $\Delta ADNV_i$ is the change in the average daily net volume (see Table 8), in b.p. of the outstanding amount, and R_i^{eq} is the issuer's equity return in the event window (post-event to pre-event), in %. Models (1)–(8) estimate the regression on different subsamples. Models (1) and (5) are for the entire sample spanning 2005–2019. Models (2) and (6) exclude years prior to 2010. Models (3) and (7) further restrict the sample to the ITM bonds. In models (4) and (8), only not-called ITM bonds are in the sample. Table 16 in Appendix runs the same regressions for alternative notice return measures and Table 17 includes the sign of the $ADNV_i$ to control for the possible effect of the bid-ask bounce. The standard errors are clustered by the bond issuer.

the Appendix shows that the result does not depend on the return metric: the intercept remains significant across the board. Table 17, also in the Appendix, controls separately for the sign of $\Delta ADNV_i$ to capture a possible effect of the bid-ask bounce and finds an excess return that is virtually the same as in Table 9. Therefore, we conclude that trading volumes and stock market news about bond issuers, despite being factors of returns, do not explain large and positive average event returns in the cross-section of bond-events.

5 Callable bond portfolio performance

We have established that missed exercise opportunities are associated with positive excess returns on callable bonds. The excess return amounts to 20–70 b.p. (depending on the choice of benchmark), which aligns with the revaluation of an embedded Bermudan call option following a suboptimal no-exercise decision. In this section, we further characterize the return of a portfolio of ATM and ITM bonds. The purpose of the section is twofold.

First, we show that the ATM/ITM portfolio generates returns above and beyond the exposure to corporate bond pricing factors. Second, we discuss the practical limitations of the strategy.

We construct an ATM/ITM portfolio the following way. For each bond in the sample, the scheduled call dates are known in advance. Once the bond enters the pre-notice period, as defined in Figure 2, its moneyness is evaluated (which does not require any forward-looking information). ATM and ITM bonds are purchased into the portfolio at $\bar{P}_i^{\text{pre}}$ and are held until the post-notice period when they are sold at $\bar{P}_i^{\text{post}}$. Portfolio weights are proportional to bond outstanding amounts, that is, we consider size-weighted portfolios.[16] We attribute the resulting return to the months of scheduled call dates. This means that, on average, the bonds stay in the portfolio for approximately a month. We now discuss the characteristics of the time series of realized gross returns on such size-weighted, monthly rebalanced portfolios of ATM/ITM bonds.

	All callable		ATM/ITM callable	
	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC
Mean spread return, % month	0.07	0.64	-0.12	0.54
Std. deviation, % month	4.02	1.71	3.61	1.75
Sharpe Ratio (annualized)	0.06	1.29	-0.12	1.06
Min return, % month	-10.21	-6.94	-11.37	-7.45
Max return, % month	8.82	6.90	7.89	4.55
Avg. number of bonds	63	55	11	31

Table 10: Performance characteristics of a size-weighted portfolio of callable bonds. The portfolios consist of either all callable bonds in the sample or at/in-the-money bonds as defined in Section 1.4 $\left(\bar{IV}_i^{\text{pre}} > 0\%\right)$. We assume here that each month portfolio bonds are bought at the average pre-notice price and sold at the post-notice price. Portfolio weights are bond outstanding amounts. The resulting return is attributed to the month into which the latest possible call notice date (day -30 on Figure 2) falls. The returns are not adjusted for transaction costs. The spread return is RS_i as defined in Section 1.3. The pre-GFC period is 2004–2007, and the post-GFC is 2010–2019.

Table 10 presents summary statistics of the time series of portfolio returns. The returns here are spread returns RS_i as defined in Section 1.3. van Binsbergen and Schwert (2022) argue that such a metric is the proper way to evaluate excess returns on individual bonds and bond portfolios with a duration longer than several months. Our main focus is the portfolio of ATM/ITM bonds (the last two columns of Table 10), but we also present the characteristics of a portfolio of all callable bonds as a reference. We find, in line with previously reported results in Table 3, that at 54 b.p. per month, excess returns on the

[16] The results are quantitatively very similar for equally weighted portfolios (unreported).

portfolio of ATM/ITM bonds are large and positive in the post-GFC sample. Pre-GFC, there is no excess return on our callable bond portfolios. The gross Sharpe ratio of the ATM/ITM portfolio post-GFC is slightly above one, which is similar to many systematic corporate bond strategies in the sample period (Ivashchenko and Kosowksi 2023).

Importantly, the ATM/ITM portfolio holds, on average, approximately 30 bonds. This is a relatively small number, which implies certain costs and benefits. The cost is, potentially, an underdiversification of idiosyncratic risks of individual corporate bond holdings (although the portfolio of all callable bonds in the sample has a comparable return volatility, according to Table 10). A potential benefit of fewer portfolio holdings is a smaller transaction cost, which is of high importance for such a large-turnover portfolio. It is important to recall that our sample consists of retail notes with relatively small outstanding amounts; therefore, the capacity of such an ATM/ITM portfolio is limited, and the portfolio may be of interest only to small institutional or retail investors. Such investors would be trading primarily in retail amounts (up to \$100 th, which is a usual threshold for institutional transactions in this market), which is particularly costly. Ivashchenko and Kosowksi (2023) estimate an average one-way transaction cost for retail-sized corporate bond trades of approximately 30 b.p., which implies a roundtrip cost (60 b.p.) that fully offsets the gross excess return on the ATM/ITM portfolio (54 b.p.). Prior studies such as Bessembinder *et al.* (2018) estimate retail-sized bond trading costs even higher at above 100 b.p. Hence, for profitable practical implementation, one has to optimize the transaction costs to make the ATM/ITM portfolio generate positive net returns. Otherwise, it will be the dealers pocketing the excess return on callable bonds in the form of transaction costs. In fact, we discussed in Section 4 that the dealers are themselves investors in such callable bond portfolios. We found that dealers are net buyers of all callable bonds pre-notice and are net sellers of ATM/ITM bonds post-notice. From this standpoint, Table 10 documents the returns to the dealers' inventory of callable bonds held during the notice period.

Table 11 presents performance attribution regressions for the time series of ATM/ITM portfolio returns. Corporate bond pricing factors here are from Bai *et al.* (2019). The first two columns are for the pre-GFC period. As previously discussed, the notice return phenomenon was not present prior to the GFC. In the post-GFC sample, however, the ATM/ITM portfolio generates a significantly positive return in excess of exposure to common bond pricing factors. Relative to the one-factor model that only controls for the exposure to the corporate bond market portfolio return, the ATM/ITM excess return is

	Spread return on the ATM/ITM portfolio, %			
	Pre-GFC	Pre-GFC	Post-GFC	Post-GFC
Intercept	−0.13	−0.15	0.67***	0.49***
	(0.61)	(0.60)	(0.17)	(0.18)
Bond market return	−0.25	−0.54	−0.36**	−0.45**
	(0.83)	(0.96)	(0.16)	(0.21)
Credit risk factor		0.05		0.28**
		(0.71)		(0.12)
Default risk factor		−0.95*		0.01
		(0.54)		(0.12)
Liquidity risk factor		1.51		0.37
		(1.17)		(0.24)
Observations	36	36	116	116
R^2	0.003	0.13	0.04	0.13
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 11: Exposure of the ATM/ITM callable bond portfolio to corporate bond risk factors. The dependent variable is the size-weighted spread return (in % per month) on a monthly-rebalanced portfolio of at- or in-the-money callable retail notes. Bond risk factors are from Bai *et al.* (2019). The market factor is the size-weighted return on a broad corporate bond portfolio (both investment grade and high yield). Credit, default, and liquidity are size-weighted returns on long-short portfolios double sorted on the bond credit rating, value at risk (the second lowest monthly return in three years prior), and Bao *et al.* (2011) illiquidity in different combinations. The pre-GFC period is 2004–2007, and the post-GFC is 2010–2019.

approximately 67 b.p. per month. The addition of other pricing factors reduces the intercept to 49 b.p., but it remains strongly statistically significant. The portfolio has a positive exposure to the credit risk factor (the returns on low-rated bonds in excess of returns on high-rated bonds controlling for drawdown and illiquidity) and a negative exposure to the market factor. The latter is probably mechanical since the left-hand side variable here is the spread return, which increases when risk-free, duration-adjusted returns (likely positively correlated with market portfolio returns) decrease. The loading on the liquidity risk factor is positive but statistically insignificant, emphasizing again that excess notice returns are not due to the callable bonds' exposure to the illiquidity risk.

Figure 5 plots the cumulative return on the ATM/ITM callable bond portfolio. The plot demonstrates yet again that prior to the GFC, the portfolio of callable notes was not generating any excess return. During the GFC, the portfolio of ATM/ITM callable notes lost almost 40% of its value due to exposure to issuers that went through debt restructuring. Starting mid-2009, the callable portfolio has been steadily generating positive returns and almost tripled in value by the end of 2019 (relative to the trough in early-2009).

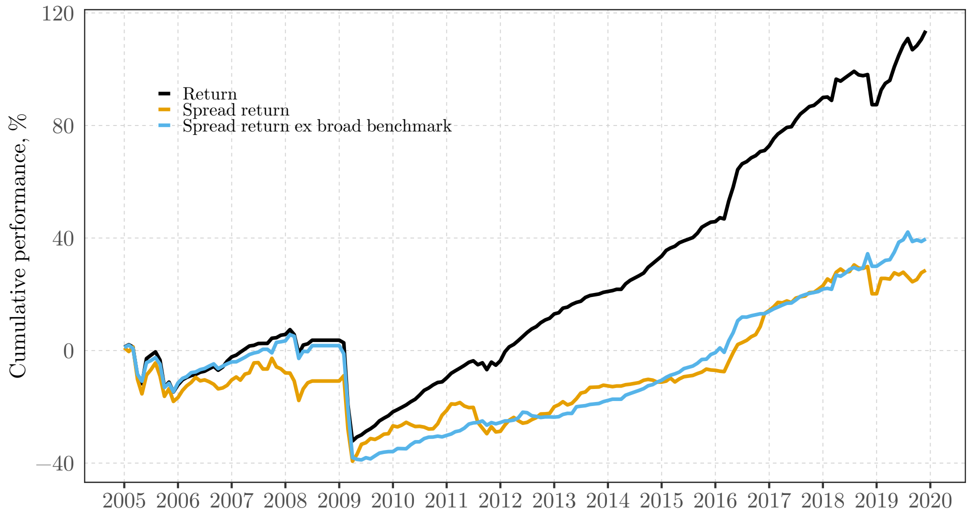

Figure 5: Cumulative returns of the ATM/ITM callable bond portfolio. The portfolio inception date is end-Dec 2004. On the y-axis is the cumulative return of the size-weighted monthly-rebalanced portfolio of at- and in-the-money callable retail notes. The returns are not adjusted for transaction costs. Three returns measures are: headline returns R, spread returns RS, and excess returns relative to a rating- and duration-matched portfolio of non-callable bonds XRS^b, as defined in Section 1.3.

Importantly, the orange line in Figure 5 demonstrates that the spread return component constitutes approximately one-half of the cumulative ATM/ITM portfolio appreciation. This is a remarkable statistic given that van Binsbergen and Schwert (2022) find that only approximately 5-10% of the performance of a representative corporate bond is due to changes in the yield spread (i.e., most of the return on such bonds is due to fluctuations in term Treasury rates). In the paper, we attributed these excess returns to surprising call exercise decisions. If unexpected no-calls were fully due to the changes in borrowing costs in the entire economy (i.e., to changes in the term structure of risk-free rates), then they would not generate positive spread returns. Therefore, we conclude that the portfolio of ATM/ITM bonds is a relevant investment instrument for retail and small institutional investors seeking exposure to risk factors beyond the systematic drivers of the yield curve.

6 Conclusion

We study the resolution of uncertainty around scheduled dates of possible call notices in the cross-section of discretely callable bonds. Our event study tracks callable bond prices and trading volumes around the time when the bond issuer could call or not call the bond, with an emphasis on non-make-whole bonds. We find that the resolution of uncertainty is associated with a substantial bond price appreciation that yields an excess callable bond return of approximately 30 b.p., on average. This effect is up to six times greater than a similar monthly excess return metric outside the event window.

We find that the main driver of the aforementioned feature is the price jump of those bonds that should have been called by the issuer (ITM bonds) but that were not called. We proxy for the call probability with a novel measure of embedded call option moneyness, which we calculate as the potential benefit to the issuer from calling the bond and replacing it with a similar non-callable bond. In our sample, issuers often miss call opportunities that seem profitable. In such cases, bond prices jump by 40-50 b.p. (in excess of the changes implied by the general level of interest rates), and the effect is higher for short-than for long-term bonds. We demonstrate in a calibrated option pricing model that a suboptimal exercise decision implies a price jump of a similar level.

By analyzing trading patterns before event dates, we establish that bond investors are net sellers of all callable bonds. Following the resolution of uncertainty, investors buy back ITM bonds that were not called. Because of the price increase, dealers holding callable bonds in their inventory during the event windows gain the price difference. An investor may attempt to mimic the dealers' position, which as we show, generates substantial risk-adjusted returns, but higher transaction costs might annihilate excess returns.

Our paper addresses a recent regulatory concern (U.S. SEC, 2019) about the lack of knowledge regarding options embedded in fixed-income instruments available to retail investors. By characterizing risk and return discrepancies between callable and non-callable bonds, we respond to the regulator's call and, hopefully, contribute to educating investors about the properties of derivative positions implicit in their corporate bond portfolios.

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Appendix A Additional Tables and Charts

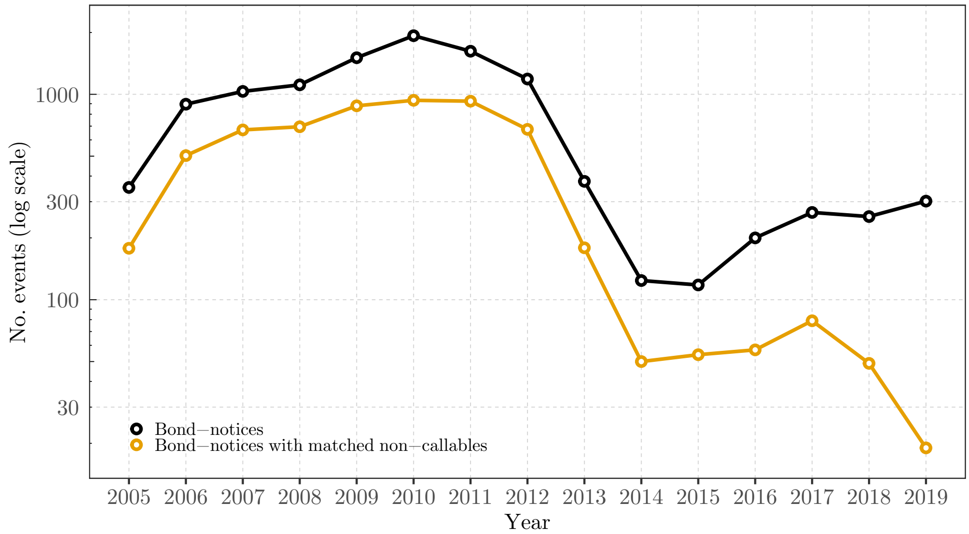

Figure 6: Sample size by calendar year. An event is a scheduled bond (no-)call notice date. The sample consists of only retail notes with at least 90 days between scheduled call dates. Some results in the paper are relative to similar-duration non-callable bonds of the same issuer. The size of such a subsample of matched callable and non-callable bonds is the bottom line in the figure.

Issuer name	No. bonds	MCap, $ bln
FORD MOTOR CO	423	28
BANK OF AMERICA CORP	329	133
GENERAL ELECTRIC CO	255	212
DUPONT DE NEMOURS INC	253	46
PRUDENTIAL FINANCIAL INC	245	25
BANK OF NEW YORK MELLON CORP	208	35
GENERAL MTRS ACCEP CORP	186	
PROSPECT CAPITAL CORP	161	3
CATERPILLAR INC	140	40
CIT GROUP INC	132	7
PRINCIPAL FINANCIAL GRP INC	56	14
CITIGROUP INC	40	110
PROTECTIVE LIFE CORP	39	2
MERCEDES-BENZ GROUP AG	38	56
HARTFORD FINANCIAL SERVICES	35	7
HSBC HLDGS PLC	34	156
TOYOTA MOTOR CORP	29	147
HARTFORD LIFE INSURANCE CO	24	
UNITED PARCEL SERVICE INC	23	79
GENERAL MOTORS CO	19	34

Table 12: Top-20 issuers of callable retail notes in the sample. 'No. bonds' is the number of unique bond CUSIPs per issuer in the entire sample (2005–2019). Market capitalization is the average market value of the issuer's equity (from Compustat) before the bond (no-)call notice. If the issuer is not a listed company in the event window, its market cap is missing. The issuers' names are from the Mergent FISD dataset.

	Full smpl	Ex-GFC	Post-GFC	Post-GFC, IG <5Y	>5Y	Post-GFC HY
OTM × Not-called	6720	4407	2544	406	1388	750
ATM × Not-called	1536	1504	1375	305	1032	38
ITM × Not-called	1761	1602	1405	310	975	120
OTM × Called	364	270	241	30	167	44
ATM × Called	341	322	307	89	158	60
ITM × Called	555	553	506	96	368	42

Table 13: The number of events (sample size) by option moneyness, call decision, credit quality, and maturity. This table presents the number of observations behind each category in Table 6.

	Dependent variable: $\mathbf{P}_i$ [Called]				
	(1)	(2)	(3)	(4)	(5)
Intrinsic value	0.21^{***}	0.21^{***}	0.22^{***}	0.22^{***}	0.22^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outstanding amount		0.01^{***}	0.01^{***}	0.01^{***}	0.01^{**}
		(0.00)	(0.00)	(0.00)	(0.00)
Rating			0.56^{***}	0.57^{***}	0.81^{***}
			(0.03)	(0.03)	(0.04)
Maturity				0.02^{**}	0.02^{**}
				(0.01)	(0.01)
Market cap.					0.01^{***}
					(0.00)
Log Likelihood	−2911.81	−2903.54	−2703.63	−2700.06	−2338.74
Num. obs.	11187	11187	11187	11187	9280

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 14: Logit model for the call dummy with issuer fixed-effects. The dependent variable equals 1 if the bond is called in event i and equals 0 otherwise. 'Intrinsic value' is the intrinsic value of an embedded callable bond option relative to a broad non-callable benchmark portfolio as defined in Section 1.4, in % of the call price. 'Outstanding amount' is the bond amount outstanding, in $ mn. 'Rating' is the bond credit rating on a conventional numerical scale from 1 (AAA) to 21 (C). 'Maturity' is the remaining time to bond maturity, in years. 'Market cap.' is the equity market capitalization of the bond issuer. All right-hand-side variables are pre-notice averages as defined in Figure 2. Every model also includes issuer fixed effects. The sample period is 2005–2019. Analogous linear probability models are in Table 5.

	Dependent variable: rs_i					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	0.13***	0.11*	0.18*	0.13***	0.01	0.51***
	(0.04)	(0.06)	(0.10)	(0.04)	(0.01)	(0.03)
ATM × Not-called	0.08*	0.09*	0.10	0.30***	−0.02	0.54***
	(0.05)	(0.05)	(0.06)	(0.04)	(0.04)	(0.02)
ITM × Not-called	0.09**	0.09**	0.12***	0.31***	0.07***	−0.05
	(0.04)	(0.04)	(0.03)	(0.08)	(0.01)	(0.12)
OTM × Called	0.23**	0.16**	0.14	0.05	0.05	0.57***
	(0.09)	(0.08)	(0.09)	(0.06)	(0.03)	(0.07)
ATM × Called	0.02	0.03	0.02	0.05	−0.04	0.12***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
ITM × Called	0.02	0.02	0.02	0.01	0.01	0.12
	(0.02)	(0.02)	(0.02)	(0.06)	(0.02)	(0.08)
Observations	11,277	8,658	6,378	1,236	4,088	1,054

Note: *p<0.1; **p<0.05; ***p<0.01

(a) Duration-adjusted notice return

	Dependent variable: XRS_i^b					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	0.40***	0.65***	0.83***	0.33**	0.89***	1.02***
	(0.11)	(0.13)	(0.15)	(0.13)	(0.12)	(0.17)
ATM × Not-called	0.47***	0.56***	0.59***	0.81***	0.49***	0.78***
	(0.07)	(0.07)	(0.07)	(0.13)	(0.09)	(0.13)
ITM × Not-called	0.60***	0.62***	0.78***	1.13***	0.68***	0.75**
	(0.15)	(0.15)	(0.10)	(0.12)	(0.10)	(0.21)
OTM × Called	0.68	0.18	−0.11	−0.10	0.06	−0.75
	(0.40)	(0.25)	(0.27)	(0.11)	(0.31)	(1.18)
ATM × Called	0.39***	0.40***	0.35**	0.13	0.31	0.79***
	(0.13)	(0.14)	(0.13)	(0.09)	(0.19)	(0.04)
ITM × Called	0.29**	0.29**	0.22*	0.16**	0.22	0.41
	(0.14)	(0.14)	(0.12)	(0.07)	(0.16)	(0.28)
Observations	11,277	8,658	6,378	1,236	4,088	1,054

Note: *p<0.1; **p<0.05; ***p<0.01

(b) Excess notice return (broad benchmark)

	Dependent variable: XRS_i^n					
				Post-GFC, IG		Post-GFC
	Full smpl	Ex-GFC	Post-GFC	<5Y	>5Y	HY
OTM × Not-called	0.50*	0.28***	0.19	0.52	0.23***	−0.27
	(0.25)	(0.08)	(0.11)	(0.31)	(0.06)	(0.17)
ATM × Not-called	0.17	0.16	0.07	0.37	−0.03	0.43
	(0.16)	(0.18)	(0.18)	(0.29)	(0.19)	(0.47)
ITM × Not-called	0.55***	0.56***	0.55***	1.20***	0.37***	2.37
	(0.10)	(0.09)	(0.09)	(0.24)	(0.04)	(0.86)
OTM × Called	−0.05	−0.18	−0.25	0.37	−0.57	0.05***
	(0.18)	(0.26)	(0.25)	(0.77)	(0.32)	(0.00)
ATM × Called	0.07	0.23	0.15	−0.01	−0.52	0.90***
	(0.35)	(0.33)	(0.34)	(0.08)	(0.35)	(0.02)
ITM × Called	0.04	0.04	0.05	0.14	−0.05	0.72***
	(0.28)	(0.28)	(0.27)	(0.21)	(0.38)	(0.00)
Observations	5,914	4,345	3,003	616	2,112	275

Note: *p<0.1; **p<0.05; ***p<0.01

(c) Excess notice return (narrow benchmark)

Table 15: Alternative measures of notice return by option moneyness, call decision, credit quality, and maturity. Same regressions as in Table 6, but with different dependent variables.

	Dependent variable: rs_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.11***	0.13**	0.09***	0.11***	0.09**	0.07***	0.10***	0.13***
	(0.04)	(0.06)	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.04)
$\Delta ADNV_i$	0.01**	0.01**	0.01***	0.01**	0.01	0.004**	0.01**	0.01*
	(0.01)	(0.003)	(0.003)	(0.004)	(0.01)	(0.002)	(0.003)	(0.003)
R_i^{eq}					0.03***	0.02***	0.02***	0.02***
					(0.01)	(0.004)	(0.003)	(0.004)
Post-GFC	NO	YES	YES	YES	NO	YES	YES	YES
Moneyness	All	All	ITM	ITM	All	All	ITM	ITM
Called?	All	All	All	No	All	All	All	No
Observations	11,276	6,377	1,880	1,375	9,383	5,503	1,797	1,341
R^2	0.003	0.003	0.01	0.01	0.08	0.18	0.20	0.21

Note: *p<0.1; **p<0.05; ***p<0.01

(a) Duration-adjusted notice return

	Dependent variable: XRS_i^b							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.45***	0.66***	0.64***	0.76***	0.50***	0.62***	0.65***	0.76***
	(0.09)	(0.07)	(0.08)	(0.10)	(0.08)	(0.06)	(0.07)	(0.11)
$\Delta ADNV_i$	0.04**	0.03***	0.03*	0.04***	0.02	0.02***	0.03*	0.04***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
R_i^{eq}					0.10***	−0.002	−0.03	−0.02
					(0.02)	(0.04)	(0.03)	(0.04)
Post-GFC	NO	YES	YES	YES	NO	YES	YES	YES
Moneyness	All	All	ITM	ITM	All	All	ITM	ITM
Called?	All	All	All	No	All	All	All	No
Observations	11,276	6,377	1,880	1,375	9,383	5,503	1,797	1,341
R^2	0.002	0.004	0.003	0.01	0.04	0.003	0.02	0.01

Note: *p<0.1; **p<0.05; ***p<0.01

(b) Excess notice return (broad benchmark)

	Dependent variable: XRS_i^n							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.42**	0.25***	0.44***	0.54***	0.40**	0.26***	0.44***	0.53***
	(0.17)	(0.06)	(0.05)	(0.09)	(0.17)	(0.08)	(0.07)	(0.08)
$\Delta ADNV_i$	0.04	0.04***	0.04***	0.03***	0.04	0.03***	0.04***	0.04***
	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)
R_i^{eq}					−0.01	−0.03**	−0.02***	−0.02***
					(0.02)	(0.01)	(0.01)	(0.005)
Post-GFC	NO	YES	YES	YES	NO	YES	YES	YES
Moneyness	All	All	ITM	ITM	All	All	ITM	ITM
Called?	All	All	All	No	All	All	All	No
Observations	5,913	3,002	1,225	948	5,635	2,955	1,225	948
R^2	0.002	0.004	0.003	0.002	0.002	0.01	0.01	0.01

Note: *p<0.1; **p<0.05; ***p<0.01

(c) Excess notice return (narrow benchmark)

Table 16: Callable bond notice returns (alternative measures), trading volume, and issuer stock returns. Same regressions as in Table 9, but with different dependent variables.

	Dependent variable: RS_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.33***	0.39**	0.50***	0.59***	0.30***	0.22***	0.54***	0.69***
	(0.11)	(0.18)	(0.10)	(0.15)	(0.10)	(0.07)	(0.11)	(0.18)
$\text{Sign}\left(\Delta ADNV\right)_i$	0.59***	0.19***	0.28**	0.26*	0.42***	0.15**	0.21*	0.14
	(0.13)	(0.06)	(0.12)	(0.14)	(0.13)	(0.06)	(0.11)	(0.10)
$\Delta ADNV_i$	−0.01	0.01	0.01	0.01	−0.02	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
R_i^{eq}					0.18***	0.19***	0.15***	0.16***
					(0.02)	(0.04)	(0.02)	(0.02)
Post-GFC	NO	YES	YES	YES	NO	YES	YES	YES
Moneyness	All	All	ITM	ITM	All	All	ITM	ITM
Called?	All	All	All	No	All	All	All	No
Observations	11,276	6,377	1,880	1,375	9,383	5,503	1,797	1,341
R^2	0.01	0.005	0.01	0.01	0.13	0.24	0.20	0.21
Note:	*p<0.1; **p<0.05; ***p<0.01							

Table 17: Callable bond notice returns, trading volume, and issuer stock returns. The regression model is $RS_i = \beta_0 + \beta_1 \text{Sign}\left(\Delta ADNV\right)_i + \beta_2 \Delta ADNV_i + \beta_3 R_i^{eq} + \epsilon_i$. It is analogous to Table 9 but includes the sign of the $ADNV$ as a binary variable that takes the value of 1 if $ADNV_i \geqslant 0$ and -1 if $ADNV_i < 0$. $\text{Sign}\left(\Delta ADNV\right)_i$ explicitly controls for the bid-ask bounce.