

NBER WORKING PAPER SERIES

ADVANCE REFUNDINGS OF MUNICIPAL BONDS

Andrew Ang
Richard C. Green
Yuhang Xing

Working Paper 19459
<http://www.nber.org/papers/w19459>

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2013

We greatly appreciate the research assistance of Karthik Nagarajan, Yunfan Gu, and Tsuyoshi Sasaki. A number of industry professionals have patiently tutored us about the details of advance refundings and/or vigorously argued with our conclusions. Thanks to Chester Spatt for originally bringing this problem to our attention. We have benefited from the comments of Vineer Bhansali, Trevor Harris, Tal Heppenstall, Andrew Kalotay, Kemp Lewis, Paul Luhmann, Matt Roggenburgh, Rich Ryffel, and Matt Whysel. We are grateful for comments and suggestions of a number of colleagues, especially Jennifer Carpenter, Dan Li, Norman Schürhoff, and Chester Spatt, along with seminar participants at U.C. Davis and the Federal Reserve Bank of San Francisco. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

NBER working papers are circulated for discussion and comment purposes. They have not been peer-reviewed or been subject to the review by the NBER Board of Directors that accompanies official NBER publications.

© 2013 by Andrew Ang, Richard C. Green, and Yuhang Xing. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

Advance Refundings of Municipal Bonds
Andrew Ang, Richard C. Green, and Yuhang Xing
NBER Working Paper No. 19459
September 2013
JEL No. G12,G28,H21,H24

ABSTRACT

Municipal bonds are often "advance refunded." Bonds that are not yet callable are defeased by creating a trust that pays the interest up to the call date, and pays the call price. New debt, generally at lower interest rates, is issued to fund the trust. Issuing new securities generally has zero net present value. In this case, however, value is destroyed for the issuer through the pre-commitment to call. We estimate that for the typical bond in an advance refunding, the option value lost to the municipality is approximately 1% of the par value not including fees. This translates to an aggregate value lost of over \$4 billion from 1996 to 2009 for the bonds in our sample, which are roughly half of the universe of advance refunded bonds that traded during the period. The worst 5% of the transactions represent a destruction of \$2.9 billion for taxpayers. We discuss various motives for the transaction, and argue that a major one is the need for short-term budget relief. Advance refunding enables the issuer to borrow for current operating activities in exchange for higher interest payments after the call date. We find that municipalities in states with poor governance generally destroy the most value by advance refunding.

Andrew Ang
Columbia Business School
3022 Broadway 413 Uris
New York, NY 10027
and NBER
aa610@columbia.edu

Yuhang Xing
Rice University
Jones School of Management, MS 531
Rice University
6100 Main Street
Houston, TX 77004
yxing@rice.edu

Richard C. Green
Tepper School of Business
Carnegie Mellon University
Pittsburgh, PA 15213
and NBER
rcgreen@cmu.edu

1 Introduction

In an advance refunding, or pre-refunding, a municipality issues new debt to pay off an existing bond. The new bond is typically issued at a lower yield than the outstanding bond, which is not yet callable but will be callable in the future. The proceeds from the new debt fund a trust that covers the remaining coupon payments up until the call date and the call price of the existing bonds. The trust generally holds risk-free U.S. Treasury bonds, which are specially issued by the Treasury for this purpose (and are called State and Local Government Securities, SLGS, or “slugs”).¹

The practice of advance refunding is widespread in municipal finance. New issues of municipal bonds in recent years have varied between \$300 and \$400 billion a year. In 2012, total new issue volume grew by 31% from \$288 billion in 2011 to \$376 billion in 2012. Only \$144 billion of the \$376 billion in 2012 volume was “new money,” representing bonds that were issued to fund new investment projects. This was actually a slight decrease from the new money in 2011. The rest of the new issues went to refund existing debt, because the bonds were advanced refunded, were called, or they matured. According to the leading trade publication, *The Bond Buyer*, “Low rates fueled the refunding boom. The triple-A 10-year yield reached historic lows in 2012.”²

Figure 1 shows par value amounts of municipal bond redemptions, by year and by different categories. Bonds can be retired at maturity, either because they were never callable or because the call was never exercised. Bonds can be called during the time period when the call provision is in effect, in a so-called “current refunding.” The third category of bond redemptions in the figure are bonds that are called after having previously been defeased through an advance refunding. In 2012, for example, \$450 billion of municipal debt was

¹This prevents the issuer from earning the (taxable) rate on assets funded by tax-exempt municipal debt, while also providing inexpensive financing for the U.S. Treasury.

²“Refunding Rage Fuels 31% Bounce in Muni Debt,” *The Bond Buyer’s 2012 in Statistics Annual Review*, February 11, 2013, p. 2A.

extinguished through redemption (including \$53 billion in maturing notes, not shown in the figure). Of this total, \$76.5 billion were bonds that were called after having previously been pre-refunded. In the early years of the last decade, more pre-refunded bonds were called than non pre-refunded bonds. In recent years the volume of called, pre-refunded bonds has been about half of the volume of current refundings.

In an advance refunding, one security is issued to fund payments on another. One of the most basic lessons of an introductory finance course is that such a transaction cannot create value. It can only transfer value between the various claimants involved. In this case, there are four parties involved: the municipal issuer, the holders of the bonds being refunded, the financial intermediaries collecting fees for arranging the transaction, and the U.S. Treasury, which issues and prices the SLGS. The transaction clearly transfers option value from the issuer to the bondholders. We discuss other possible ways in which surplus may be generated for other parties through the methods used to set rates on the SLGS at the expense of the Treasury. We quantitatively evaluate the magnitudes of the losses to the issuers in aggregate and in the cross section with a large sample of advance refundings.

Advance refunding generally provides short-term budget relief. As the interest rate on the new debt is lower than the yield on existing debt, advance refunding decreases the municipality's interest cost between the pre-refunding date and the date at which the original bonds could have been called. It also hedges the issuer's future borrowing costs, and industry professionals argue that alternative means of hedging can be costly.

Unfortunately, however, advance refunding destroys value for the issuer. By pre-committing to call, the issuer surrenders the option not to call should interest rates rise before the call date. The value lost to the issuer, and transferred to bondholders, is the value of a put option on the bonds. In addition, since the assets in the trust are Treasury securities, the transaction provides free credit enhancement for the bondholders, also at the expense of the issuer. Finally, the intermediaries who create the trust and issue the new bonds collect fees to do so.

Payment of these fees would be delayed if the issuer waited to refund at the call date, and, since pre-refundings do not extend the maturity of the debt, would be avoided altogether if at the call date the call option were ultimately not exercised. Indeed, underwriters and traders are known to jokingly refer to advance refundings as “de-fees-ance.”

In this paper, we describe the effects of pre-refunding on the cash flows and the present value of the issuer’s obligations. Examining a sample of almost 150,000 pre-refunded bonds over 1996 to 2009, which represents over 50% of the the pre-refunded bonds that traded during the period, we estimate that advance refunding has erased over \$4 billion in option value for taxpayers. The distribution of the option value lost is highly skewed. While the majority of advance refundings represent only small losses, the worst 5% of advanced refunded bonds represent over \$2.9 billion of lost value. If we include a 2% transaction cost as a fraction of the refunded bond value, the aggregate value of losses to advance refunding is over \$14 billion. The fees municipalities paid in these “de-fees-ance” deals are substantial compared to the option value lost. In cross-sectional analysis, we find that states with the highest number of convictions of public officials per capita are also states where municipal officials have destroyed more option value by advance refunding. Assuming our sample is representative, these numbers can be roughly be doubled to assess the aggregate impact of advance refunding.

Why, given the costs, do municipal issuers pre-refund their bonds? Almost all municipalities are required by statutes, charters, or state constitutions to balance their operating budgets. They can only borrow for capital projects. They are rarely restricted from refunding or pre-refunding existing debt, however, as long as the maturity is not increased. We show that advance refunding allows the municipality to, in effect, borrow against future potential interest savings. Current interest expense, which is paid out of the operating budget, is reduced, while future payments after the call date are increased. The transaction is effectively a swap, with zero net present value.

We compute that the amount of implicit borrowing being done by advance refunding totals over \$7 billion. Like the distribution of option value lost, the distribution of implicit borrowings is highly skewed, so the 95% quantile represents over \$5.30 per \$100 par value of the refunded bond in implicit borrowing. The median borrowing amounts to approximately \$1.60 per \$100 par value. An advance refunding may help the issuer avoid the need to increase taxes or lay off public workers, which may be laudable, even urgent, priorities. The restrictions on borrowing to fund these priorities are presumably in place for equally commendable reasons, which are evidently being circumvented. By accelerating interest savings at the expense of future savings, advance refundings can help elected officials defer cost cutting or tax increases in an election year, and the borrowings done through advance refunding come at the expense of destroying option value. Thus, advance refundings can be viewed as a non-transparent means of borrowing to fund operating activities.

Advance refunding is also seen as a means of locking in or hedging future borrowing costs. If the municipality waits to the call date, and does a current refunding, it will pay whatever the prevailing interest rate is at that point. Indeed, it may choose not to refund if rates are sufficiently high at that point. Advocates argue that the forward rates implicit in the transaction are often lower than those available directly, because the yields on the SLGS in the trust exceed short-term municipal rates. As a practical matter, moreover, hedging the interest rate risk directly may be difficult to arrange at low transaction costs. Thus, some surplus in the transaction may be created for other participants at the expense of the Treasury. We discuss these considerations in detail in Section 2.4. We show empirically that the magnitude of this advantage does encourage municipalities to engage in deals that destroy more option value, but also note that in recent years the advantage has disappeared, and yet pre-refunding activity has not. As a matter of policy, we argue that subsidizing a form of hedging through the SLGS rates, which are set at the discretion of the Treasury, is counter productive if it encourages transactions that destroy value for issuers on other

dimensions.

Advance refundings of municipal bonds have received very limited attention in the academic literature.³ In an unpublished note, Dammon and Spatt (1993) describe the transaction and explain how it destroys option value for the issuer. Analyses in specialized journals aimed at practitioners often acknowledge that option value is lost, but generally prescribe comparing this loss, along with fees paid, to the interest savings over the remaining time to maturity. For example, Kalotay and May (1998) or Kalotay and Abreo (2010) advocate calculating “refunding efficiency,” the ratio of the present value of interest savings over the life of the newly issued debt to the lost option value. While they acknowledge the option value lost in pre-refunding, these studies do not compute the typical value lost in an advance refunding deal, or compute the implicit borrowing involved.

Two empirical studies examining the determinants of municipal refundings are Vijayakumar (1995) and Moldogaziev and Luby (2012). They do not take into account the losses from advance refunding. Several papers have used pre-refunded, or defeased bonds, in analysis but do not examine the pre-refunding decision. Fischer (1983), for example, uses the public announcement of an advance refunding to examine efficiency of the municipal bond market, and Chalmers (1998) shows that the steeper slope of the municipal yield curve compared to Treasuries cannot be explained by default risk by showing the phenomenon is exhibited in pre-refunded municipal bonds with no default risk.

The paper is organized as follows. The next section illustrates the cash flow and valuation effects of advance refundings. Section 3 describes the data and provides descriptive evidence on pre-refundings and the pervasiveness of the practice. Section 4 describes the methods we use to price the option value destroyed through the transaction for the issuers. Section 5

³There is an older literature looking at the (early) refunding decisions of corporations, like Weingartner (1967) and Kraus (1973). In the 1970s and early 1980s, several companies advanced refunded debt and were able to book profits and defease debt. This practice was severely curtailed by FASB in 1984 (Technical Bulletin No. 84-4). There was no such corresponding restriction issued by GASB for municipalities.

evaluates the quantitative consequences of pre-refunding. We discuss value destroyed in the advance refundings in our sample and estimate the present value of interest savings that are accelerated through time by means of the transaction. We also discuss which municipalities do the worst deals. In Section 6, we discuss common misconceptions about advance refund before concluding in Section 7.

2 The Pre-Refunding Decision

This section illustrates the effects advance refunding has on the value of the issuer's liability, and on the pattern of cash flows associated with that liability through time. We begin with the simplest case, a flat term structure with certainty about future rates, as it is sufficient to illustrate the implicit borrowing the transaction involves.

2.1 Example

Suppose the term structure is flat at all points, and ignore default risk.⁴ We assume coupon payments are made annually. A municipal entity has previously issued bonds with \$100 face value and a 6% coupon. Interest rates have since fallen to 4%. There are six years to maturity, and the bonds are callable at \$100 the end of three years. Let us first abstract from the optionality in the call provision for the bonds, and assume it is known with certainty that rates remain at 4% forever.

In the first row of Table 1, we list the cashflows of the existing bond. The value of the original bond at 4% is:

$$\frac{6}{(1.04)} + \frac{6}{(1.04)^2} + \dots + \frac{106}{(1.04)^6} = \$110.48.$$

⁴Keep in mind that the credit risk for most of the municipal sector has been quite low in modern times compared to the corporate sector—recent fiscal problems at the state and local level notwithstanding.

If the bond was callable at the current date, the decision would be easy. The municipality would issue new bonds with six years to maturity and refund the old bonds. The annual interest payments per \$100 par value would drop from \$6 to \$4, and the present value of these savings would be:

$$\frac{2}{1.04} + \frac{2}{(1.04)^2} + \dots + \frac{2}{(1.04)^6} = \$10.48$$

per \$100 of face value.

Unfortunately, the bonds are not immediately callable, and the issuer must choose between waiting three years to call or pre-refunding now. If the issuer pre-refunds it must issue a six-year bond at a coupon rate of 4% sufficient to fund the payments over the next three years and the call price. The face value of the new bond that must be issued is:

$$\frac{6}{(1.04)} + \frac{6}{(1.04)^2} + \frac{106}{(1.04)^3} = \$105.55.$$

The coupon payments on the new bonds are:

$$105.55 \times 0.04 = \$4.22.$$

The cashflows of the refunding issue are given in the second row of Table 1. After the new bond is issued, the original bond is defeased and no longer appears as a liability on the balance sheet of the municipality.

Standard industry practice, endorsed in 1995 and 2010 by the Government Finance Officers Association (GFOA), which is the professional association of municipal finance officers in the U.S. and Canada, is to compare the cash flows of the original bond (row 1) with the cash flows of the new bond (row 2). The best practice guidelines of the GFOA recommends that a refunding be considered when the “minimum net present value (NPV) savings” is

at least 3-5%.⁵ Row 3 of Table 1 computes this value by taking the difference between the original bond’s coupons of \$6 and the cashflows of the pre-refunded bond of \$4.22. The NPV savings are

$$\frac{1.78}{(1.04)} + \frac{1.78}{(1.04)^2} + \dots + \frac{-3.77}{(1.04)^6} = \$4.94.$$

It appears that using the “NPV method,” the municipality obtains a savings of 4.5% = 4.94/105.55. This analysis, however, ignores what the issuer is giving up—the ability to call the bond at the end of three years. The relevant comparison is not advance refunding or leaving the existing bond in place to maturity. The relevant comparison is advance refunding or waiting until the call protection expires and proceeding with a current refunding.

If the issuer waits the three years to call the bonds, it pays \$6 for three years, and the strike price at the end of three years, financed by issuing a new three-year bond at 4%. We examine the cashflows associated with the call decision in the rows labeled “Wait to Call” in Table 1. The savings of waiting to call, and calling at the end of three years, compared to paying the coupons of the original bond to maturity are

$$\frac{2}{(1.04)^4} + \frac{2}{(1.04)^5} + \frac{2}{(1.04)^6} = \$4.94.$$

That is, the savings from waiting to call are exactly equal to the apparent savings from the issue of the pre-refunding bond. In this case, interest rates are certain, so the present values of the interest savings under the two alternatives are equal. Only the timing of the interest savings differs. The final line in the table shows the savings associated with pre-refunding less the savings associated with waiting to call. The pre-refunding accelerates the interest savings at the expense of higher interest payments over the later years, and an higher payment at maturity.

⁵Analyzing and Issuing Refunding Bonds (1995 and 2010) (DEBT), GFOA Best Practice approved by the GFOA’s Executive Board in February 2011. This practice follows early academic studies like Dyl and Joehnk (1976) and Joehnk and Dyl (1979) that ignore the option value of pre-refunding.

The last row of Table 1 shows this explicitly. It takes the difference between the cash flows of the pre-refunding case and waiting to call. The present values of the positive and negative flows are equal. The issuer is effectively borrowing against future interest savings associated with the opportunity to call, as well as a higher principal repayment, to reduce interest expense now. The present value of the accelerated interest savings, \$4.95 per \$100 face value, is achieved by surrendering the same present value of savings later. Alternatively, the issuer could achieve the payment stream associated with pre-refunding by entering a swap contract that paid the municipality \$1.78 each year for three years, in exchange for the promise to pay \$0.22 annually starting in year four, augmented by \$5.55 in year six. It has zero present value at the current date, but effectively borrows over the first three years in exchange for payments over the last three years.

Evidently then, under certainty about the evolution of future interest rates, waiting to refund, versus pre-refunding has no effect on the present value of the issuer's liability. Why then would an issuer want to do this? When pre-refunding, the issuer has interest expense each period between the \$6 associated with the existing debt and the \$4 it will pay after the call date if it waits to call. Though this has no effect on the present value of the issuer's liabilities, it may very well affect its freedom to spend money or reduce taxes. Municipalities can only borrow to fund capital projects, and even then there are often elaborate restrictions (or safeguards), such as requiring approval of voters or of a state-wide board for a new bond issue. There are generally no such restrictions associated with refunding activities, however, so long as they do not extend the maturity of the original debt.

2.2 Uncertainty

To this point, the pre-refunding is neutral in terms of present value because interest rates are fixed. Suppose, however, there is some possibility interest rates will rise over the next three years above the 6% rate on the existing debt. Then the pre-commitment to call must

be destructive of option value, because it forces the firm to call even when it is suboptimal to do so.

When there is uncertainty about future rates, the interest savings that will eventually be realized by waiting to call are uncertain, and so are the differences through time associated with an advance versus a (delayed) current refunding.⁶ Indeed, surely part of the appeal of pre-refunding is confusion about the need to engage in the practice to “lock in” interest savings that would otherwise be lost should rates rise before the call date. If the goal is to hedge this uncertainty, then a variety of hedging strategies can achieve this without pre-committing to call. Even if the goal is to accelerate or borrow against the uncertain future interest savings associated with the call provision, a swap contract could achieve this more efficiently. If we denote the uncertain three-year spot rate that will prevail three years from now as \tilde{r}_3 percent, then the interest payments from years 4-6 associated with waiting to call are $\min\{6, \tilde{r}_3\}$. The issuer could arrange to swap some portion of this liability for cash payments of equal present value over the first three years. Such a step would be more transparent as “borrowing” to the public, to the Internal Revenue Service, or to any supervisory authority, and thus might be politically or legally infeasible. This raises the question, however, of why the issuer should be permitted to borrow in an opaque manner that destroys value when doing so directly and transparently would not be allowed.

The insight of Boyce and Kalotay (1979) and Kalotay and May’s (1998) is to recognize that advance refunding involves the early exercise of an option. Kalotay and May define a “refund efficiency” measure, which is the ratio of the option value lost by the value of the interest savings involved in issuing the refunding bond compared to the refunded bond. Like the rest of the municipal finance literature investigating advance refundings, they do not estimate the option value lost by an issuer in a typical refunding deal, as we do below.

⁶Under the tax code, a bond is current refunded when there are 90 days, or fewer, between the closing of the refunding issue and the final payment of the refunded issue.

2.3 General Case

Suppose the price of a bond at date t is V_t . The bond is callable at an exercise price of $\$K$ at date τ and matures at date $T > \tau > t$. It pays a continuous coupon of rate c . We consider the simplest case of a one-time opportunity to pre-refund the bond at the current date of t , and a single opportunity to call at date τ . That is, we treat the call provision as a European option. The cost of early exercise for this case is a conservative estimate of the true cost. It ignores the value of delaying exercise further, after the call date, but that option is also foregone through a commitment to call in a pre-refunding. The consequences of credit risk on present values are obvious, though difficult to quantify theoretically and empirically, so as in the previous example, we ignore them here.

Let V_τ be the present value of the coupon stream between the call date and maturity. Let $r(s)$ denote the instantaneous riskless rate prevailing at date s . We can represent the value of any security as the discounted expectation of its payoffs under the risk-neutral measure:

$$V_\tau = E_\tau^* \left\{ \int_\tau^T c e^{-\int_\tau^s r(v)dv} ds + 1 e^{-\int_\tau^T r(v)dv} \right\}, \quad (1)$$

where $E_\tau^*(\cdot)$ denotes the risk-neutral expectation conditional on information available at date τ .

Consider two alternatives:

1. Wait until the call date and then decide whether to call and refund the bonds.
2. Advance refund the bonds at the current date, t .

The payoffs up to the call date are the same in either case. If it waits to call, the issuer pays the coupon until the call date. If the issuer pre-refunds the bonds, the old debt is defeased, but new debt must be issued to fund the trust making the payments up to the call date. The issuer's liability at the call under the first alternative is $\min\{K, V_\tau\}$. Under

the second alternative, the advance refunding, the issuer must pay K unconditionally. The difference between the two alternatives is then

$$K - \min\{K, V_\tau\} = \max\{K - V_\tau, 0\}. \quad (2)$$

This is the payoff on a put option on the bond. The present value of this put is the option value transferred from the issuer to the bondholders by the advance refunding. Thus, the value of the issuer's liability today if the bond is not pre-refunded, L_t , is

$$L_t = E_t^* \left\{ \int_t^\tau c e^{-\int_t^s r(v)dv} ds + \min\{K, V_\tau\} e^{-\int_t^\tau r(v)dv} \right\}. \quad (3)$$

The issuer's liability under a pre-refunding, \hat{L}_t , is:

$$\hat{L}_t = E_t^* \left\{ \int_t^\tau c e^{-\int_t^s r(v)dv} ds + K e^{-\int_t^\tau r(v)dv} \right\}. \quad (4)$$

The difference between these, $\hat{L}_t - L_t$, is the value that is destroyed for the issuer by the advance refunding. Evidently,

$$\hat{L}_t - L_t = E_t^* \left\{ \max\{K - V_\tau, 0\} e^{-\int_t^\tau r(v)dv} \right\}, \quad (5)$$

which is the the value of a put option on the coupon bond exercisable on the call date.

Note that we treat the call option as a European option here. This is conservative. If the call is American, as most are, this increases the set of circumstances under which calling as soon as the call protection expires would be suboptimal, and thus increases the value destroyed for the issuer by precommitting to do so. Industry participants sometimes argue that pre-refunding is like any other exercise of an American option, in that time value is lost. As we explain in detail in Section 6, a pre-refunding is different than exercising a call in a

current refunding, because the interest payments on the original debt still have to be paid.

2.4 A Subsidized Hedge?

If we consider the issuers, financial intermediaries, and bondholders as a group, there is one possible source of surplus for them—the Treasury, which issues the SLGS. The SLGS are zero-coupon bonds that are created by the Treasury to exactly match the remaining payments on the bonds being defeased. The yield on the assets in the escrow is capped by the yield on the new, long-term bonds that are issued to fund the trust, unless current Treasury rates are below that level. The intent of the cap is to rule out the obvious tax arbitrage of issuing tax-exempt debt to purchase taxable securities. This could be advantageous for the Treasury, as it gives it the opportunity to issue debt at rates below current (taxable) Treasury rates, implicitly allowing it to share in the benefits of tax-exempt financing for municipal entities.

Note, however, that the assets in the trust are short maturity, while the debt being issued to fund it is long maturity. Industry professionals point to this as a rational motive for advance refundings. The transactions hedges the issuer’s borrowing rate from the call date to maturity. The issuer is borrowing long term, and lending short term (the latter by purchasing SLGS in the escrow). The SLGS generally pay higher rates than short-term municipal rates. Accordingly, the forward interest rate implicitly obtained through the pre-refunding is more attractive than the rate that could be achieved if the issuer had to hedge directly by borrowing long-term and lending short-term (the latter by buying short-term municipals).

In effect, the issuer faces different short-term borrowing and lending rates, and as in other such cases this creates some ambiguity regarding what the opportunity cost of the transaction actually is. The municipality is only “lending” to fund the repayment of its own securities, and if it did not borrow long term to do this, there would not be any point to the transaction. Is the “cost” of funding the trust the rate on the long-term bond? Or, is it

the short-term municipal rate? Crediting the advance refunding with the subsidy due to the difference between the yield on the trust and the short-term municipal rates effectively treats the short-term municipal rates as the cost of funds for the trust. The advance refunding would indeed be a good deal if issuers could borrow at the (low) short-term muni rates and lend at the SLGS rates. But they cannot do that.⁷ If they attempted to, the cap would be the short-term rate. On the other hand, it is certainly the case that if the issuer attempted to exactly replicate the hedge associated with the advance refunding by borrowing at long municipal rates and lending at short municipal rates, the terms would be less favorable than those implicit in the advance refunding.

The normative question for an issuer anxious to hedge future borrowing costs is a quantitative one. Is the subsidy for the implicit hedge sufficient to offset the value destroyed on other dimensions. We takes some steps to address this question in Section 5, and show that the size of the implicit subsidy is, indeed, correlated with the option value destroyed. For the moment, we note that since the financial crisis in 2008 Treasury rates have generally been so low that this subsidy to the hedge cannot provide a motive for advance refundings. Treasury rates are below both short-term and long-term municipal rates, a situation referred to by practitioners as “negative arbitrage.” Nevertheless, the practice has continued to be in widespread use.

The broader policy question is why the Treasury would wish to subsidize advance refundings, and why financial markets are so incomplete in this sector that something as straightforward as hedging future borrowing costs should be inextricably bound up with the need to surrender option value and borrowing for current cash needs. If the Treasury does not wish to subsidize these transactions, they can simply set the yields on the SLGS to reflect short-term rather than long-term municipal rates. If the Treasury does wish to subsidize municipalities in this non-transparent way, it is counterproductive to force them

⁷Section 148(f) of the Internal Revenue Code places limits on “arbitrage” issues.

to precommit to call. Nevertheless, attempts to decouple the option from the advance refunding are explicitly disallowed by the IRS. For the defeasance to be effective, the issuer is not permitted to have any contingent control over the trust or the payments on the bonds. Finally, if hedging by municipalities is a good thing, and their citizens benefit from reducing the risk associated with future borrowing, why not encourage the introduction and marketing of simple, transparent, sensibly regulated derivative or insurance instruments that would protect them from a general rise in rates? It seems ironic and counter productive that the usefulness of advance refundings to hedge interest rate risk is directly related to the value destruction through precommitment to call. In situations where the option is deep in the money and there is a short time to call, little option value is destroyed, but there is also not much interest rate risk to hedge!

2.5 A Case Study

Given that it is obvious from the above that option value is destroyed for the issuer by the pre-refunding, why do issuers engage in this practice? The new debt that is issued to fund the trust will generally have a lower interest rate than does the old debt, as long as interest rates have fallen between the advanced-refunding date and the date when the bonds were originally issued. The lower rate does contribute to the municipality's operating budget, but at a cost – it destroys value for the issuer by substituting lower coupon rates today for higher interest payments in the future.

Consideration of a specific example may provide some sense of the political context in which advance refundings are carried out. In the spring of 2005 the city of Pittsburgh, Pennsylvania, faced some very difficult choices. The city's debt had accumulated to \$821 million in gross bonded debt, representing \$2,456 owed for every person living in the city. Debt service amounted to a quarter of spending by the city.⁸ A state board had been

⁸*Pittsburgh Post-Gazette* "City's Debt Looms: Large Principal and Interest Now 25% of Spending," April

appointed under Pennsylvania state law to oversee the city's finances. The administration of Mayor Tom Murphy, in a desperate effort to balance the 2004 budget, had accelerated revenues and deferred expenses. Revenue shortfalls relative to that budget were \$7 million, and expenses exceeded the budget by \$13 million, depleting the city's cash reserves. The city council found itself with no funds available for continuing maintenance on the city streets, and the mayor had previously pledged not to increase the city's debt any further.

At this point, the city council debated two proposals aimed at generating funds for road maintenance.⁹ Murphy's proposal involved advance refunding approximately \$200 million of city bonds that had been issued in 1995 and 1997. Their maturities ranged from one to thirteen years. The 1995 bonds would otherwise have been callable in September of 2005, or in roughly four months. The 1997 series would otherwise have been callable in August of 2007. The transaction would, after \$2.4 million in fees, contribute \$6 million in funds over the next year for street resurfacing and "fixing pot holes." The alternative, offered by the chairman of the Council's Finance Committee, Doug Shields, was to borrow \$5 million from a regional development authority for one year, with interest and fees of \$164,000. The fees for the advance refunding included approximately \$1.86 million for bond insurance, \$1 million to the underwriters, Lehman Brothers and National City, and \$370,000 for the bond counsel and underwriter's attorneys.

After two hours of debate, the city council voted 6 to 2 for the advance refunding. Proponents of the mayor's plan argued it did not require the city to increase its debt. Councilman Sala Udin declared, "The \$6 million is free money. I think it would be a mistake to leave \$6 million on the table." Afterwards, the mayor's spokesman explained, "The mayor made a commitment that he would not increase the city's debt this year, and the Shields plan obviously would have done that."

30, 2005.

⁹Details and quotations from *Pittsburgh Post-Gazette* "Council OKs Bond Refinancing Plan Will Fund Paving, Other Work," April 7, 2005.

3 Data Sources and Descriptive Statistics

We draw data from several sources.

3.1 Municipal Bond Transactions

We obtain transaction data for municipal bonds from the Municipal Securities Rule Making Board (MSRB). This database includes every trade made through registered broker-dealers, and identifies each trade as a purchase from a customer, a sale to a customer, or an interdealer trade. We augment this with data from Bloomberg that includes information about the refunding status of the bonds.

Over our sample period from January 1995 to December 2009, the MSRB database contains 95,162,552 individual transactions involving 2,516,534 unique municipal securities, which are identified through a CUSIP number. The MSRB database contains only the coupon, dated date of issue, and maturity date of each security. We obtain other issue characteristics for all the municipal bonds traded in the sample from Bloomberg. Specifically, we collect information on the bond type (callable, puttable, sinkable, etc.); the coupon type (floating, fixed, or OID); the issue price and yield; the tax status (federal and/or state tax-exempt, or subject to the Alternative Minimum Tax (AMT)); the size of the original issue; the S&P rating; whether the bond is insured; and information related to advance refunded municipal bonds. The information on advance refunded municipal bonds includes an indicator of whether the bond is a pre-refunded bond, the pre-refunded date, the pre-refunded price, and the escrow security type.

We wish to price the options on coupon bonds, which are the primary source of the value lost through pre-refunding, and also to evaluate the present values of interest savings to the call date, which represents the amount of borrowing implicit in the refunding. For these purposes we require information on the term structure for tax-exempt bonds. We follow

Ang, Bhansali and Xing (2010) and use zero-coupon rates inferred from transactions prices on municipal bonds in the MSRB database. These zero-coupon yield curves are constructed using the Nelson and Siegel (1987) method, fit each day in the sample period to interdealer prices on highly rated bonds. Details are provided in the internet appendix to Ang, Bhansali and Xing (2010).

3.2 Advance Refunding Sample

Pre-refunded municipal bonds are collateralized by some of the safest securities available. The most common types of collateral used are: U.S. Treasury Securities; State and Local Government Securities (SLGS); U.S. Agency Securities: FNMA, FHLMC, TVA, HUD and FHA ; Aaa/AAA rated Guaranteed Investment Contracts (GICS). Among them, SLGS are a form of U.S. Treasuries created explicitly for municipalities to use for debt refinancing purpose.

Among the 2,516,534 unique cusips, 258,822 are identified by Bloomberg as pre-refunded bonds with a total par value of \$886.48 billion. We apply the following data filters. We focus on pre-refunded bonds that are exempt from federal and state income taxes and are not subject to the AMT. This reduces our sample to 245,184 bonds. We take only pre-refunded bonds with the following escrow security type: U.S. Treasury Securities; SLGS; and cash. This reduces our sample to 237,703. We also limit our bond universe to bonds issued in one of the 50 states, and so we exclude bonds issued in Puerto Rico, the Virgin Islands, other territories of the U.S. such as American Samoa, the Canal Zone, and Guam. After this filter, we have 237,660 bonds. We require bonds to have non-missing information on when they became pre-refunded and this left us 158,477 bonds. And finally, we require all bonds to have a non-missing fixed, semi-annual coupon, non-missing information on the call date, call price, and a valid CUSIP. We delete some obvious data errors.

Our final sample contains 148,961 bonds with a par value of \$454.38 billion. This rep-

resents 51.25% of total aggregate par amount of the full pre-refunded universe. Thus, our estimates of the aggregate impact of pre-refunding transactions are clearly conservative. The bonds that trade during the sample period, and therefore appear in MSRB database, are a subset of the bond universe. Of these, roughly half have sufficient information to compute the lost option value. If our sample is representative, then our estimates of aggregate impacts of advance refundings could be roughly doubled to approximate the true aggregate losses to issuers and their tax payers.

Table 2 compares the bonds for which we have data that excluded from our sample to those that were included. The excluded CUSIPs have slightly larger par value outstanding. For both the included and excluded bonds, the mean par value exceeds that upper quartile, reflecting the extreme skewness in the size of the bond issues in the municipal market. The excluded bonds also have slightly shorter maturities and higher coupons. Given the general secular decline in interest rates through this period, this suggests the bonds with incomplete data (primarily, the pre-refunding date) tend to be older bonds that were issued at earlier points in time.

Table 3 provides descriptive statistics covering all the pre-refundings in our final sample, treating the unit of observation as the CUSIP (Panel A) and the “deal” (Panel B). We define a deal as any set of bonds from the same issuer that become pre-refunded on the same date. The average CUSIP that is advance refunded involves just over \$3 million in par value, though the lower median suggests skewness in the size of pre-refundings. The smallest CUSIPs that were pre-refunded were issued by small health care facilities and school districts. The largest pre-refundings involved New Jersey Tobacco Settlement Bonds, the Los Angeles Unified School District, Long Island Power, and the Tri-Borough Bridge and Tunnel Authority. All of these were pre-refunded 2-5 years before they became callable.

Figure 2 shows the number of advance refundings, the par value of advance refundings, and the average 15-year municipal bond yield, by month, in our sample. The volume of

pre-refunding activity rises as interest rates fall, though evidently with something of a lag. Activity peaked in 2005, and slowed when municipal credit spreads rose in response to the credit crisis of 2007-2008 and the collapse of the major bond insurance firms, which played a major role in municipal markets. Over the most recent period, municipal credit spreads have fallen and long-term interest rates have achieved historic lows. As we noted in the introduction, press reports suggest this has led to a revival of advance refunding activity.

3.3 Time to Call

The distribution of the time to call is of particular importance in evaluating the financial implications of the advance refundings. If the only bonds being pre-refunded are bonds that are about to be called in any case, not much option value is being lost. Table 3 reports that the average time to call is 2.8 years. There is, however, considerable dispersion in the call date. Figure 3 plots a histogram of the number of years to call at the time of the pre-refunding. Over 32,000 of the roughly 150,000 pre-refunded CUSIPs have less than six months to call, and the short maturity suggests that the option value lost in the refunding decision may be small in these cases. On the other hand, there is a substantial number (35,379) of pre-refunded bonds with five or more years to call, and small numbers (306) with ten or more years to call.

4 Valuing the Advance Refunding Option

The value lost to issuers from the pre-refunding decision is the value of a put option exercisable at the call price of the original bond with a maturity equal to the call date of the original bond. We compute a value for the put for each pre-refunded bond in the sample. The single-factor Vasicek (1977) model provides a particularly simple means of doing this, although it has well-known limitations. In the Vasicek setting, the value of an option on

pure-discount bond can be expressed in closed form. A more flexible one-factor model is the Hull and White (1990) model which allows a deterministic time-varying central tendency.¹⁰

Using both the Vasicek model or the Hull and White model, the method of Jamshidian (1989) can then be used to price options on coupon bonds. Since a coupon bond can be viewed as a portfolio of pure-discount bonds, and since the prices of all zero-coupon bonds are monotonic in the short-term rate for a single-factor model, the value of an option on a coupon bond can be expressed as a portfolio of options on the zero-coupon components, each with an appropriately chosen exercise price.

We assume that the underlying call option on the bond is a European option, and that the decision to pre-refund is made at a single point in time. In both cases, these assumptions would lead our estimates of the lost option value to be conservative.

4.1 Single Factor Term Structure Models

The Vasicek (1977) model postulates that the short interest rate, $r(t)$, is Gaussian and mean-reverting:

$$dr(t) = \kappa(\theta - r(t))dt + \sigma dW(t), \quad (6)$$

where $W(t)$ is a Brownian motion. We assume that under the risk-neutral measure, the short rate follows:

$$dr(t) = \kappa(\bar{\theta}(t) - r(t))dt + \sigma dW(t), \quad (7)$$

where

$$\bar{\theta}(t) = \theta - \frac{\sigma\lambda(t)}{\kappa}.$$

¹⁰Since municipal yield curves have, to date, always sloped upwards, we expect that our option values using a two-factor model will be very similar since our one-factor models already incorporate time-varying prices of risk. The great advantage of the single-factor model is that it allows us to compute option values for coupon bonds directly.

We further assume that the market price of risk is linear in the short rate:

$$\lambda(t) = \lambda_0 + \lambda_1 r(t). \quad (8)$$

The yield on a bond maturing in τ periods, $z[r(t), \tau]$, can then be written as an affine function of the short rate:

$$z[r(t), \tau] = -\frac{A(t, \tau)}{\tau} + \frac{B(\tau)}{\tau} r(t), \quad (9)$$

where

$$\begin{aligned} B(\tau) &= \frac{1}{\kappa}(1 - e^{-\kappa\tau}), \\ A(t, \tau) &= \frac{\gamma(t)(B(\tau) - \tau)}{\kappa^2} - \frac{\sigma^2 B(\tau)^2}{4\kappa}, \\ \gamma(t) &= \kappa^2 \bar{\theta}(t) - \frac{\sigma^2}{2}. \end{aligned}$$

We use daily fitted zero-coupon yields to calibrate the parameters of the model, sampled at 15-day intervals. The fitted rates rely on data that do not include extremely short-term instruments, so we use the three-month rate as the short-term rate. We set σ to match the volatility of the short-term rate:

$$\hat{\sigma}^2 = \sum_{i=0}^{N-1} \frac{[r(t_{i+1}) - r(t_i)]^2}{N\Delta t}, \quad (10)$$

and calibrate κ using the first-order autocorrelation of the short rate ρ_r ,

$$\hat{\kappa} = (1 - \rho_r)/\Delta t. \quad (11)$$

Finally, θ can be set to the average level of the short rate.

We use the average yield spreads and differences in volatility to calibrate the market price of risk. We use the ten-year yield. Since the linear specification for the market price of risk preserves the linearity of yields in the short rate, then given the other parameters, we can write

$$z[r(t), \tau] = f_0(\lambda_0) + f_1(\lambda_1)r(t),$$

and we can solve for λ_1 from the differences in variance:

$$\text{Var}(z[r(t), \tau]) = f_1(\lambda_1)^2 \text{Var}[r(t)], \quad (12)$$

and then solve for λ_0 from the average spread:

$$E(z[r(t), \tau]) = f_0(\lambda_0) + f_1(\lambda_1)E[r(t)], \quad (13)$$

using the sample analogues to compute estimates.

We calibrate the parameters $\Theta = (\kappa, \theta, \sigma, \lambda_0, \lambda_1)$ using the whole sample period, 1996-2009. Table 4 reports the parameter values we calibrated in this manner, along with alternative values based on subperiods. The long-run mean, θ , is quite sensitive to the sample period employed, since our sample was a period of gradually declining interest rates. (See the third panel of Figure 2.) The estimates of the option values we obtain are, in turn, fairly sensitive to the value of θ we choose. This is not surprising. If current rates, and expectations about future rates, are low relative to the historical average over the sample period, our estimates of the put option values will be misleading, although the direction of the effect may depend on the strength of the mean-reversion parameter.

We also use the Hull and White (1990) model, which has a time-varying long-term mean parameter:

$$dr(t) = \kappa(\theta(t) - r(t))dt + \sigma dW(t), \quad (14)$$

which is similar to equation (6), except the central tendency parameter, $\theta(t)$, is now a deterministic function of time. Bond yields can still be written as an affine function of the short rate as in equation (9), except $A(t, \tau)$ now satisfies

$$A(t, \tau) = - \int_t^\tau \kappa B(t) \theta(t) dt + \frac{\sigma^2}{2\kappa^2} \left(\tau + \frac{1 - e^{-2\kappa\tau}}{2\kappa} - 2B(t) \right).$$

In the Hull and White (1990) model, we estimate σ and κ by matching the three-month volatility and standard deviation (see equations (10) and (11)). Note that given κ and σ , we only need to know $\theta(t)$ in order to get bond price. The time-varying central tendency parameter, $\theta(t)$ is calibrated assuming that today is time 0 and we choose the path of θ_t to match the current term structure. Thus, $\theta(t)$ represents a vector of values corresponding to each maturity, which changes over time. We assume the mean-reversion target is piecewise linear and changes once per year. We iteratively calibrate $\theta(1)$, $\theta(2)$ up to $\theta(30)$. In particular, we first match the one-year zero-coupon bond market price with model implied zero coupon bond price to get $\theta(1)$. Given $\theta(1)$, we then match the two year zero-coupon bond market price with model implied price to get $\theta(2)$ and so on. We continue this procedure until we match the 30-year zero coupon bond market price with the model-implied price to get $\theta(30)$.

4.2 Option Valuation

In a one-factor term structure model, options on zero-coupon bonds have known closed-form solutions. Define $P[r(t), \tau]$ as the price of a zero-coupon bond with maturity τ , $P[r(t), \tau] = A(t, \tau) - B(\tau)r(t)$. The price of a European put option on $P[r(t), \tau]$ with maturity T and strike price K is given by

$$\text{Put}[r(t), T, K] = KP[r(t), \tau]N(-h + \sigma_P) - P[r(t), \tau]N(-h), \quad (15)$$

where

$$\begin{aligned}\sigma_P &= \frac{\sigma}{\kappa} [1 - \exp(-\kappa(\tau - T))] \sqrt{\frac{1 - e^{-2\kappa T}}{2\kappa}}, \\ h &= \frac{1}{\sigma_P} \ln \frac{P[r(t), \tau]}{P[r(t), T]} + \frac{1}{2} \sigma_P,\end{aligned}$$

and $N(\cdot)$ is the cumulative normal distribution.

An option on a coupon bond, however, can be viewed as an option on a portfolio of zero-coupon bonds. Suppose there are N payments remaining after the exercise date for the option, and these occur at times (measured from the current date), $\tau_i, i = 1, \dots, N$. Then we can write the value of the coupon bond, $V[r(t)]$, as a function of the short rate:

$$V[r(t)] = \sum_{i=1}^{N-1} C \cdot P[r(t), \tau_i] + [100 + C]P[r(t), \tau_N]. \quad (16)$$

Jamshidian (1989) takes advantage of the fact that each zero-coupon bond, $P[r(t), \tau_i]$, is monotonic in the short rate under the Vasicek (or any other single-factor) model to derive the value of an option on a coupon bond. We can define a critical interest rate, r^* , such that $V[r^*] = K$: the value of the coupon bond equals the strike price. Now define $K_i \equiv P(r^*, \tau_i)$. We know by monotonicity that $V[r(t)] > K$ if and only if $P(r^*, \tau_i) > K_i$, for all i . Thus, we can treat the option on the coupon bond as a portfolio of options on the zeroes, each with an appropriately chosen exercise price. It is a simple matter to find r^* iteratively. It can then be used to find K_i for each coupon maturity, τ_i . The value of each option on each zero can then be computed using the close-form solution in equation (15), and the value of the option on the coupon bond is the sum of these options on the zeroes times the payments at those dates.

5 Losses from Advance Refunding

The option value lost in an advance refunding is the value of a put option on the coupon bond expiring on the call date. We compute the option value lost for each of the 148,961 separate pre-refunded CUSIPS for which we have sufficient data during our sample period over 1996-2009 using the Vasicek (1977) model with time-varying prices of risk and the Hull and White (1993) model.

5.1 Value of the Put Option

Panel A of Table 5 summarizes the distribution of the put option values: the value destroyed per \$100 face value and the total value destroyed for each CUSIP and deal. As we can see from the large differences between the means and medians, the distributions of the value lost are extremely skewed for both CUSIPs and deals. The majority of advance refundings are relatively innocuous in terms of the option value surrendered. These are cases where the call option is deep in the money or the bond is relatively close to the call date. Using the Vasicek (1977) model, the average advance refunding deal loses 79 cents per \$100 of par value, representing a loss of \$28,000 per bond, and \$236,000 per deal. Because of the large skewness, the median losses are lower: 41 cents per \$100 of par value, corresponding to a loss of \$2,300 per bond, and \$12,000 per deal.

There are, however, some extremely large and very bad deals. On July 7, 2005, the Triborough Bridge and Tunnel Authority advance refunded four bonds. One of these was the largest pre-refunded bond in our sample by par value, \$584,155,000. Our estimates suggest refunding it destroyed more value than any other bond in our sample, with a loss of \$19.9 million. The other three bonds in the deal involved \$21.3 million, \$36.6 million, and \$75.3 million in par value. The put option value for the entire advance refunding deal was over \$21 million. On April 1, 2007, the state of California advance refunded 135 different

CUSIPs. Only one of these had less than a year to call. The total par value of these bonds was \$3.920 billion, and we estimate the lost option value to California to be \$97 million.

Table 6, Panel A reports our estimates of the total value destroyed by the pre-refundings in our sample. In total, the option value surrendered is approximately 1% of the par value of the bonds that are pre-refunded. Since there are a great many bonds, however, the losses total over \$4 billion for the Vasicek (1977) model and over \$5 billion using the Hull and White (1990) model. These estimates are relatively insensitive to the parameters other than the long-run mean, θ . Since interest rates decline over our sample, estimates with higher values of θ are larger than those given in Table 6.

Most of the value lost is due to a small fraction of the transactions. The pre-refundings that generate losses in excess of the 95th percentile account for almost \$3 billion of the \$4 billion in estimated losses. These tend to be CUSIPs with large par value outstanding, which are issued by large public entities. The correlation between issue size and total option value lost is 63% and the correlation between total value lost and years to call is 12%. The distribution of option value lost is more skewed than that of issue size. The largest 5% of deals and of CUSIPs account for 50.2% and 51.7% of total par value in our sample.

There are some smaller pre-refundings that destroy large fractions of the par value re-funded. Indeed, many of the refundings that have high put option values per \$100 face value would be poor candidates even for a current refunding. For example, on December 14, 2006, the New Jersey State Education Facility advance refunded two bonds that had originally been issued at par value with coupons of 3.875%. The bonds would have matured in 2028. Our estimate of the zero-coupon municipal interest rates for all maturities beyond 10 years on that date exceed 4%. The bonds were advance refunded along with a large number of other maturities that had been originally issued in the same offering. Apparently, the issuer chose to pre-refund the whole series, rather than to selectively pick and choose, despite the fact that new bonds were being issued at higher rates than some of the bonds being defeased.

In some cases, this may be motivated by bond indentures that apply to the entire series, and these indenture restrictions can only be lifted by pre-refunding all the bonds.

5.2 Estimate of Fees Lost

The fees associated with advance refundings are numerous: there are fees paid to underwriters, rating agencies, lawyers, municipal debt advisors, swap advisors in cases where derivatives are used in the financing arrangements associated with the refunding deal, and other miscellaneous fees. Furthermore, the vast majority of advance refundings are sold via negotiated sale (see Wood, 2008). Robbins (2002) and McCaskill (2005) estimate the cost of nontendered offerings are 20-35 basis points higher than competitive auctions. The cost of advance refundings is unknown, especially when derivatives are used as part of the refunding issue. Nevertheless, estimates of fees paid range from 0.375% in Kalotay, Yang and Fabozzi (2007) to 3-10% by the GFOA. The GFOA states fees of 0.5% to 1.0% for issuance fees, 0.5% to 1.0% for the underwriter's discount, 2.0% to 3.0% for the redemption premium, 0.5% to 1.0% for bond insurance, and 1.0% to 3.0% associated with the negative carry in the trust created to defease the refunded issue.¹¹

In Panel B of Table 6 estimates the fees paid with advance refundings. We use a range of values from 0.375% to 10% as a fraction of the value of the bond being refunded. In general, we do not observe the actual market value of the callable bond at the time of the pre-refunding deal. This value, which will generally be at a premium over par, will determine the size of the trust required to fund the remaining payments. To estimate it, we value a straight bond with the same coupon rate and same maturity as the refunded bond. This approximation will overestimate the callable bond value because the callable bonds should have a lower price than the comparable straight bond. Under the lowest fee assumption of 0.375%, the total fees paid amounts to a large \$1.908 billion. The total fees paid exceeds \$5

¹¹Numbers are from "Analysis of a Refunding," Government Finance Officers Association, 2007.

billion dollars with an assumed 1% fee structure. With a 2% fee, the total fee paid is over \$10 billion, representing 2.2% of total par value. Thus the “de-fees-ance” fees are at least as much, and probably an order of magnitude larger, than the total option value lost of \$4.206 billion under the Vasicek model.

The fees paid are higher for larger issues. The total fees paid from CUSIPs above the 95th percentile constitutes over 50% of all the fees paid in our sample. The fees are highly correlated with total option value lost with a correlation coefficient of 59.5%. This is not surprising as both are related to issue size. The correlation of option value lost and fees paid, both expressed as a percentage of par value is 3%; although the correlation is small, the p-value of the correlation coefficient is less than 0.001.

We note that the fees paid in an advance refunding cannot all be viewed as incremental to the transaction. If the bond is not advance refunded, it is likely that in most cases the call option would be in the money eventually, and the bond refunded at that point. Only in those cases where the original bond issue would be allowed to mature would the fees be avoided completely. Thus, the estimates above are amounts that could either be avoided or deferred by choosing not to advance refund.

5.3 Ex-Post Losses

The value of the put option is the value being transferred from the municipality to the bondholders at the pre-refunding date. It is the economic increase in value that a bondholder enjoys immediately from holding the original bond that becomes pre-refunded. (It is actually a conservative estimate because it ignores the lower credit risk once the bond becomes pre-refunded.) While put options are ex-ante, or present values, we can also estimate the ex-post loss of refunding. The realized loss in value will differ from the ex-ante loss, just like the realized value of any option at expiration will be higher or lower than its value today. We can compute the ex-post loss of pre-refunding by examining the exercise decision at the first

call date, τ :

$$\text{Ex-post value lost} = \max(K - P_\tau, 0), \quad (17)$$

where P_τ is the value of the original bond at the call date—which we value as a straight bond from the call date to maturity using the municipal zero curves and K is the call price. If $P_\tau > K$, then the option would not be exercised and the ex-post value lost from pre-refunding is zero. If $P_\tau < K$, then the value lost from advance refunding is $K - P_\tau$.

We compute the ex-post losses from advance refunding in Panel C of Table 6. Not surprisingly, since interest rates trended downwards in our sample, the realized losses in Panel C are much smaller than the option values reported in Panel A. In our sample, we are able to compute the ex-post loss for 112,895 refunded bonds as their call dates occur before the end of our sample. The total realized loss for these 112,895 bonds is \$0.309 billion in total. Municipalities, as a whole, got lucky. As interest rates were trending down during the sample, issuers were not in situations where the put option from advance refunding expired in-the-money. The total ex-post loss represents 0.10% of total par value. This ex-post loss is small as only 1.9% of the time would exercising the call at the call date (when the call is in-the-money) resulted in a loss. This is largely driven by the general downward trend of interest rates over the last 15 years. If interest rates trend upwards, municipalities would experience severe ex-post losses.

5.4 Implicit Borrowing

Along with destroying part of the value of the issuer’s call option, advance refunding immediately reduces interest expense to the issuer at the expense of expected higher interest payments after the call date. In effect, the issuer is borrowing against future interest savings. In this section, we attempt to measure this implicit borrowing.

As with the option value destroyed, the amount of borrowing implicit in an advance

refunding increases with the time to call. Unlike the lost call option value, however, the amount of implicit borrowing increases the more interest rates have dropped since the bonds were issued. In these situations, because the chances the call will expire out of the money are low, the lost option value is small even though the amount of implicit borrowing may be significant.

The example in Section 2.1 illustrates that the amount of borrowing against expected future interest savings is the present value of the difference, up to the call date, between the coupon on the old debt and the coupon payments on the new debt issued to fund the trust. The latter reflects both the lower interest rates on a new par issue and the higher par value amount required to fund the trust for the remaining payments up to call. Assuming interest rates have fallen since the original issue date, the old debt will be at a premium, so the value of the trust exceeds the par amount of the issue.

Given information about the municipal term structure on the date of the advance refunding, calculating the amount of implicit borrowing for a given CUSIP or deal would be straightforward if we could observe the amount put in trust and the coupon rates on the newly issued debt. For a given CUSIP, this information is available in the official statements (analogous to a prospectus for municipals) associated with the new debt. Formats are not standardized, however, and the new debt issue may involve purposes in addition to the advance refunding. There may also be derivatives associated with the advance refunding, which may not be reported in the official statements. In any case, the official statements are available, at best, only as pdf documents online through the EMMA system of the MSRB and have been disseminated only recently.¹² Our large sample of almost 150,000 bonds precludes gathering this data by hand.

Accordingly, we attempt to approximate the magnitudes involved using information from

¹²Between May 2011 and September 2012, there were more than 21,000 new municipal issues. But there were only 62 pre-sale documents filed through EMMA. See “MSRB Wants Dealers to Post POS on EMMA Site,” by Jonathan Hemmerdinger, *The Bond Buyer*, July 29, 2013.

the term structure to estimate the coupon rates at which debt could be issued on the pre-refunding date. Using the fitted zero-coupon municipal yields, we first calculate the present value of coupon payments that remain until the call date, and of the call price. This we treat as the size of the trust and the par value of new debt that must be issued to fund it. Let F denote this funding requirement, per \$100 par value. Since typically interest rates will have fallen, we will generally have $F > 100$. The same fitted zero-coupon yields can be used to approximate the coupon on a new par bond with a maturity equal to that of the old bond. If d_t is the zero-coupon price for a zero that pays \$1 in t periods, and the original bond has T periods to maturity, then the coupon of a par bond solves:

$$100 = C^* \sum_{t=1}^T d_t + 100d_T. \quad (18)$$

The per period reduction in interest cost is then $C - FC^*$, where C is the coupon on the bond being advance refunded. The present value of this difference, up to the call date, times the total par value outstanding of the pre-refunded issue, is our estimate of the present value of interest savings that are accelerated, or borrowed, through the transaction.

Table 7 reports summary information on the cross-sectional distribution of the implicit borrowing associated with advance refundings. It reports statistics for both individual CUSIPs and deals as the unit of observation. As in the case for lost option value, the distribution is extremely skewed; there are dramatic differences between means and medians for both deals and CUSIPs. The present value of accelerated interest deductions is only \$10,000 for the median CUSIP and \$88,000 for the median deal. The corresponding means are \$48,000 and \$403,000, respectively. Most of the implicit borrowing is associated with a small number of very large deals. In total, the advance refundings in our sample give issuers over \$7 billion worth of estimated accelerated interest savings. This represents 1.57% of the par value of pre-refunded bonds. Over 60% of the total, however, comes from only 5% of

the CUSIPs or deals.

The CUSIP that triggered the most implicit borrowing is a New Jersey Tobacco Settlement bond that was pre-refunded in January of 2007, one of twelve such CUSIPs in what is also the deal for which implicit borrowing was the largest. The deal involved \$2.163 billion in par value with an average time to call of over five years. This deal was also in the top one percent in terms of estimated option value lost (\$7,911,690). As noted earlier, however, this need not be the case, because deals for which the call is deep in the money will involve a large amount of implicit borrowing, but relatively little destruction of option value. Indeed, while the correlation between implicit borrowing and option value lost is 21.3% at the deal level, it is slightly negative (-7.9%) when the unit of observation is the individual CUSIP.

5.5 Which Municipalities do the Worst Deals?

Table 8 provides some descriptive information on the municipalities destroying the most value in advance refundings. For the 17,806 deals in our sample, we sort the deals on the basis of amount of estimated option value destroyed and value destroyed per \$100 par value, both using the Vasicek (1977) model, as well as par value of the deal and the estimated amount of implicit borrowing. Then, based on the name of the issuing entity, we categorize the 50 extreme deals by the type of issuer. For the three criteria where size is obviously important (total par value, total put value, and implicit borrowing), states and transportation authorities dominate the distribution. Indeed, universities, water authorities, and development authorities that appear in these sets tend to be state-wide or state-affiliated. In contrast, the deals that are most destructive of value in percentage terms are primarily small and, presumably, relatively unsophisticated issuers. Here 30 of the worst 50 deals were done by school districts.

A full cross sectional analysis is difficult to perform given the limited data available on

the individual issuers.¹³ While information at the municipal level is highly incomplete, we do have information about the states. This information is certainly relevant since state law, rather than the federal law, ultimately governs the behavior of municipal bond issuers. Standards of transparency and governance are therefore likely to be shared by issuers within a state.

Table 9 reports regression results using state and bond specific characteristics to explain the amount of value destroyed. We focus on the put value per \$100 face value as the independent variable, measured with the Vasicek (1977) model. The independent variables include the bond’s S&P rating, scored 10 for a AAA rating, to 3 for a D rating, 2 for not rated, and 1 for “other.” We include several measures of state-wide economic and demographic characteristics: unemployment rate, nominal state GDP growth, population growth, median real income, and state population. Two other variables provide information about the quality and transparency of municipal and state governance within the state. The state government’s debt per capita can be viewed as a measure of the quality of a state’s fiscal governance. The variable “Convictions” is the number of public officials convicted divided by the state’s population. This is available on an annual basis on the U.S. Department of Justice’s web site. We report results using both annual and quarterly fixed effects.

We include two interest rate series matched to the date of the advance refunding. A long-term municipal bond rate, accounts for the fact, evident in Figure 2, that there are more refundings when interest rates fall. The variable “Spread” captures the size of the subsidy to the forward hedge provided by the spread between the return on the escrow that pays off the pre-refunded bonds, and and short-term municipal rates. The yield on the escrow account is capped by the short-term Treasury rates or the yield on the new debt issued by the

¹³The only two studies empirically examining municipal refundings also use limited samples. Vijayakumar (1995) examines only 102 general obligation bonds called between 1977 and 1988. Moldogaziev and Luby (2012) examine only bonds refunded in California between 2000 and 2007. Both of these studies do not distinguish between current refundings and pre-refundings. They also do not take into account the option value lost by early refunding.

municipality. In our sample, the average time-to-maturity is 9.18 years. BondBuyer provides average municipal bond yield for maturities at 1-year, 11-year and 20-year. We therefore choose the 11-year yield series as our long-term municipal yield. The spread variable is thus defined as:

$$\min\{Y_{M,11}, Y_{T,1}\} - Y_{M,1}$$

where $Y_{M,11}$ is the average yield on the BondBuyer 11-year General Obligation index, $Y_{T,1}$ is the one-year Treasury yield and $Y_{M,1}$ is the BondBuyer yield on the one-year municipal note index. This monthly series varies between 10 and 200 basis points in the early years of the sample, and goes negative in the fall of 2008. It remains negative through the rest of our sample period, and indeed through 2012.

Across the two specifications the most robustly significant variable is the state corruption index, “Convictions.” States in which public officials are irresponsible to the point of criminal culpability are also states where municipal officials will destroy more value in advance refundings, possibly to achieve short-term budget relief at the expense of higher interest payments in the future. This result is reminiscent of Butler, Fauver and Mortal’s (2009) findings that states with more corruption have higher borrowing costs. Higher state-level debt per capita is associated with more value destruction, in percentage terms, Population growth and high unemployment are both associated with less value lost in deals within the state, for reasons that seem less immediately obvious. Higher rated bonds are more likely to be pre-refunded on disadvantageous terms for municipalities.

Not surprisingly, lower long-term rates encourage refundings of all sorts, but keep in mind these are cross sectional results. They seem to especially encourage bad deals. Issuers are also more likely to sacrifice option value when the implicit subsidy to the hedge is higher. This is not surprising. Issuers focused on the need to hedge interest rate risk will destroy more option value, because the situations where the value of the put option is low are precisely

those in which there is relatively less need to hedge.

Figure 4 plots the estimated coefficients for the annual fixed effects (top panel) and quarterly fixed effects (bottom panel). Note that the regressions already include a long-term municipal bond rate and the spread variable, which should capture increases in refunding activities due to changing interest rates. Thus, the fixed effects capture increases in value-destructive pre-refundings through time that are not due to interest rate declines. All of the annual fixed effects are significant at conventional levels (p-values less than 0.001). All of the quarterly fixed effects are highly significant except for those in the first five quarters, and the last quarter of 1999. The estimated fixed effects show clear patterns. Issuers were doing worse deals, controlling for interest rates, in periods associated with high liquidity, easy credit, and high volumes of financial activity generally. Perhaps it is easier to convince issuers to employ solutions involving financial engineering in periods when “Wall Street is booming” more generally.

6 Industry Misconceptions

Practitioners advance at least five arguments in favor of advance refundings:¹⁴

1. To realize interest savings.

Our analysis shows that there are no interest savings in the advance funding decision. While the coupon payments associated with the refunded issue are lower than the original bond, the municipality is giving up the call option when pre-refunding. With no uncertainty, the advance refunding is zero net present value. With uncertain interest rates, advance refunding destroys value because the municipality is suboptimally exercising its call option. Put another way, advance refunding a bond destroys

¹⁴Items 1, 2, and 5 are from Wood (2008). Item 3 is from Kalotay and May (1998) and Brooks (1999). Item 4 is from Kalotay (2013).

value because the issuer pre-commits to call. In fact, over 1996 to 2009, a conservative estimate of the option value destroyed in advance refunding is \$4 billion, representing approximately 1% of the par value of the original bonds.

2. To restructure debt, typically to extend the payments of principal and interest.

Advance refunding enables a municipality to reduce interest expense immediately, but at the cost of increasing expected interest payments after the call date. Thus, advance refunding accelerates interest savings at the expense of future savings. We estimate that over 1996 to 2009, advance refundings implicitly gave issuers over \$7 billion of borrowings that need to be paid back in the future. This additional debt bypasses the traditional restrictions that do not allow many municipalities to borrow to fund current operating expenses.

3. To monetize the call option today.

The call option is certainly an asset of the municipality. Kalotay and May (1998) argue that the option is similar to an illiquid employee stock option, which the holder may choose to exercise to extract some of its value, even though it is not extracting the full value. Some practitioners argue that call option can be exercised when the municipality wishes to “lock in” interest rate savings today. Both of these arguments are problematic. First, as detailed in Section 2.1, a swap that lowers payments today for higher payments after the call date can achieve the same cashflows more efficiently and preserves the option on the original bond. Second, the option value incorporates the predictability of interest rates (and predictable deviations from the Expectations Hypothesis captured by time-varying prices of risk as shown by Dai and Singleton, 2002). Taking a view on interest rates by advance refunding today removes the optionality that interest rates move adversely, or move even more advantageously, for the municipality. Ex post, municipalities have not lost much in advance refunding as we

show in Section 5.3 over 1996-2009. This is because interest rates have trended downwards and the put options would have expired out-of-the-money. In a period of rising interest rates, however, the ex-post losses from advance refunding will be substantial.

4. Any exercise of an American call before expiration destroys some time value.

This point is often advanced to argue that there is nothing special about the pre-committing to call in an advanced refunding. It is certainly the case that the call provisions on municipal bonds are generally American. Call protection typically lasts for ten years, and the bond can then be called any time after this up to maturity. It is therefore not always the case that it will be optimal to call as soon as call protection expires. This depends on the tradeoff between the interest savings achieved over the next period and the time value lost on the option. Committing to call through an advanced refunding is qualitatively different. While calling at the first call date may or may not be optimal, committing to call before that date cannot be optimal, because there are no real interest savings. The apparent interest savings before the call date are really the result of borrowing against expected savings after the call date. The old bonds remain in place, and interest on them must be paid. It is paid through a trust, that is funded by the issuer, rather than directly. So the standard tradeoff between interest savings and time value does not exist. Only the time value is relevant.

5. To amend bond covenants.

This is the only economic argument which may benefit the municipality. However, because the trust created by advance refunding typically holds U.S. Treasuries, bond investors enjoy an immediate upgrade in credit risk to a fully risk-free security. Any improvement in bond covenants that a municipality can negotiate in the refunding issue are offset by the creation of risk-free assets in the trust for the refunded bond. Exercising the advance refunding option today also restricts a municipality – because

the issuer has pre-committed to exercising the call. This loss of optionality also offsets any flexibility the issuer gains in amending bond covenants. Bond covenants are very specific to particular bond issues, and it is unclear why advance refunding for this reason would lead to such pronounced systematic cycles (see Figure 1). This is also rarely the reason cited by the municipality in undertaking an advance refunding, or the underwriters and investment bankers involved in the transaction.

7 Conclusion

The widespread practice of advance refunding of municipal bonds is, at best, zero net present value, though wasteful of fees. If there is any chance that the bonds would otherwise not be called, or any risk of default, the transaction destroys value for the issuer. Advance refunding does allow the municipality to realize interest savings prior to the call date, at the expense of savings that would otherwise be realized afterwards. While this can relieve pressure on current operating budgets, it increases borrowing costs in the future and can subvert restrictions prohibiting municipalities from borrowing to fund operating activities.

Using a large sample of municipal bonds over 1996 to 2009 that have been advance refunded, we estimate both the option value destroyed and the amount of borrowing implicit in the transactions. In aggregate, advance refunding loses approximately 1% of the par value of the original bond, which represents at least \$4 billion over the sample. The aggregate amount of implicit borrowing is over \$7 billion. However, both the option value and the implicit borrowing quantities are highly skewed. For the majority of advance refundings, the option value lost is small. For the median CUSIP, the practice of advance refunding results in an option value lost of approximately 40 cents per \$100 of par value. There are some deals which result in extremely large destruction of value. The option value lost in the top 5% of CUSIPS is over \$2.80 per \$100 of par value. Advance refunding allows municipalities

to implicitly borrow over \$5.30 per \$100 par value in the top 5% of cases. With an estimate of 2% in fees as a fraction of the refunded issue value, we estimate that advance refunding has resulted in a destruction of \$3.166 per \$100 par value over our sample, or \$1.027 billion dollars per year.

We find that issuers in states with the most problematic governance tend to engage in advance refundings that destroy more value. This is consistent with municipalities treating advance refunding as a non-transparent way to borrow money. The borrowings result in temporarily lower interest payments, but at the expense of future potential interest savings. While municipal borrowings are often restricted to fund capital projects, there are typically no restrictions on advance refunding borrowings which can be used for operating budgets. Advance refunding, then, can be interpreted as “shrouded” borrowing, which is not unlike the true costs of public pension obligations which are often hidden by misleading accounting and are difficult for taxpayers to calculate (see Novy-Marx and Rauh, 2009; Glaeser and Ponzetto, 2013).

The Federal government already limits the number of advance refundings: bonds issued after the 1986 Tax Reform Act are entitled to only one advance refunding.¹⁵ The U.S. Treasury already provides one tax exemption for the original municipal bond issue, which funds a new investment project, and the limit means that the U.S. Treasury gives a double subsidy when the advance refunding occurs. Given the economic losses imposed on taxpayers by advance refunding, Federal authorities should carefully consider the tax-exempt status of *any* advance refunding.

While we used a single-factor model to value the option value lost by advanced refunding, we expect our results will be robust to using other multi-factor models. In particular, given the underlying patterns of remaining time to call and of the par value of bond issues, which are highly skewed, we expect that more sophisticated option valuation will still produce a

¹⁵New money bonds issued before January 1, 1986, can be advance refunded a maximum of two times.

highly skewed distribution of the losses incurred through advance refunding where the worst deals involve egregious destruction of present value.

References

- Ang, Andrew, Vineer Bhansali, and Yuhang Xing, 2010, "Taxes on Tax-exempt Bonds," *Journal of Finance*, 65, 2, 565-601.
- Ang, Andrew and Richard C. Green, 2012, "Reducing Borrowing Costs for States and Municipalities Through CommonMuni," Brookings Institute, Hamilton Project Discussion Paper 2011-01, February 2011.
- Boyce, William M., and Andrew J. Kalotay, 1979, "Optimum Bond Calling and Refunding," *Interfaces*, 9, 36-49.
- Brooks, Robert, 1999, "Municipal Bonds: A Contingent Claims Perspective," *Financial Services Review*, 8, 71-85.
- Butler, Alexander W., Larry Fauver, and Sandra Mortal, 2009, "Corruption, Political Connections, and Municipal Finance," *Review of Financial Studies*, 22, 2673-2705.
- Chalmers, John M. R., 1998, "Default Risk Cannot Explain the Muni Puzzle: Evidence from Municipal Bonds That are Secured by U.S. Treasury Obligations," *Review of Financial Studies*, 11, 281-308.
- Dai, Qiang, and Kenneth J. Singleton, 2002, "Expectation Puzzles, Time-Varying Risk Premia, and Affine Models of the Term Structure," *Journal of Financial Economics*, 63, 415-441.
- Damon, Robert M. and Chester S. Spatt, 1993, "A Note on Advance Refunding of Municipal Debt," working paper, Carnegie Mellon University.
- Dyl, Edward, and Michael Joehnk, 1976, "Refunding Tax-Exempt Bonds," *Financial Management*, 5, 59-66.

- Fischer, Philip J., 1983, "Advance Refunding and Municipal Bond Market Efficiency," *Journal of Economics and Business*, 35, 11-20.
- Glaeser, Edward L., and Giacomo A. M. Ponzetto, 2013, "Shrouded Costs of Government: The Political Economy of State and Local Public Pensions," NBER Working Paper 18976.
- Hull, John C., and Alan White, 1990, "Pricing Interest-Rate-Derivative Securities," *Review of Financial Studies*, 3, 573-592.
- Jamshidian, Farshid, 1989, "An Exact Bond Option Formula," *Journal of Finance*, 44, 1, 205-209.
- Joehnk, Michael, and Edward Dyl, 1979, "A Practical Framework for Evaluating Municipal Bond Refunding Decisions," *State and Local Government Review*, 11, 10-21.
- Kalotay, Andrew J., 2013, "Advance Refunding: A Misguided View from the Ivory Tower," *The Bond Buyer*, September 4, 2013.
- Kalotay, Andrew J. and Leslie Abreo, 2010, "Making the Right Call," *Credit*, October 2010, 57-59.
- Kalotay, Andrew J. and William H. May, 1998, "The Timing of Advance Refunding of Tax-Exempt Municipal Bonds," *Municipal Finance Journal*, Fall 1998, 1-15.
- Kalotay, Andrew J., Deane Yang, and Frank Fabozzi, 2007, "Refunding Efficiency: A Generalized Approach," *Applied Financial Economics Letters*, 3, 141-146.
- Kraus, Alan, 1973, "The Bond Refunding Decision in an Efficient Market," *Journal of Financial and Quantitative Analysis*, 8, 793-806.

- McCaskill, Claire, 2005, "General Obligation Bond Sales Practices Follow-Up," Report No. 2005-101, Office of the State Auditor of Missouri.
- Moldogazeiv, Tima T., and Martin J. Luby, 2012, "State and Local Government Bond Refinancing and the Factors Associated with the Refunding Decision," *Public Finance Review*, 40, 614-642.
- Nelson, Charles R., and Andrew F. Siegel, 1987, "Parsimonious Modeling of Yield Curves," *Journal of Business*, 60, 473-489.
- Novy-Marx, Robert, and Joshua D. Rauh, 2009, "The Liabilities and Risks of State-Sponsored Pension Plans," *Journal of Economic Perspectives*, 23, 191-210.
- Robbins, Mark D., 2002, "Testing the Effects of Sale Method Restrictions in Municipal Bond Issuance: The Case of New Jersey," *Public Budgeting and Finance*, 22, 4056.
- Vasicek, Oldrich, 1977, "An Equilibrium Characterisation of the Term Structure," *Journal of Financial Economics*, 5, 177-188.
- Vijayakumar, Jayaraman, 1995, "An Empirical Analysis of the Factors Influencing Call Decisions of Local Government Bonds," *Journal of Accounting and Public Policy*, 14, 203-231.
- Weingartner, H. Martin, 1967, "Optimal Timing of Bond Refunding," *Management Science*, 13, 511-524.
- Wood, W. H., 2008, "Municipal Bond Refundings," in Feldstein, S. G., and F. Fabozzi, eds., *The Handbook of Municipal Bonds*, John Wiley & Sons, pp. 235-246.

Table 1

Numerical Example of Advance Refunding. Assume there is an existing bond with annual 6% coupon payments with six years to maturity, but is callable at the end of three years at a price of \$100 per face value. Interest rates are currently 4% across all maturities. The first row gives the cashflows of this existing bond. In the rows under “Pre-Refund,” we consider the case where the municipality issues new debt with a maturity of six years, with a face value of \$105.55 and an annual coupon of \$4.22. The proceeds of the new issue go into a trust, which pays the \$6 coupons of the original debt for the next three years and the call price of \$100. The rows under “Wait to Call” list the cashflows of the case where the municipality waits three years, and then calls the original bond. The final line shows that the interest savings associated with pre-refunding are equal to the savings associated with waiting to call.

Periods	1	2	3	4	5	6
Original Bond Payments (PV=110.48)	6	6	6	6	6	106
Pre-Refund						
Payments (PV=105.55)	4.22	4.22	4.22	4.22	4.22	109.77
Savings (PV=4.94)	1.78	1.78	1.78	1.78	1.78	-3.77
Wait to Call						
Payments (PV=105.55)	6	6	6	4	4	104
Savings (PV=4.94)	0	0	0	2	2	2
Difference in Savings (PV=4.94-4.94=0)	1.78	1.78	1.78	-0.22	-0.22	- 5.77

Table 2

Comparison of Included and Excluded Data. The table lists characteristics—number of CUSIPs, par value, coupon, and maturity—of bonds included in our sample (Panel B) compared to the excluded universe of refunded issues (Panel A).

Characteristic	Number of Observations	Mean	Lower Quartile	Upper Quartile
Panel A: Excluded Bonds				
Number of CUSIPs	109,861			
Par Value (\$)	102,834	3,839,203	315,000	2,520,000
Coupon (%)	109,590	5.64	5.00	6.30
Maturity Year	109,861	2011	2007	2016
Panel B: Included Bonds				
Number of CUSIPs	148,961			
Par Value (\$)	148,961	3,050,312	285,000	2,195,000
Coupon (%)	148,961	5.27	5.00	5.60
Maturity Year	148,961	2013	2009	2017

Table 3

Descriptive Statistics of Pre-Refunded Bonds. We report statistics on the CUSIPs (Panel A) and the deals (Panel B) of pre-refunded bonds in our sample. We list par value, coupon, the time to the call date, and the years to maturity at the refunding date.

	Par (\$ thousands)	Coupon (%)	Yrs. to Call	Yrs. to Maturity	No. CUSIPs
Panel A: CUSIPs (N=148,961)					
Mean	3,050	5.27	2.80	9.18	—
Median	710	5.25	2.30	8.47	—
Maximum	584,155	12.5	23.01	40.64	—
Minimum	1	0.05	0.01	0.20	—
Panel B: Deals (N=17,806)					
Mean	25,518	5.43	2.60	9.37	8.27
Median	7,210	5.31	2.08	8.63	7
Maximum	3,919,815	12.25	19.17	40.64	197
Minimum	5	2	0.01	0.36	1

Table 4

Calibrated Parameter Values. We estimate a Vasicek (1977) model with short rate given in equation (6) and time-varying prices of risk in equation (8). We estimate σ and κ by matching the three-month volatility and autocorrelation. To calibrate θ , we match the sample three-month rate. The price of risk parameters, λ_0 and λ_1 , are pinned down by matching the average long-term yield spread and volatility using the ten-year yield.

	Parameters				
	σ	θ	κ	λ_0	λ_1
Whole Sample					
1996-2009	0.0138	0.0301	0.5416	-0.4244	-9.3883
Subsamples					
1996-2002	0.0156	0.0373	1.1348	-0.0089	-23.287
2003-2009	0.0146	0.0224	0.7616	-0.9987	-4.7053

Table 5

Distribution of Value Lost from Advance Refunding. The value lost in an advance refunding is equal to the value of a put option on the coupon bond expiring on the call date. We value the put option using a Vasicek (1977) model with time-varying prices of risk and the Hull and White (1990) model. In both cases, we use the closed-form method of Jamshidian (1989) to compute the value of the put option.

	Put Value Per \$100 Par	Put Value Per CUSIP	Put Value Per Deal
Vasicek (1977) Model			
Mean	0.786	28,235	236,195
Standard Deviation	1.036	190,654	1,278,196
Quantiles			
30%	0.052	217	582
50%	0.419	2,327	12,413
90%	2.145	45,061	410,086
95%	2.833	95,490	914,340
Maximum	30.502	19,876,458	97,068,393
Hull and White (1990) Model			
Mean	0.486	34,062	284,953
Standard Deviation	1.221	374,970	2,287,915
Quantiles			
30%	0.002	11	66
50%	0.067	404	3122
90%	1.264	24,146	302,892
95%	2.358	70,888	825,329
Maximum	27.76	34,028,569	138,128,017

Table 6

Aggregate Losses from Advance Refunding. In Panel A, we sum all of the put options associated with the pre-refunding decision in our sample. The put is valued using the Vasicek (1977) model with time-varying prices of risk or the Hull and White (1990) model. All figures are in \$ billions except percent of par lost. In Panel B, we estimate the fees associated with advance refunding. We sum all fees assuming transaction costs ranging from 0.375% to 10% as a fraction of the value of the bond that is pre-refunded. The ex-post value lost in advance refunding reported in Panel C is the payoff of the call option at the call date (pre-refunded date). It is the realized value of the call option at the call date, which was given up by the municipality committing to refund early (see equation (17)).

Panel A: Option Value Lost

	Vasicek	Hull-White
Total Option Value Lost (\$ Billions)	4.206	5.074
Total Par Value Pre-Refunded	454.337	454.337
Percent of Par Lost	0.926	1.117
Total Value Lost From CUSIPs below 95% Quantile	1.292	0.607
Total Value Lost From CUSIPs above 95% Quantile	2.914	4.467

Panel B: Estimates of Fees

	Transaction Costs				
	0.375%	1%	2%	5%	10%
Total Fees Paid (\$ Billions)	1.908	5.088	10.176	25.439	50.878
Total Fees Paid as a Percent of Par	0.420%	1.120%	2.240%	5.599%	11.198%
Total Fees Paid from CUSIPS below 95% Quantile	0.919	2.450	4.900	12.251	24.502
Total Fees Paid from CUSIPS above 95% Quantile	0.989	2.638	5.275	13.188	26.375

Panel C: Ex-Post Value Lost

Total number of observations	112,895
Total Par for bonds with computed ex-post loss (\$ Billions)	294.375
Percentage of time when there is ex-post value lost	1.940%
Total Value Lost Ex-Post (\$ Billions)	0.309
Total Value Lost Ex-Post as a % of Par Value	0.104%
Total Value Lost Ex-Post From CUSIPs below 95% Quantile	0
Total Value Lost Ex-Post From CUSIPs above 95% Quantile	0.309

Table 7

Distribution of Implicit Borrowing. We estimate the size of the trust, F , required at the pre-refunding date and the coupon of the par bond required to fund it, C^* (see equation (18)). The per period reduction in interest cost is then $C - FC^*$, where C is the coupon on the bond being advanced refunded. The present value of this difference, up to the call date, times the total par value of the pre-refunded issue is our estimate of the present value of interest savings that are being accelerated in the advance refunding transaction. The table reports summary statistics of the distribution of this implicit borrowing for individual CUSIPs and deals. There are 148,961 CUSIPs and 17,807 deals.

	Implicit Borrowing Per \$100 Par	Implicit Borrowing Per CUSIP	Implicit Borrowing Per Deal
Mean	1.95	48,201	403,235
Standard Deviation	1.89	273,417	1,759,034
Quantiles			
30% Quantile	0.87	3,599	31,457
50% Quantile	1.59	9,839	87,876
90% Quantile	4.39	122,595	926,170
95% Quantile	5.31	236,524	1,799,647
Maximum	27.43	34,112,482	90,478,872
Total Implicit Borrowing	–	7,180,002,583	7,180,002,583
Total Above 95th percentile	–	4,490,941,884	4,385,278,973

Table 8

Distribution of Types of Issuers for Top Worst Deals. The entries in the table represent the number of issuers of the 50 deals with the largest observations for each quantity listed at the top of the table. That is, they are the 50 worst deals subdivided by the type of issuer, in terms of par value destroyed, the total put value, and the amount of implicit borrowing being done in the advance refunding. There are a total of 17,806 deals.

Issuer Type	Par Value Total	Put Value Total	Implicit Borrowing	Put Value Per \$100 Par
State	11	10	24	1
City	6	6	7	2
County	2	4	0	3
Town, Borough	0	0	0	3
Highway, Airport, Public Transit	20	12	8	0
Utility, Water	4	9	2	4
Development Authority	5	3	2	2
University	1	2	1	3
Hospital	0	1	3	2
School District	1	3	3	30
Total	50	50	50	50

Table 9

Which Municipalities Destroy the Most Value? We run a pooled cross-sectional regression where the dependent variable is the amount of option value destroyed per \$100 par value, as measured using the Vasicek (1977) model. The table lists the coefficients and t-statistics with year or quarterly fixed effects. The unit of observation is the CUSIP. There are 142,849 observations for which we were able to identify the state of the issuer.

	Coefficient	t-statistic	Coefficient	t-statistic
Long Muni Rate	-25.04	-16.85	-7.34	-2.88
Spread	0.20	16.33	0.16	5.45
Number of Convictions	0.037	31.53	0.036	31.08
S&P Rating	0.003	4.33	0.004	5.77
State Unemployment	-0.035	-12.26	-0.036	-12.73
State GDP Growth	0.22	1.51	0.19	1.31
State Debt Per Capita	0.055	5.31	0.064	6.26
State Population Growth	-6.06	-15.29	-5.93	-15.03
State Median Income/1,000	-0.005	-5.23	-0.005	4.98
State Population	0.016	2.74	0.017	2.89
R^2	0.17		0.18	
Time Fixed Effects	Each Year		Each Quarter	

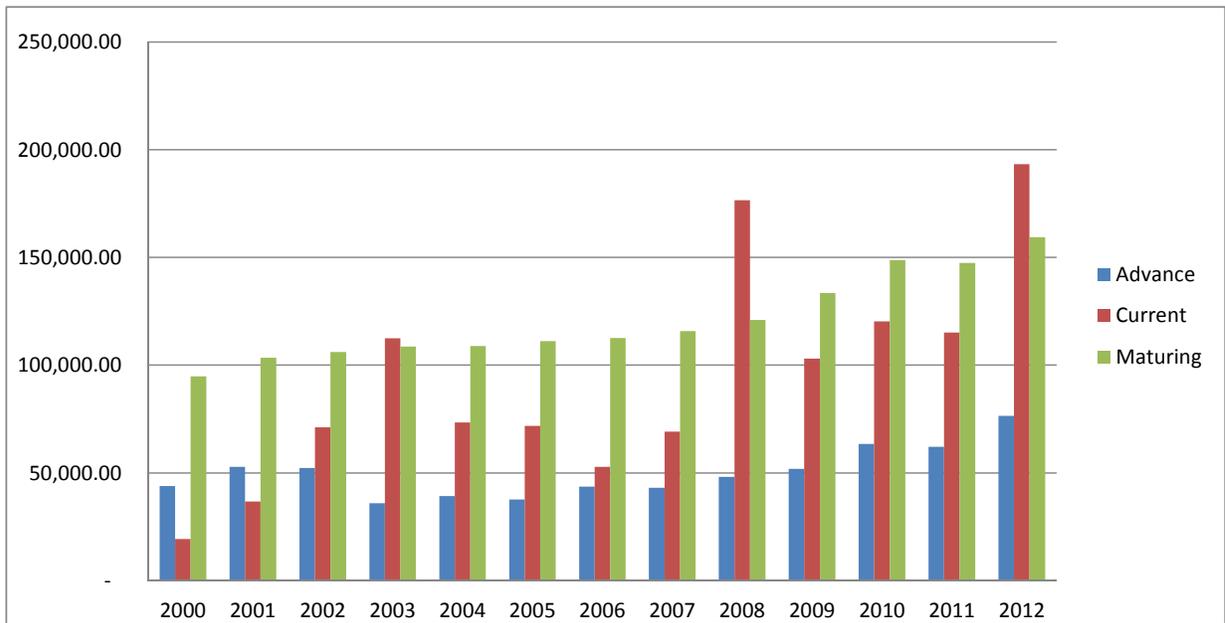


Figure 1
 Redemptions of Municipal Bonds by Year. The plot shows the par value (in millions) of municipal bonds redeemed in each year through reaching maturity, through exercise of a call provision in a current refunding, and through exercise of a call provision after having been previously advance refunded. Source: Bondbuyer Statistical Yearbooks and Annual Statistical Review.

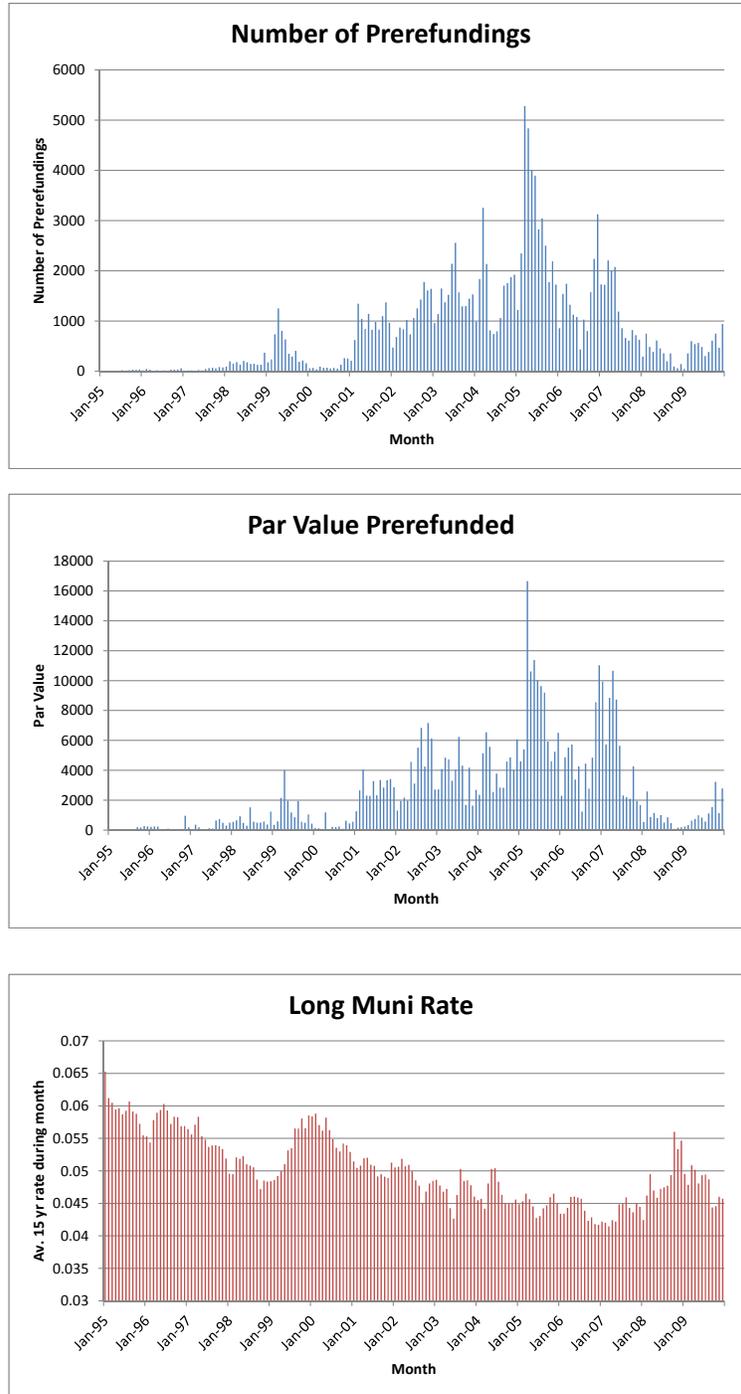


Figure 2
 Advanced Refundings Over Time. We plot the number of pre-refundings (top panel), the par value (in millions) of pre-refundings (middle panel), and the average 15-year zero-coupon tax-exempt yield for each month in our sample.

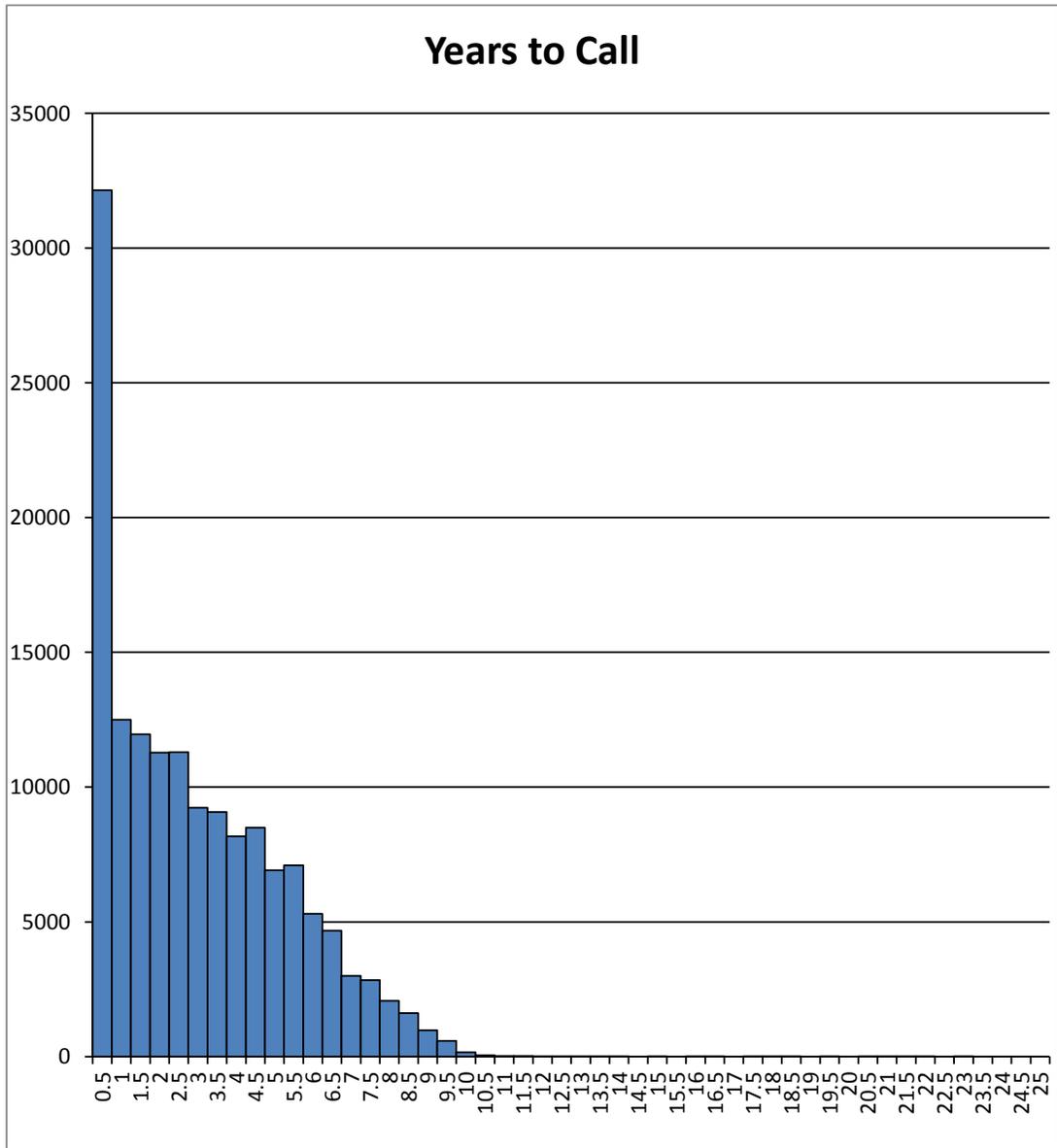


Figure 3
 Years to Call Date for Pre-Refunded Municipal Bonds. The plot shows the distribution (histogram) of years to the call date at the time of refunding for each bond in the sample.

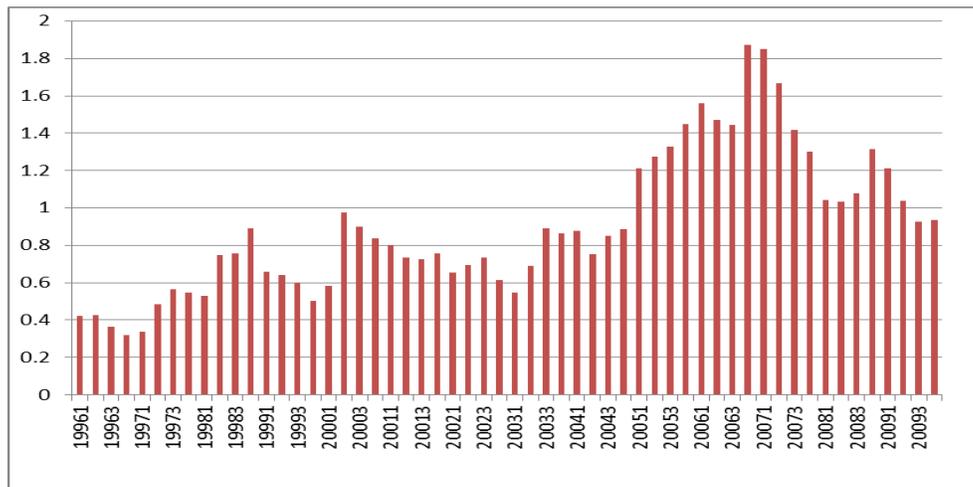
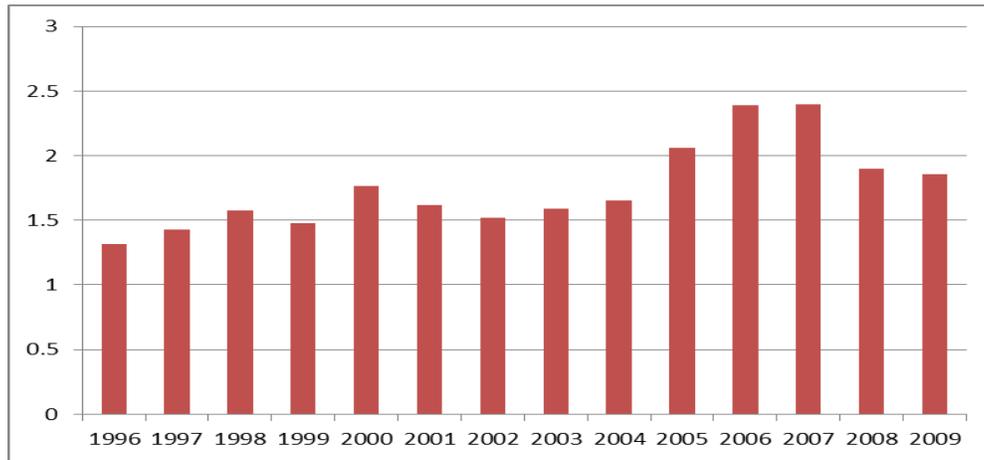


Figure 4

Time Fixed Effects. We show estimated coefficients on fixed effects for years (top panel) and quarters (bottom panel) from the cross-sectional regressions reported in Table 9 explaining the magnitude of advance refunding losses. All annual fixed effects are associated with p-values of less than 0.0001. Quarterly fixed effects for 2-1995 to 4-1995, 2-1996 to 2-1997, and 1-2003 have p-values greater than 0.05. The other quarterly fixed effects are statistically significant at conventional levels.