Option-based Analysis of Tender/Refunding Transactions

Andrew Kalotay[1] and Martin Luby[2]

Abstract

Tender/refunding of tax-exempt bonds has been a recent trend in municipal finance. In these transactions issuers refund their tax-exempt bonds through a tender process in expectation that interest rates will be higher in the future. Through case study analysis, this paper applies the generalized refunding efficiency (GRE) framework to evaluate the economics of a typical transaction. GRE is an essential tool for deciding the appropriateness of any refunding transaction. We also discuss why investor participation level has been lower in these tax-exempt tender refundings relative to similar corporate bond transactions.

I. Introduction

Municipal issuers sell bonds for two primary reasons: 1) to finance new projects ("new money bonds") or to refinance outstanding indebtedness ("refunding bonds"). The use of bonds for refunding has been a significant part of the municipal bond market for decades. For example, between 2010 and 2017, refunding bonds annually made up between 23% and 41% of the entire market of municipal bond sales (Luby et. al, 2026). These issuance levels have declined since 2017 as we will discuss below. However, even in the 2018 to 2025 time period, refunding bond issuance annually ranged from 12% to 31% of the entire municipal bond market, which translates into almost $700 billion in refunding bonds (Luby et. al, 2026).

Until 2018 tax-exempt municipal bonds were eligible for advance refunding on a tax-exempt basis.[3] In these transactions, the municipal issuer would issue new tax-exempt bonds, and use the proceeds to defease the outstanding bonds to their call date (Kalotay and Luby, 2024). The usual purpose of advance refunding transactions was to lock in cashflow savings well

[1] Corresponding author, President, Kalotay Advisors, kalotay@msn.com, (917)-359-8075
[2] Associate Professor, LBJ School of Public Affairs, University of Texas at Austin
mluby1@austin.utexas.edu (512) 232-1286
[3] "Advance refunding" is a technical term used in the capital markets to denote a refinancing of existing debt more than 90 days before the call date of the outstanding bond.

in advance of the call date of the defeased bonds. The defeased bonds remained outstanding until their call date, resulting in a proliferation of tax-exempt securities until that date, since there would be two bond issues outstanding for the financing of the same project.

The 2017 Tax Cuts and Jobs Act ("2017 Tax Act") eliminated tax-exempt advance refunding bonds.[4] Subsequently, tax-exempt borrowers have employed two prominent ways to 'profitably' refund not-yet-callable bonds. First, they used *taxable* bonds to advance refund their outstanding tax-exempt bonds. Between 2018 and 2022 'taxable' advance refundings were particularly popular, and resulted in a more than doubling of the percent of taxable municipal bond issuance between January 2019 and January 2020 (Barcena and Wessel, 2020). With the Federal Reserve raising interest rates in early 2022, taxable advance refunding no longer produced attractive debt service savings levels for municipal issuers.

The 2017 Tax Act and the rising interest rate environment post-2022 led to the second and more recent refinancing innovation dubbed "tax-exempt tender refunding", which is the focus of this paper. In a typical tax-exempt tender transaction, high-coupon (5%) not-yet-callable tax-exempt bonds are purchased by the municipality by fixed price tender offers, usually at a substantial premium (2 to 4 points) over the bonds' fair values. The repurchase is funded by issuing new tax-exempt bonds. From the federal government's perspective, the use of tax-exempt bonds to tender for outstanding tax-exempts bonds is permissible, since it does not result in two bond issues outstanding to finance the same project. That is, the investors of the tendered bonds are immediately repaid and thus are no longer earning tax-exempt income.

Rather than tendering for the outstanding bonds, the municipal issuer could wait until the call date to refund the bonds in the traditional way. The implicit rationale for these tax-exempt

[4] Municipal issuers could still refund their bonds as long as the refunding took place no earlier than 90 days of the call date of the outstanding bonds. This is known as a :current refunding."

tender transactions is the expectation that by the time the outstanding bonds become callable, interest rates will be substantially higher than they are today. Thus, by tendering for the bonds today, issuers imply that they are realizing greater savings than if they waited until the call date to refund.

The participants in the tender transactions are betting that rates will be higher than expected. The expectations on such implicit bet can be estimated from available market data. For example, in the case of the Massachusetts Water Resources Authority (MWRA) transaction considered later in this paper, according to our calculations, the implicit assumption is that MWRA expects rates to increase by more than 60 basis points by the time the bonds become callable in 2028. Thus, these transactions are driven mainly by speculation on the future direction of interest rates.

One can assess the performance of tax-exempt tenders only with hindsight, based on the actual evolution of interest rates. Nevertheless, we can make an educated assessment of the likelihood of success, by focusing on the value of the call option of the bonds repurchased by the tender. The key is to compare the savings from actual tender refunding to the value of the forfeited call option. This ratio, known as the generalized refunding efficiency (Kalotay, Yang and Fabozzi, 2007), is an extension of the fundamental refunding efficiency method developed in Boyce and Kalotay (1979).

We will illustrate the use of generalized refunding efficiency analysis for a typical tax-exempt tender transaction, one executed by the MWRA. The primary aim of this paper is to apply a formal analytical framework in evaluating the economics of this recent refunding trend in municipal finance. We hope that exposition of this approach will help municipal issuers make superior refunding decisions.

Another aspect of the tax-exempt tender transactions is the response by the investors to the generous tender prices. In sharp contrast to corporate bond tenders in the past, acceptance ratios turned out to be remarkably low, in some cases less than 30% (Phalon, 1977; Office of the New York City Comptroller Brad Lander, 2023). We will discuss the likely reasons for the low participation in tax exempt tenders, which, in addition to the composition of the investors, include accounting and tax considerations. Investor participation level is a significant factor in the overall economics of these transactions, so such discussion is germane in assessing the likelihood of the success of tax-exempt tenders.

II. Previous Research

Given the importance of refunding in the debt management activities of municipal issuers as described above, it is no surprise this topic has received a good amount of attention from the scholarly community. The original strand of research on municipal bond refunding occurring in the 1970s provided general framework (Dyl and Joehnk, 1976; Joehnk and Dyl, 1979). Luby (2014) extended on these frameworks applying them to different types of financings including transactions with interest rate swaps and pension obligation bonds. Another strand of research focused on factors that influence municipal issuers decision to refund bonds (Vijayakumar, 1995; Moldogaziev and Luby, 2012).

There has also been more recent research on the economics of bond refundings in terms of these transactions' overall economics and whether they were executed at the right time (Luby, 2012; Ang et. al, 2017; Kalotay and Luby, 2024; Chen, Cohen and Liu, 2025). Kalotay and Luby (2024) is most germane for our study in that it explores taxable advance refundings in the 2018-2022 time period. Based on perfect hindsight using a counterfactual methodology, the paper showed these taxable advance refundings ended up realizing billions of dollars less in savings

compared to waiting to refund later. More specifically, the authors found that for a sample of just 14 taxable advance refunding transactions, issuers would have realized 58% more in debt service savings (i.e., $577 million) by waiting until the call dates and then refunding with tax-exempt bonds.

Finally, the framework presented in this paper extends the prescriptive body of research that focuses on the value of the call option in making a refunding decision. This line of research began in the 1970s, with newer studies published much more recently (Boyce & Kalotay, 1979; Kalotay & May, 1998; Kalotay et al., 2007; Kalotay & Raineri, 2016; Zhang & Li, 2004). This paper extends this research to the emerging area of tax-exempt tender transactions resulting from the 2017 Tax Act.

III. The Appeal of 5% Coupon Bonds

The typical tender/refunding transactions considered in this paper entail repurchasing 5% not-yet-callable tax-exempt bonds and funding the purchase by issuing new 5% NC-10 bonds[5] (Government Finance Officers Association, 2025). The 5% NC-10 structure callable at par in Year 10 has dominated the municipal bond market since the Great Financial Crisis (Vanguard, 2023). Because tax-exempt rates have been well below 5%, these 5% bonds have been selling at a substantial premium over par. We will explore below the reason for the appeal of high coupon bonds callable at par.

Let's start by considering the investor perspective. As discussed in Kalotay and Davidson (2021), institutional investors avoid buying bonds near par because of their negative convexity.[6]

[5] 5% NC-10 tax-exempt bonds are callable ten years from issuance, at 100% of the par value

[6] Convexity depicts the effect of interest rate change on a bond's price. If a bond is optionless, the price increase due to lower rates exceeds the drop due to an equal rise of rates. Such behavior is referred to as positive convexity. In the case of negative convexity, the decline in price due to higher rates exceeds the increase due to a like drop. Negative convexity is displayed by callable bonds when the call option is 'in the money', because the call option impedes the upside potential when rates decline.

That is, in the event interest rates rise, due to the "de minimis effect" bonds purchased near par underperform the market.[7] By purchasing 5% bonds significantly above par, the de minimis event is effectively avoided. Thus, the institutional investor appetite for 5% bonds is understandable.

Now, let's turn to the issuers' perspective of 5% bonds and focus on the par call after 10 years. The traditional financial reason for including the call feature is to enable borrowers to save interest by refunding, in the event rates decline below where they were at the time the bond was issued. The call at par accomplishes this, provided that the bond was issued near par. Specifically, the combined cost of the original callable bond and the refunding bond to the nominal maturity date will be lower than that of a single long-term optionless bond (i.e., a bond that the issuer did not have an option to call and refund early).

However, such is not the case with 5% bonds. One could issue long-term 5% bonds at a premium when rates are roughly 3%, call and refund them 10 years later when rates are in the 4% range and claim significant interest cost savings, even though issuing long-term optionless bonds originally at a 3% interest rate would have been obviously preferable. Thus, issuers are

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In the case of tax-exempt municipal bonds, the so-called de minimis effect is a manifestation of negative convexity. If a (non-OID) municipal bond is purchased in the secondary market at a discount, the resulting gain is taxed at maturity. The tax rate applicable to large, so-called non-de-minimis discounts, defined as 0.25 times the remaining years to maturity, is the ordinary income rate. The eventual tax on the gain reduces the prices of bonds selling below par. In fact, even bonds selling slightly above par are negatively convex, because their prices could drop below par if interest rates rise.

Due to the de-minimis effect, when interest rates rise bonds selling close to par will underperform those selling at a high premium to par. Institutional investors, whose performance is regularly reported, avoid such possibility of underperformance by not purchasing bonds at prices near par. Their preferred investments are 5% bonds, at large premiums to par.

On the other hand, retail investors of municipal bonds focus on cashflow, rather than on short-term performance. Due to the high transaction cost, they tend to follow a 'buy and hold' strategy, and the de-minimis effect does not impact their cashflows. Because retail investors tend to be averse to paying a premium, they prefer bonds selling near par to those with 5% coupons. As a result, the municipal market is somewhat bifurcated; the 5% bonds are held by institutional investors, and the par bonds are purchased by retail.

[7] The de minimis tax treatment for municipal bonds determines whether the gain from buying a bond at a discount is taxed as ordinary income or capital gain. Due to the "de minimis market effect," bonds purchased near par experience larger declines in prices when interest rates rise.

virtually certain to show substantial savings by refunding their 5% NC-10 bonds by the end of Year 10.

Missing from the discussion above is the cost and the value of the call option. At the time of issuance, the ten-year par call option is acquired at a significant cost. Depending on the maturity and the prevailing interest rates, the cost of a par call in Year 10 of a 5% long-term bond can easily exceed 20 points (Kalotay, Yang and Fabozzi, 2007). In other words, the market price that an issuer would receive from selling a noncallable long-term bond would be 20 points higher. On the other hand, when refunding a bond, the issuer forfeits the associated call option – once the bond is retired, it cannot be called. Thus, the critical question in the refunding decision is whether the savings from refunding provide adequate compensation for the forfeited call option. The methodology we describe in this paper and its attendant analyses specifically includes the value of the call option in assessing the economics of the tax-exempt tender transaction.

IV. Historical Background on Corporate Bond Tenders

To better understand tax-exempt tender transactions, it is useful to review the experience in the corporate taxable bond market. During the first two decades following WWII interest rates increased, and in 1974 they reached a post-war high (Boyce and Kalotay, 1979). Independent of the level of interest rates, utilities in general, and Bell Telephone companies in particular, continued to issue long-term callable bonds, including three with 10% coupons and one with a 9.5% coupon in 1974. The Bell bonds were issued near par, and they were callable at a premium (not par) after 5 years. By late 1976 interest rates substantially declined, and there was an opportunity to economically refund the 1974 bonds. In January 1977 the issuers of the 10% and 9.5% bonds tendered and refunded them with lower-coupon bonds, and other utilities followed

(Metz, 1977; Laber, 1978).[8]

The logistics of the 1977 tenders are notable. The 10% and 9.5% bonds were trading well over par, and the tender premiums were roughly 3 points above the market prices. The tender period was open for one month. It turned out that the sophisticated investors would wait literally until the last day to decide whether to participate. This prompted the question of how the issuer could mitigate the interest rate risk associated with fixed-price tenders. Subsequent solutions included shortening the tender period and changing the tender from a fixed price to a fixed spread to a benchmark Treasury bond.[9]

In 1981 interest rates reached yet another high, with 30-year Treasury bond rates at15%. Utilities continued to issue long-term callable bonds, some with coupon rates over 18%. And history repeated itself –by 1984 interest rates substantially declined, bringing the opportunity to tender and refund. By then the mechanics of the transaction were well understood, and a flood of corporate tenders and associated refundings followed.

The beneficial tax treatment played a critical role in these transactions. From the perspective of a corporate issuer, the difference between the premium purchase price and the (near-par) tax basis was treated as an ordinary tax-deductible expense. In 1980, the top corporate tax-rate was 46%. At that marginal tax rate, the after-tax cost of purchasing a bond at 110.00 was 105.40.[10] Needless to say, the tax-deductibility of the premium substantially improved the economics of the transaction. Since state and local governments do not pay taxes, such tax deduction benefit is not available to them in these tender transactions.

[8] It is noteworthy that the first author of this manuscript participated in the 1977 tender at AT&T and many other tenders around 1984 at Salomon Brothers.
[9] Fixed spread tenders were used as early as 1984, which is decades prior to the municipal market's "innovative" use of this structure mentioned later in this paper (Kalotay, 2026).
[10] That is, par plus the 10% premium multiplied by 1 - 46% corporate tax rate)

V. Recent Municipal Bond Tender Landscape

As discussed above, the 2017 Tax Act's elimination of tax-exempt advance refundings led municipal issuers to seek alternative ways to refund their debt for budgetary savings. Issuers originally continued the use of advance refundings, simply supplanting tax-exempt refunding bonds with taxable refunding bonds in the 2018-2021 time period (Kalotay and Luby, 2024). Due to the rise in interest rates since March 2022, taxable advance refundings have no longer been economical (Lerner, 2023). In response, issuers explored other refunding strategies, including the tendering for their not-yet callable bonds and refunding them with tax-exempt bonds. According to the GFOA, municipal issuers executed over $48 billion in tender refundings between 2019 and 2024 (Government Finance Officers Association, 2025). Such surge in issuance necessitated that the GFOA develop a best practice on tender refundings, which was completed in June 2025 (Government Finance Officers Association, 2025).

Table 1 details select tender transactions in 2023. This is not a comprehensive list. However, even in this abridged table, one can see that the issuers tendering for bonds are a diverse lot, including states, school districts, public utility commissions, and turnpike authorities. Illustrating the salience of these tax-exempt tender transactions, *The Bond Buyer*, which is the daily newspaper covering the municipal market, awarded a Wisconsin fixed-spread tax-exempt tender refunding as 2025 Deal of the Year in the innovating financing category (Shea, 2025).[11] *The Bond Buyer* has also published commentary on these transactions in recent years (Kalotay, 2024).

[11] The fixed-spread purchase aspect of this transaction differed from most other tender transactions (including the MWRA transaction analyzed in this paper) that were executed on a fixed-price basis.

TABLE 1 Select Recent Tax-Exempt Tender Transactions				
	Issuer	Issue	Issue Date	Issue Par Amount
1	Massachusetts Water Resources Authority	General Revenue Refunding Bonds, 2023 Series C	4/27/23	$100,340,000
2	State of Wisconsin	General Obligation Refunding Bonds of 2023, Series 2	5/11/23	$495,425,000
3	San Diego Unified School District	Series SR-3A	11/29/23	$34,435,000
4	Public Utilities Commission of the City and County of San Francisco	2023 Sub Series C and D	8/10/23	$514,855,000
5	Stockton Unified School District	2023 General Obligation Refunding Bonds Series B	12/14/23	$72.925,000
6	District of Columbia	Income Tax Secured Revenue Refunding Bonds Series 2023C	12/6/23	$189,165,000
7	Pennsylvania Turnpike Commission	Turnpike Subordinate Revenue Refunding Bonds, First Series of 2023	3/16/23	$343,800,000
Source: Municipal Market Analytics				

VI. Analytical Approach

As mentioned earlier, the true performance of a refunding can be determined with hindsight (ex post), based on the actual evolution of interest rates until the call date. However, using standard bond analytics, we can estimate expected performance at the time of the refunding transaction (ex-ante). The following two sections detail the analytical approach that we propose municipal issuers should utilize in evaluating tax-exempt tender transactions.

Refunding entails a trade-off between the cashflow savings and the value of the forfeited call option – once refunded, the bond cannot be called in the future. The efficiency ratio, defined below, is a measure of expected performance:

$$\text{Efficiency Ratio} = \text{Savings}/\text{Option Value}$$

The maximum attainable efficiency ratio is 100%. Anything below 100% is a loss to the issuer, and in the case of tax-exempt tenders, a windfall to the bond holders.

Conceptually, the calculation of efficiency is straightforward, it is the ratio of the savings to the suitably defined option value. The required inputs to determining savings and option value are the issuer's optionless par yield curve and the interest rate volatility. Although optionless par benchmark yield curves are not readily available for municipal bonds, they can be extracted from the standard 5% non-call 10 municipal yield curves. The challenge is to identify the appropriate volatility. Another source of complications is that if the refunding bond is itself callable, as is the case with tax-exempt tenders, the value of that option should be incorporated into the analysis. The recommended method to accomplish this is the so-called generalized refunding efficiency (see formula below) as described in Kalotay, Yang and Fabozzi (2007).[12]

$$\text{GRE} = \text{Savings} / (\text{Old Option Value} - \text{New Option Value})$$

The calculation of generalized refunding efficiency will be illustrated in the case study detailed in the following section.

VII. Case Study: Massachusetts Water Resources Authority (MWRA)

MWRA executed a tax-exempt tender transaction in late April 2023.[13] The transaction

[12] Early academic publications assumed that the refunding bond was optionless and of like maturity. Under these assumptions, refunding could be considered a riskless transaction. In practice, refunding bonds tend to extend maturity, and they are often callable. Municipal bonds maturing over 10 years are virtually always callable. When the maturities are mismatched, the estimated savings may significantly depend on the discount rate, and therefore correct discounting is essential. As long as the maturities of the outstanding and the refunding bonds coincide, the GRE is relatively insensitive to the discount rates. The treatment of the call option of the refunding bond is also critical; it reduces reported cashflow savings but may provide additional savings in the future if the refunding bond itself could be profitably refunded. The valuation of the call option of a municipal bond is discussed in 'Kalotay and Luby (2025). The problem is how to extend the original refunding efficiency approach to incorporate this option value. As shown in Kalotay, Yang and Fabozzi (2007), the correct approach is to reduce the denominator of the refunding efficiency formula (subtract it from the forfeited option value of the outstanding bond), rather than to increase the numerator (add it to the cashflow savings).

[13] See Kalotay and Luby (2025) for a more mechanical discussion and analysis on the details on this transaction

included tendering for not-yet-callable 5% tax-exempt bonds. MWRA sold two series of refunding 2023 bonds (Series B and Series C) with the same repayment pledge and tax status. We use the actual pricing of each of these bond series to assess the economics of the tender transaction on a matched maturity basis for the example provided below.

Details on the MWRA tender are available in following three documents: Refunding issue official statement[14], pricing notice (tender prices)[15] and notice of results (acceptance/rejection)[16]. These documents are freely available from the Municipal Securities Rulemaking Board's Electronic Municipal Market Access (EMMA) data portal. The outstanding tax-exempt bonds available for tender totaled $411,065,000. Of that amount, $46,770,000 was tendered by investors, representing 11.38% of the outstanding bonds, and $31,160,000 was accepted by MWRA representing 7.58% of the outstanding bonds. This success rate is very low relative to the historical corporate tender participation rate detailed previously. Based on our preliminary review of the select tax-exempt tender transactions referenced in Table 1 above, such low participation level seems common.

Our objective is to assess the economics of this transaction based on the generalized refunding efficiency. This will be done in three steps:

Step 1: From the terms of the refunding issue, determine the optionless yield curve. These yields are essential for discounting and option valuation.

Step 2: Using the optionless rates, calculate the call option values of both the refunded and refunding bonds, along with the values of the underlying optionless bonds.

Step 3: Calculate the generalize refunding efficiency, based on the savings and the

[14] http://watertower.mwra.com/finance/documents/bondofficialstatement/2023/OS_MWRA_2023B%20and%20C%20Official%20Statement.pdf
[15] https://emma.msrb.org/P21731688.pdf
[16] https://emma.msrb.org/P21735198.pdf

option values. Note that the savings depend on the tender prices.

MWRA Optionless Rates

We deploy the industry-standard log-normal interest rate process to extract MWRA's optionless rates from its callable interest rates, which are available from the official statement. The methodology, given the interest rate volatility, is described in both Kalotay (2017) and Kalotay and Luby (2024). The challenge is to estimate the volatility, as discussed in Kalotay and Luby (2025). The guiding light is the ratio of the tax-exempt rate to the identical maturity Treasury rate. The higher the volatility, the lower is the estimated tax-exempt rate and the lower this ratio will be. We note that the T/E to Treasury ratio is observable for the first 10 years, because municipal bonds shorter than 11 years are generally not callable. The ratios must be reasonable – for example, according to previous studies they should increase with maturity, while common sense dictates that for investment-grade issuers the ratio cannot exceed 1 (Kalotay and Dorigan, 2008). In the case of the MWRA yield curve, we have found that in 2023 30% interest rate volatility provided reasonable estimates of the optionless rates (Kalotay and Luby, 2024).

Table 2 below displays the implied optionless rates for selected maturities of the MWRA Series 2023 refunding bonds (Step 1).

TABLE 2
Massachusetts Water Resources Authority, Series 2023 Refunding Bonds
Implied Optionless Yields at 30% Volatility

Maturity (years)	5% NC-10	Implied Optionless Yield	Treasury Yield[17]	Ratio
2	2.50	2.50	4.24	0.59
5	2.39	2.40	3.71	0.66
10	2.53	2.54	3.60	0.71
15	3.20	3.325	N/A	N/A
20	3.51	3.40	3.90	0.87

[17] 15-year Treasury rates are not reported

Table 3 shows the option values of the MWRA 2023 refunding bonds, calculated as the difference between the actual prices and estimated optionless prices (Step 2).

TABLE 3
Massachusetts Water Resources Authority, Series 2023 Refunding Bonds
Option Values of Selected Bonds (5% NC-10)

Maturity (years)[18]	Yield	Price	Optionless Price[19]	Option Value
10	2.53	121.70	121.70	0.00
15	3.20	115.26	120.31	5.06
20	3.51	112.50	123.83	11.32

Table 4 details the option value and optionless price on select MWRA tender candidates related to the 2018 Series B bonds (Step 2).

TABLE 4
Massachusetts Water Resources Authority
Tender Candidates (2018 MWRA Series B, Callable on 8/1/2028, 5% coupon rate)
Option Value and Optionless Price

Maturity	Fair Value	Optionless Price	Option Value
8/1/2033	111.74	121.98	10.24
8/1/2038	107.87	120.29	12.48
8/1/2043	106.36	123.77	16.16

Refunding Efficiency (Step 3)

We assume MWRA intended to fund the tender by issuing similar maturity callable bonds. The generalized efficiency calculation below illustrates how to incorporate the value of the NC-10 call option. The required information for the tender candidates is displayed in Table 5 below.

[18] The number of years to maturity correspond to the maturity of the tendered candidates detailed in Table 4 below. For example, the 2023 refunding bonds 10-year maturity (2033) corresponds to the 2018 bonds 2033 maturity.
[19] In the case of optionless bonds we use 'price' and 'value' interchangeably.

TABLE 5 **Massachusetts Water Resources Authority** Tender Candidates (2018 MWRA Series B, Callable on 8/1/2028, 5% coupon rate) Generalized Efficiency Inputs					
Maturity	Fair Value	Option Value	Total Value	Tender Price	Tender Premium
8/1/2033	111.74	10.24	121.98	114.47	2.73
8/1/2038	107.87	12.48	120.29	111.48	3.61
8/1/2043	106.36	16.16	123.77	109.86	3.50

Now, let's consider the 2018 Series B 5% bond maturing in 2043 and callable in 2028. As indicated above, its current fair value is 106.36, the value of its call option is 16.16 and the tender price is 109.86. The 3.50% tender premium is the difference between the 109.86% tender price and the 106.36 fair value. The cost of leaving the bond outstanding until maturity is the value of the host optionless bond, which is 106.36+16.16+1.25 (accrued) =123.77

The tender price is 109.86, as detailed in the tender pricing notice document. We assume that the purchase would be funded with a 5% NC-10 tax-exempt bond also maturing in 2043. As shown in Table 3, the price of this refunding bond is 112.50 (based on pricing in the 2023 bonds official statement), its option value is 11.32, and therefore the value of the replacement optionless bond is 123.82 (as expected, because the terms of the refunded and the refunding bonds are virtually identical).

Disregarding underwriting costs, the funding of the 109.86 tender price requires 109.86/112.50=0.976 new bonds per old bond. Therefore, the cost of the replacement bond per outstanding bond is 0.976x123.82, or 120.86. It follows that the cashflow savings in present value terms (S) amount to: 123.77-120.86=2.91 points per outstanding bond.

Now, we are ready to calculate the generalized refunding efficiency (GRE), which is defined as Savings/(Old Option Value – New Option Value). Note that the 11.32 option value of the refunding bond needs to be scaled down by 0.976, to 11.05. Accordingly, GRE = 2.91/ (16.16-11.05) =2.91/5.11=57%. Thus, in the absence of transaction costs, the refunding captures

a little over half of the option value.[20] The low efficiency ratio signals low cash flow savings relative to the value of the forfeited call option.

Refunding with Optionless Bonds

If the municipal issuer's objective is to lock in interest savings, it could be accomplished by issuing maturity-matched optionless bonds, instead of callable bonds. Optionless bonds would be sold at higher prices, resulting in greater nominal savings relative to callable bonds. Moreover, optionless bonds would negate the need for the future refunding bond issuances and their attendant transaction costs.

We analyze the repurchase of the MWRA bond maturing in 2043 by assuming that the purchase is funded with hypothetical optionless bonds. The cost of leaving the bond outstanding until maturity is 123.77. As shown in Table 2, the purchase could be funded by issuing 109.86 amount of 20-year 3.40% optionless bonds sold at par. Or, to avoid the de minimis risk, issue optionless 20-year 5% bonds at a dollar price of 123.83. In the latter case, the principal amount would be reduced to 109.86/123.83=88.7% of the outstanding principal. Disregarding transaction costs, either alternative would result in present value savings of 123.77-109.86=13.91, and efficiency 13.91/16.16=**86%**. In fact, optionless bonds of other maturities would provide the same savings and efficiency, but mismatching maturities would introduce interest rate risk (Kalotay, 1976).

In the above case, refunding with an optionless bond would result in a higher efficiency than refunding with a callable bond, but still well under 100%, which is the maximum attainable.

[20] Transaction costs reduce both the savings and the option value. The transaction cost should be subtracted from the savings. The effect of transaction cost on option value should be handled by adding it to the call price. If the transaction costs amount to 1% of the principal amount and the contractual call price is 100, from the issuer's perspective the call price should be represented as 101. For now, we observe that transaction costs reduce efficiency, but in the case of the tax-exempt tenders considered in this paper the effect is modest.

Kalotay, Yang and Fabozzi (2007) discusses why the efficiency of a *suboptimal* refunding depends on the structure of the refunding bond. In the ideal world, without the tender premium and without transaction costs, the efficiency would be 100%, independent of the structure of the refunding bond. But as the examples demonstrate, the real world is far from being ideal since tender premium tends to be close to 3%, and the transaction costs can amount to 1%.

Break-Even Analysis

For those unfamiliar with option valuation, break-even analysis is an alternative framework for analysis refunding economics, which we discuss below. MWRA funded the tender by issuing 5% NC-10 bonds. Issuing callable bonds instead of optionless bonds reduces nominal savings, but it may present opportunities in the future to add to the savings by refunding the newly issued bonds. Thus, a break-even analysis versus the current tender/refunding transaction depends on both the rates when the outstanding bonds become callable in 2028 and when the refunding bonds become callable in 2033.

The calculation of the break-even rate is more manageable if we assume that the refunding bonds are optionless; in that case only the rates in 2028 are relevant.[21] We have shown that refunding the 5% bonds due 2043 with optionless 3.40% bonds due 2043 would have resulted in 13.91 points savings. The break-even analysis estimates what the level of 15-year optionless rates would need to be in 2028 to generate the same savings.

First, we note that in PV terms, a dollar in 2028 is worth 88.81 cents today. To break even, refunding must produce savings of 15.66 points (13.91 ÷ 0.8881). It can be shown that this

[21] General break-even methodology: If one assumes the refunding bonds are optionless, only the rates as of the call dates of the tendered bonds matter. To compute the break-even rate, determine the savings based on maturity-matched optionless refunding bond and solve for the refunding rate as of the call date that would generate the same savings. Note that the PV date is the date of the tender (rather than the call date).

would occur by an **85-basis point increase of the yield curve**. In particular, the 15-year rate would rise from its 2.91% current level to 2.91+0.85=3.76%.

VIII. Institutional Investor Considerations

With the framework developed in assessing the refunding efficiency of tax-exempt tender transactions, we now turn to a discussion of the second success driver of these transactions, namely, institutional investor participation levels. The investors' response to the corporate tender offers in the '70's and '80's was markedly different from the response to the recent tender offers for tax-exempt bonds (Phalon, 1977; Laber, 1978; Office of the New York City Comptroller Brad Lander, 2023). In the case of the corporate tenders, the typical acceptance ratio was around 80%. In contrast, the tax-exempt tenders attracted less than 30% participation. Let's explore the reasons for this remarkable difference.

Taxable corporate bonds are usually held in non-taxable accounts, such as pension funds and retirement accounts. For these, tax considerations are irrelevant. If the accounts are marked to the market, as is customary for institutional accounts, selling and reinvesting has negligible accounting impact. As discussed above, from the perspective of the corporation the tax-deductibility of the premium significantly enhances the economic benefit of the transaction. At the same time, for accounting purposes the premium is reported as a loss, resulting in a hit to earnings. To avoid such one-time earning impacts, methods have been devised to amortize the loss over the remaining life of the outstanding issue or over the life of the refunding issue.

Turning to municipal bonds, we note that small retail investors are unlikely to hold large amounts of 5% bonds because of their aversion to paying over par. Therefore 5% bonds are mostly held in institutional accounts and by financially sophisticated large investors. For institutional investors, accounting and tax considerations are relevant. If they sell the bond above

its current tax basis, the resulting gain is taxable (Kalotay and May, 1998).

If the tender price of a tax-exempt municipal bond is below the investor's tax basis, selling would result in a loss, and the tax savings would be beneficial. A likely obstacle in this case is the 'hold to maturity' accounting method. This is the method normally used by banks and insurance companies for their investment portfolios, as they prefer not to mark to market. Although selling at a loss would be tax-beneficial, the resulting decline of book value would be unacceptable. For this reason, 'hold to maturity' institutions don't participate in the tenders. We also observe that from the perspective of the municipal issuer tax considerations are irrelevant.

IX. Policy Implications for Municipal Debt Management

This paper has shown how generalized refunding efficiency can be used to analyze tax-exempt tender/refunding transactions by municipal issuers. Such analysis stands in contrast to the way municipal issuers often present the economics of these transactions. For example, the City of New York issued a press release on June 1, 2023 announcing the results of a recent bond issue that included a tender of its not yet callable *taxable* outstanding bonds. The portion of the press release related to the tender transactions read as follows:

> "To achieve additional savings, the City also conducted a tender process to purchase back certain outstanding (taxable) bonds from bondholders. The City received nearly 1,200 offers from bondholders during the tender process for a total of roughly $454 million, or 40% of the outstanding principal of the relevant bonds. This level of bondholder participation makes the City's tender one of the most successful tender solicitations to date in the municipal bond market.
>
> The City will purchase $353 million of the bonds offered – about 78% of the total amount offered for tender. The tender process generated approximately $26 million of total debt service savings, or 24% of the total savings achieved by the overall transaction." *Office of the New York City Comptroller Brad Lander*[22]

[22] The City of New York Announces Successful Sale of $1.56 Billion of General Obligation Bonds and Strong Results from Tender Offer: Office of the New York City Comptroller Brad Lander (nyc.gov)

The 40% participation rate of the NYC taxable tender is much greater than what we observed in the tax-exempt MWRA tender. This is unsurprising given our previous discussion detailing how taxable bonds are more suitable for tenders than tax-exempts. The press release is also revealing since it is fairly typical in how refundings for tax-exempt bonds are described by municipal issuers. While it is clearly written in non-technical terms for an average taxpayer, its entire focus is on debt service savings, without reference to what the forfeited value of the call option. The City of New York certainly realized savings. At the same time, it is also important to understand the opportunity cost of refunding today, rather than waiting until the call date.

Such reporting of debt service savings as a percentage of the total bonds refunded is typical for issuers in describing the economics of advance refunding/tendering. While referencing generalized refunding efficiency is certainly too much to expect in a press release, such analyses should be considered internally in making refunding decisions. Of course, there may be other justifiable reasons for an issuer to advance refund or tender for bonds beyond debt service savings.[23] However, such justifications should be explicit, recognizing the opportunity cost of potentially greater savings by waiting until the call date.

Improving the economic analyses of refunding transactions could be advanced by the Government Finance Officers Association (GFOA) and Municipal Securities Rulemaking Board (MSRB). Specifically, the GFOA could enhance its technical training efforts for government officials to include exposition of refunding efficiency analytics. It could also revise its debt refunding policy statement to include the use of the refunding efficiency. The GFOA should reconsider its policy statement recommending minimum PV savings thresholds (e.g., 3-5%) in making refunding decisions with a stronger push towards the use of refunding efficiency

[23] For example, the use of a different bond credit in the tendering/refunding may provide necessary additional future bonding capacity for the tendered/refunded bond credit.

approaches. Concomitantly, the MSRB could enhance its municipal advisory technical standards in certifying and regulating municipal market financial advisory professionals to include a certain proficiency in option valuation and refunding efficiency analysis. Stronger intellectual leadership from these prominent municipal finance industry groups could significantly improve the economics of municipal refunding transactions.

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