Advanced Refundings of Municipal Bonds*
(Preliminary and Incomplete)

Andrew Ang
Columbia Business School
and NBER

Richard C. Green
Tepper School of Business
Carnegie Mellon University
and NBER

and

Yuhang Xing
Jones Graduate School of Management
Rice University

May 20, 2013

*We greatly appreciate the research assistance of Karthik Nagarajan, Yunfan Gu, and Tsuyoshi Sasaki. Tal Heppenstall of Unversity of Pittsburgh Medical Center, Rich Ryffel of Edward Jones, and Paul Luhmann of Stifle Financial provided information about advanced refunding.

Abstract

Municipal bonds are often "advanced 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. If there is no uncertainty and no fees, the transaction has zero net present value. Interest expense is reduced before the call date in exchange for higher payments afterwards. Effectively, the issuer is able to borrow against future interest savings to fund current operating activities. If there is uncertainty (or fees) advanced refunding is negative net present value. The issuer pre-commits to call and provides free credit enhancement. We examine the practice empirically for a large sample of prerefunded bonds. We estimate the option value destroyed and the amount of implicit borrowing the transaction affords.

1 Introduction

New issues of municipal bonds in recent years have varied between $300 and $400 billion a year. In 2012 volume grew by 31%. A total of $376 billion of bonds were issued versus $288 billion in 2011. This increase was not due to increased investment activities on the part of municipal issuers. Only $144 billion of this volume was "new money," bonds that were issued to fund new investment projects.[1] This was actually a slight decrease from 2011. The rest went to refund existing debt, because the bonds matured, were called, or were "advanced refunded." 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]

In an advanced refunding, the municipality issues new debt at a lower interest rate than existing bonds which are 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 on the bonds, along with the call price. The transaction typically lowers the issuer's interest cost between the pre-refunding date and the date at which the bonds can be called.

The practice of advanced refunding, or "pre-refunding," outstanding bonds that are not yet callable is widespread in the municipal finance. Figure 1 shows par value amounts of different categories of municipal bond redemptions, by year. The figure shows the par value of municipal bonds that are retired at maturity, either because they were never callable or because the call was never exercised. Also shown are bonds that are 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 advanced refunding. In 2012, for example, $450 billion of municipal debt was extinguished through redemption (including $53 billion in maturing

[1] These figures were reported in *The Bond Buyer's 2012 in Statistics Annual Review*, February 11, 2013.

[2] "Refunding Rage Fuels 31% Bounce in Muni Debt," *The Bond Buyer's 2012 in Statistics Annual Review*, February 11, 2013, p. 2A.

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.

Prerefunding provides short-term budget relief, but it 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 advanced refundings as "de-fees-ance."

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. As we show in the next section, advanced 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. Ignoring the option value lost and credit enhancement provided, the transaction is effectively a swap, with zero net present value.

Thus, an advanced refunding may help the issuer avoid the need to increase parking rates or to lay off teachers and police. These may be a laudable, even urgent, priorities.

Nevertheless, the restrictions on borrowing to fund these priorities are presumably in place for equally commendable reasons, which are evidently being circumvented. Advanced refundings could be viewed as a non-transparent means of borrowing to fund operating activities.

In this paper, we describe the effects pre-refunding has on cash flows and on the present value of the issuer's obligations. Advanced refunding a bond has two effects. It destroys value for the issuer, because the issuer pre-commits to call. It also accelerates the realization of anticipated future interest savings, effectively borrowing against them. Thus, while it allows issuers to circumvent restrictions on borrowing to fund operating expenses, it does so at the expense of present value. We then empirically examine the extent of the practice and quantify its consequences. For a sample of almost 150 thousand pre-refunded bonds, we estimate the value that is destroyed by pre-refunding and the value of accelerated interest savings, or implicit borrowing, by issuers.

The paper is organized as follows. The next section illustrates the cash flow and valuation effects of advanced refundings. Section 3 describes the data and provides descriptive evidence on pre-refundings and the pervasiveness of the practice. Section 4 evaluates the quantitative consequences of pre-refunding. It describes the methods we use to price the option value destroyed through the transaction for the issuers, and provides estimates for the advanced refundings in our sample. We also estimate the present value of interest savings that are accelerated through time by means of the transaction. Section 5 summarizes and concludes.

2 The Pre-Refunding Decision

This section illustrates the effects advanced refunding has on the value of the issuer's liability, and on the pattern of cash flows associated with that liability through time.

2.1 Present Value Effects

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 at 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 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 prerefunding.

The consequences of credit risk on present values are obvious, though difficult to quantify theoretically and empirically, so we ignore them here. Keep 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.

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.

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

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

If the issuer waits until the call date, and then chooses a current refunding, it will issue new debt equal in value to the call price of \$K. If this exceeds the value of the bond at that point, V_τ, the issuer will not exercise the call option. Thus, the value of the issuer's liability today, if it is not pre-refunded will be,

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

Alternatively, the issuer can fund a trust that pays the coupon stream to the call date, and pays the $K call price at that time. Since the issuer must float new debt equal in present value to the value of the trust, the value of the issuer's net liability is simply the present value of the payments the trust will make. Thus, the issuer's liability under a pre-refunding will be:

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

The difference between these, $\hat{V}_t - V_t$, is the value that is destroyed by the advanced refunding for the issuer. Evidently,

$$\hat{V}_t - V_t = E_t^* \left\{ \max\{K - V_\tau, 0\} e^{-\int_t^\tau r(v)dv} \right\}.$$

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

2.2 Cash Flow Effects

Given that it is obvious from the above that 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.

We can illustrate these effects with a simple example. Suppose the term structure is flat at all points, and, again, ignore any default risk. To keep the exposition simple, we will 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 6 years to maturity, and the bonds are callable at $100 the end of 3 years. Let us first abstract from the optionality in the call provision for the bonds, and assume it is known with certainty that rates will remain at 4% forever.

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

$$\frac{2}{.04}\left(1-\frac{1}{1.04^6}\right)=\$10.48$$

per $100 of face value.

Unfortunately, the bonds are not immediately callable, and the issuer must choose between waiting three years to call or prerefunding now. If the issuer waits the three years to call the bonds its pays $6 for three years, and the strike price at the end of three years, financed by issuing a new 3-yr bond at 4%. The payments over the six-year horizon, the interest savings, and their present values are given in rows two and three of Table 1.

If the issuer prerefunds it must issue a 6-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 bond must be

$$\frac{6}{.04}\left(1-\frac{1}{1.04^3}\right)+\frac{100}{1.04^3}=105.55$$

The coupon payments on the new bonds will be:

$$105.55*0.04=4.22$$

The interest savings associated with prerefunding are in rows 4 and 5 of Table 1.

Notice that, because we are assuming certainty about future rates, 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 prerefunding less the savings associated with waiting to call. The prerefunding accelerates the interest savings at the expense of higher interest payments over the later years, and an higher payment at maturity.

The present values of the positive and negative flows in the last line are equal. The issuer is effectively borrowing against future interest savings associated with the opportunity to call, as well as a higher principle 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 prerefunding 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 of 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 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.

2.2.1 Uncertainty

To this point, in our example the pre-refunding is neutral in terms of present value. Suppose, however, that there is some possibility interest rates will rise over the next three years above the 6% rate on the existing debt. Then the precommitment to call must be destructive of 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 thus so are the differences through time associated with an advanced versus a (delayed) current refunding. 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 could achieve this without precommitting 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 interest 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. Of course, such a step would be more transparent as "borrowing" to the public or to any governmental entity supervisorial 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.

3 Data Sources and Descriptive Statistics

We draw data from several sources. 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, putable, 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 advanced refunded municipal bonds. The information on advanced 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.

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, SLUGS 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 886,478,744,590 dollars. We apply for following data filter for our analysis. 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 non-missing coupon rate, fixed coupon rate only with semi-annual coupon payment, non-missing information on call date, call price, proper information on CUSIP and delete obvious data errors and our final sample contains 148,961 bonds.

The sum of par value in our final sample is 454,377,469,426 dollars, which is about 51.25% of total aggregate par amount of pre-refunded bonds. Thus, our estimates of the aggregate impact of these transactions is clearly conservative. As we shall see, however, most of the loss in option value is associated with a relatively small fraction of the pre-refundings with very large par value. These large deals are presumably less likely to have missing data associated with them.

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 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. Details are provided in the internet appendix to Ang, Bhansali and Xing (2010).

Table 2 provides descriptive statistics covering all the pre-refundings in our dataset, treating the unit of observation as the CUSIP and as the "deal." 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 advanced 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 were 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.

The average time to call is 2.8 years. The distribution of time to call is of particular importance in evaluating the financial implications of the advanced 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. Figure 2 suggests this is often the case. Over 32,000 of the roughly 150,000 pre-refunded CUSIPs have less than six months to call. There are substantial numbers (35,379) of pre-refunded bonds with five or more years to call, however, and small numbers (306) with ten or more years to call.

Figure 3 shows the number of advanced refundings, the par value of advanced refundings, and the average 15-year municipal bond yield, by month, in our sample. The volume of pre-refunding activity clearly 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, on which the municipal market was heavily dependent. Over the most recent period, since our sample ended, 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 advanced refunding activity.

4 Quantitative Consequences of Prerefundings

It should be clear from the analysis above that advanced refundings destroy value for the issuer, but allow the issuer to borrow against expected future interest savings. How much value is destroyed in the typical deal, in aggregate, and in the worst deals? How much "borrowing" is going on? In this section we take some preliminary steps towards a quantitative assessment of these questions.

4.1 Lost Option Value

First, we provide estimates of the value lost to issuers from the precommitment to call in prerefundings. This requires that we calculate, for each prerefunded bond, the value of a put option exercisable at the call price and call date on a coupon bond. 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. 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 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. While this approach provides a rough idea of the magnitudes involved, our intention in future versions of this paper is to implement a two-factor model that, while necessitating numerical solution methods, can provide more realistic estimates.

We assume that the underlying call option on the bond is a European option, and that the decision to prerefund 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.

The Vasicek (1977) model assumes the short interest rate is Gaussian and mean-reverting:

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

where $W(t)$ is a Brownian motion. Under the risk-neutral measure, the short rate follows

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

where

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

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

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

The yield on a bond maturing in τ periods can then be written as linear functions of the short rate:

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

where

$$B(\tau) = \frac{1}{\kappa}(1 - e^{-\kappa\tau}),$$

$$A(t,\tau) = \frac{\gamma(t)(B(\tau) - \tau)}{\kappa^2} - \frac{\sigma^2 B(\tau)^2}{4\kappa},$$

and

$$\gamma(t) = \kappa^2 \bar{\theta}(t) - \frac{\sigma^2}{2}.$$

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 many extremely short-term instruments, so we use the three-month rate as the short-term rate. We set σ to the volatility of of the short-term rate

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

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

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

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

We can then 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:

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

and then λ_0 from the average spread:

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

using the sample analogues.

We used the entire sample period, 1996-2009, to calibrate these values. Table 3 provides the parameter values we calibrated in this manner, along with alternative values based on subperiods. The long-run mean, θ, is quite sensitive to sample period employed, since this was a period of gradually declining interest rates. (See the third panel of Figure 3.) The estimates of the option values we obtain are, in turn, quite 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.

In subsequent versions of this work we hope to augment these estimates of the option values with those from a two-factor model. The great advantage of a single-factor model in this context is that it allows us to compute option values for coupon bonds directly.

Under the Vasicek model, options on zero-coupon bonds have known closed-form solutions. 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 current date), $\tau_i, i = 1, \ldots, N$. Then we can write the value of the bond as function of the short rate as

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

Note that each zero-coupon bond price, $P[r(t), \tau_i]$ is monotonic in the short rate under the Vasicek (or any other single-factor) model. Therefore, as Jamshidian (1989) shows, we can define a critical interest rate r^* such that $V[r^*] = K$: the value of the coupon bond equals the stike 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 known close-form solution, 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.

We applied this procedure to each of the 148,961 separate CUSIPS that were pre-refunded during our sample period and for which we have the variables needed to perform the calculations. Recall that the option value that is lost by committing to call before the call date is the value of a put option on the coupon bond expiring on the call date. Table 4 provides summary information 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 is evident from the large differences between the means and medians, these distributions are extremely skewed for both CUSIPs and deals. The vast majority of advanced refundings are relatively innocuous in terms of the option value surrendered. The call option is deep in the money and/or the bond is relatively close to the call date. There are some very large and very bad deals, however. On July 7, 2005, the Triborough Bridge and Tunnel Authority advanced 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 also destroyed more value than any other bond in our sample, $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 advanced refunding deal was over $21 million. On April 1, 2007, the state of California advanced 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 the lost option value to the state is estimated by our model to be $97 million.

Table 5 shows our estimates of the total value destroyed by the prerefundings in our sample, along with some indication of how these numbers change with the parameter values. In total, the option value surrendered is less than 1% of the par value of the bonds that are prerefunded. Since there are a great many bonds, however, the losses total over $4 billion. These estimates are relatively insensitive to the parameters other than the long-run mean, θ. Most of the value lost is due to a small fraction of the transactions. The prerefundings 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, issued by big 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 50.23% and 51.70% of total par value in our sample.

There are some smaller prerefundings that destroy large fractions of the par value refunded. 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 advanced 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 advanced 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 which can only be lifted by pre-refunding all the bonds.

4.2 The Magnitude of Implicit Borrowing

Along with destroying part of the value of the issuer's call option, advanced refunding reduces interest expense to the issuer immediately at the expense of expected interest savings 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 advanced refunding will increase with the time to call. As we have seen, the typical bond is pre-refunded quite close to the call date, and so we would expect both of these quantities to be relatively small. 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 2.2 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 will reflect 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 advanced 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 advanced refunding. In any case, the official statements are available, at best, only as pdf documents on line. 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 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 per 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:

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

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 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 6 provides summary information about the cross-sectional distribution of the amount of implicit borrowing associated with the advanced refundings. It reports statistics for both individual CUSIPs and deals as the unit of observation. As is the case for lost option value, the distribution is extremely skewed. This is evident in the dramatic differences between means and medians for both deals and CUSIPs. The present value of accelerated interest deductions is only \$9,839 for the median CUSIP and \$87,876 for the median deal. The associated means are \$48,201 and \$403,235, respectively. Most of the implicit borrowing is associated with a small number of large deals. In total, the advanced refundings in our sample give issuers over \$7 billion worth of estimated accelerated interest savings. This is 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 Conclusion

The widespread practice of advanced 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. Advanced 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, and this can relieve pressure on operating budgets. Municipalities are generally prohibited from borrowing to fund operating activities. Advanced refunding can be a means of circumventing these restrictions.

Using a large sample of municipal bonds that have been advanced refunded, we estimate both the option value destroyed and the amount of borrowing implicit in the transactions. For the vast majority of refundings, both quantities are small in either dollar terms or percentage terms. The distributions of both quantities are highly skewed. Most of the value destroyed and the largest amount of implicit borrowing is associated with a small fraction of pre-refundings, typically very large ones.

Our results to this point are preliminary. They use derivative-pricing methods that are particularly straightforward to implement, although they have well understood deficiencies in capturing the dynamics of interest rates. In future versions of this work we hope to construct more accurate estimates of the option value lost with more sophisticated models. Given the underlying patterns of remaining time to call and of the par value of bond issues, which are also highly skewed, we expect the above conclusions to prove qualitatively robust.

References

Ang, Andrew, Vineer Bhansali, and Yuhang Xing, 2010, "Taxes on Tax-exempt Bonds," *Journal of Finance*, 65, 2, 565-601.

Ang, Andrew, Vineer Bhansali, and Yuhang Xing, 2011, Decomposing Municipal Bond Yields, working paper, Columbia University.

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.

Jamshidian, Farshid, 1989, "An Exact Bond Option Formula," *Journal of Finance*, 44, 1, 205-209.

Nelson, Charles R., and Andrew F. Siegel, 1987, "Parsimonious Modeling of Yield Curves," *Journal of Business*, 60, 473-489.

Vasicek, Oldrich, 1977, "An Equilibrium Characterisation of the Term Structure," *Journal of Financial Economics*, 5, 2, 177188.

Periods	1	2	3	4	5	6
Original payments (PV=110.48)	6	6	6	6	6	106
Wait to call						
payments (PV=105.55)	6	6	6	4	4	104
savings (PV=4.94)	0	0	0	2	2	2
Prerefund						
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
Difference in savings (PV=4.94-4.94=0)	1.78	1.78	1.78	-0.22	-0.22	- 5.77

Table 1
Numerical example of interest savings

	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 2
Descriptive Statistics for Pre-Refunded Bonds

	Parameter Values				
Sample period	σ	θ	κ	λ_0	λ_1
1996-2009	0.0138	0.0301	0.5416	-0.4244	-9.3883
1996-2002	0.0156	0.0373	1.1348	-0.0089	-23.2871
2003-2009	0.0146	0.0224	0.7616	-0.9987	-4.7053

Table 3
Calibrated Parameter Values

	Put Value Per $100 Par	Put Value Per CUSIP	Put Value Per Deal
Mean	0.795	28,252	236,195
Maximum	30.502	19,876,458	97,068,393
Standard Deviation	1.036	190,389	1,278,196
30% Quantile	0.053	218	582
50% Quantile	0.042	2,334	12,413
90% Quantile	2.143	45,225	410,086
95% Quantile	2.830	95,825	914,340

Table 4
Distribution of lost option value

Panel A: Aggregate Value	
Total option value lost ($ billions)	4.224
Total par value prerefunded	457.557
Percent of par lost	0.923
Total Value Lost From CUSIPs below 95% quantile	1.301
Total Value Lost From CUSIPs above 95% quantile	2.924
Panel B: Sensitivity	
Total Value Lost if θ Increases 10%	11.006
Total Value Lost if σ Increases 10%	4.349
Total Value Lost if κ Falls 10%	4.088

Table 5
Aggregate lost option value and sensitivity to parameters. All figures are in $ billions except percent of par lost.

	Implicit Borrowing Per $100 Par	Implicit Borrowing Per CUSIP	Implicit Borrowing Per Deal
Mean	1.95	48,201	403,235
Maximum	27.43	34,112,482	90,478,872
Standard Deviation	1.89	273,417	1,759,034
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
Total Implicit Borrowing	–	7,180,002,583	7,180,002,583
Total Above 95th percentile	–	4,490,941,884	4,385,278,973

Table 6
Distribution of implicit borrowing. There are 148,961 CUSIPs and 17,807 deals.

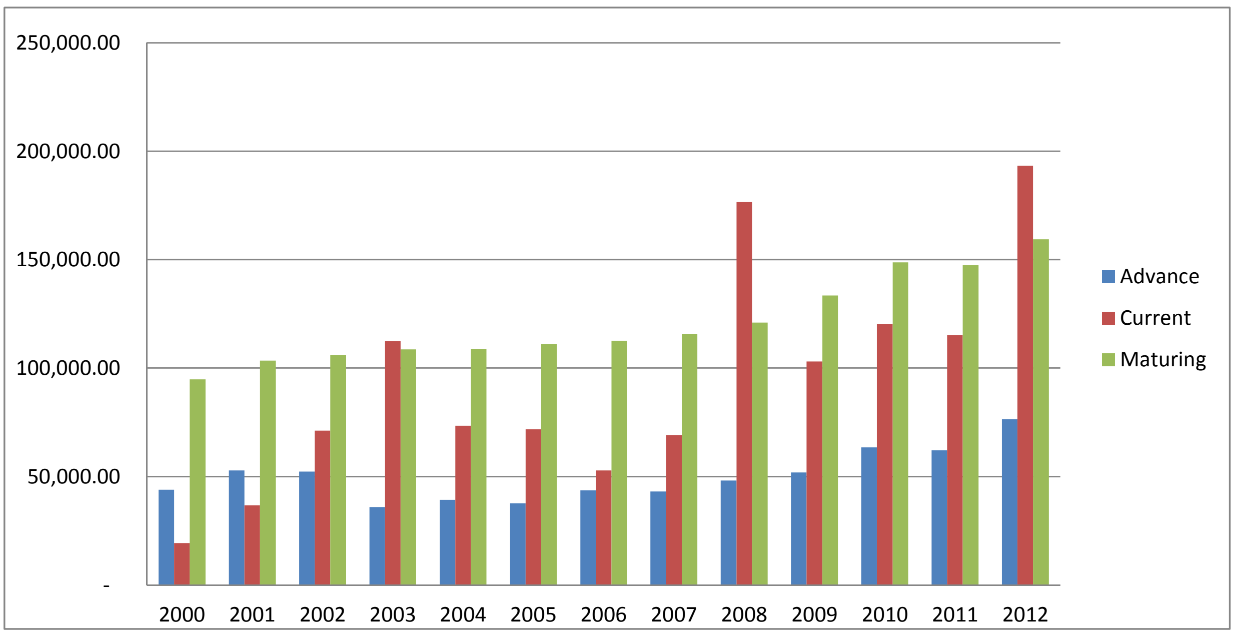

Figure 1
Redemptions of Municipal Bonds by Year. The plot shows the par value (in millions) of municipal bonds redeemed in each year through reaching maturity, through exercise of a call provision in a current refunding, and through exercise of a call provision after having been previously advanced refunded.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

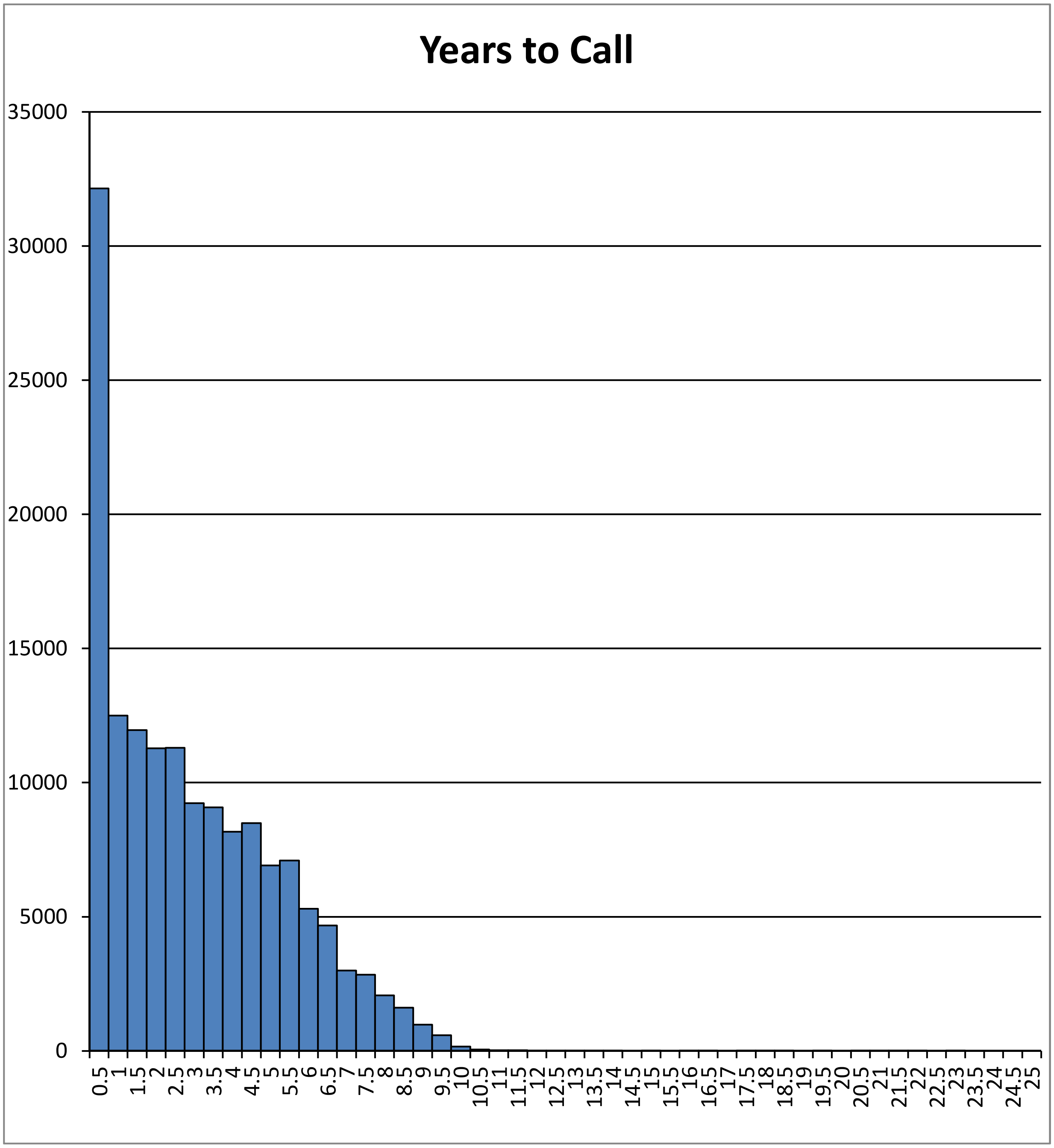

Figure 2
Years to Call Date for Pre-Refunded Municipal Bonds.

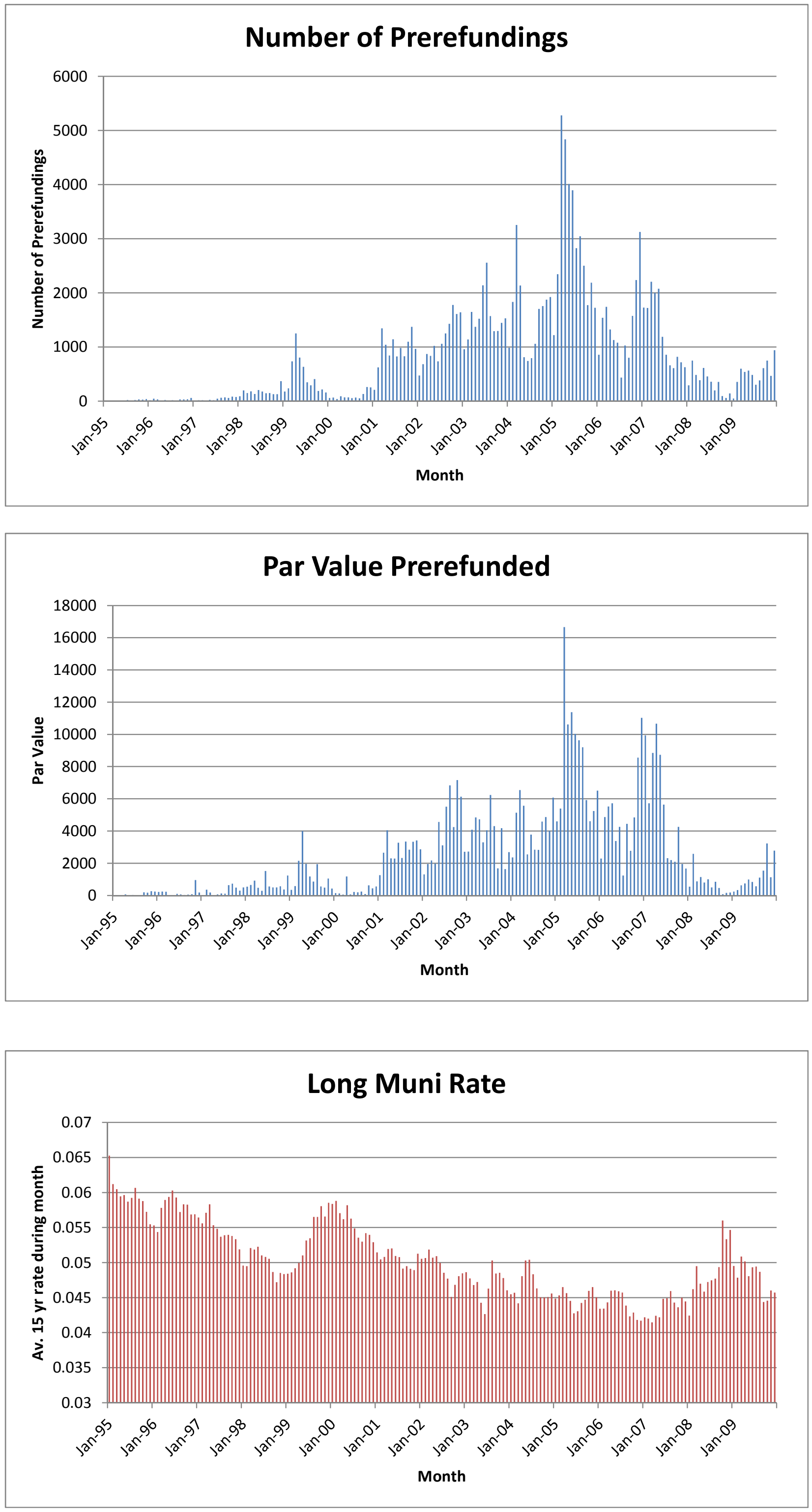

Figure 3

Volume of Advanced Refundings by Month. The plot shows the number of pre-refundings, the par value (in millions) of pre-refundings, and the average 15-year zero-coupon tax-exempt yield for each month during our sample period. The long municipal yield is from fitted zero-coupon yield curves created from MSRB transactions data.