Bond Insurance: What Is Special about Munis?

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ABSTRACT

Close to 50% of municipal bonds are pre-packaged with insurance at the time of issue. We offer a tax-based rationale for the emergence of third-party insurance of tax-exempt bonds. We argue that insurance adds value as it allows a third party to become, in a probabilistic sense, an issuer of tax-exempt securities. Insurance, however, reduces value by eliminating the possibility of a capital tax loss. While the net benefit from insurance increases with bond maturity, the benefit may not increase monotonically with default risk. We also provide empirical evidence supportive of the model's predictions.

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As with security markets everywhere, new financial products and institutional arrangements have radically altered the nature of the municipal bond market. A major development is the explosive growth in insurance for municipal bonds, in which a third-party insurer promises to step in and make timely payments to the bondholder in the event of a default. From humble beginnings in the 1980s, insurance is now commonly provided and about 50% of municipal bonds are pre-packaged with insurance at the time of issue. Insurance can also be purchased directly by investors. Our objective in the paper is to understand why it is attractive for municipalities to issue bonds bundled with third-party insurance.

We show that the demand for insuring municipal bonds can be attributed, at least in part, to an indirect form of tax-arbitrage. Critical to our argument is the fact that unlike other forms of credit-enhancement, insurance maintains the timing of payments in the event of default, and thus preserves the tax-status of the payments received by the investors.[1] Maintaining the tax status of a taxable bond is shown to be unimportant, suggesting that various forms of credit enhancement like credit derivatives and swaps, reflecting investor preferences, will tend to be used more widely in the corporate bond market.

We can characterize the tax-related impact of bond insurance in terms of two primary components. First, bond insurance adds value by increasing the expected tax subsidy associated with risky tax-exempt debt. The structure of the insurance contract enables an insurer to become, in effect, an issuer of tax-exempt securities in the event of a default. Insurance enables the capture of tax-exemption subsidies that might otherwise have been lost, increasing the size of the pie available to market participants (at the expense of the taxing authority). We refer to this as the tax arbitrage (TA) effect.

Insurance has a second type of tax effect as well, one that stems from the elimination of default risk and that can lower the potential benefits of bond insurance. Insurance results in investors no longer receiving tax loss benefits in the event of default by the issuer. There is also a corresponding decrease in the tax-exempt coupon payment associated with insured bonds. The consequence is to render the insurance less desirable. We refer to this as the capital loss (CL) effect. The combination of these two effects — tax arbitrage and capital loss — determines the tax-related costs or benefits of bond insurance. The magnitude of the tax effects and, therefore, the desirability of insurance is affected by various bond characteristics, in particular the bond's default risk and maturity.

Default risk is shown to have an ambiguous effect on the desirability of insurance. Insurance can, for instance, be valuable for some low-risk bonds, while it can be undesirable for other higher-risk bonds. This is consistent with the observation that though many low-risk bonds are insured, many ostensibly high-risk bonds (ratings of C or below) are left uninsured. It is also shown that the value added by insuring a bond is always positive for bonds of sufficiently long maturity. This is largely driven by an increase in value due to the tax arbitrage effect for longer maturity bonds. The effect of maturity on the capital loss effect is ambiguous. However, for a long enough maturity, the tax arbitrage effect dominates and insurance is always value-enhancing.

While the tax effects of insurance can add value, a reasonable question is whether these are big enough to influence the widespread adoption of insurance in the municipal bond market. Using numerical examples, we argue that for plausible parameter values, the benefits of insurance are substantial. Even in the absence of other benefits of insurance, the tax effect may be of sufficient scale to stimulate the development of the municipal bond insurance industry.

We use an extensive sample of municipal bond offerings in 2001 to test the predictions of the model regarding the effect of bond maturity and default risk on the value of insurance. Our final sample, derived from Bloomberg, consists of 108,407 bond offerings by 6,812 unique issuers. The market value of these bond offerings is $225 billion, of which 54.9% were issued as insured bonds. We find cross-sectional evidence on bond insurance to be generally consistent with the model's predictions. Longer maturity bonds have a significantly greater likelihood of being insured. Further, the relation between default risk (as captured by the bond's underlying rating)[2] is distinctly non-monotonic, with a relatively small fraction of the lowest and the highest rating bonds being issued as insured bonds. Callable-bonds and smaller-sized offerings are less likely to be insured. This is consistent with callable bonds being treated as having an effective maturity less than their nominal maturity. The presence of fixed costs in providing bond insurance may explain the lower rate of insurance among smaller issues.

While our focus is on the tax consequences of insurance, other potential benefits, such as improved diversification and liquidity, have also been proposed in the existing literature. These benefits can coexist along with the tax-related benefits, adding to the demand for insurance.[3] The diversification argument for insurance is based on the idea that bond insurers can diversify default risk better than individual investors. In terms of our evidence, the diversification argument appears to be consistent with the finding that larger issues are more likely to be insured. However, it does not appear that diversification by itself can account for the empirical findings on the effect of bond risk (non-monotonic) and maturity (increasing) on insurance.

It has also been argued that insurance can be beneficial for information-related reasons, resulting in greater liquidity for insured bonds. The notion is that uninformed traders are subject to lower adverse selection costs (in the form of price impact) when they trade insured, AAA-rated bonds. Also, to the extent that insurers might have private information about bond quality, their willingness to insure may be a signal of quality to the market. We agree that there may be benefits from the reduction in information asymmetry on account of bond insurance in both the corporate and the municipal bond markets. However, insurance provides an additional tax-related benefit for municipal bonds. Information-based arguments are also hard to reconcile with the empirical finding that relatively few higher-risk bonds are insured.

I. The Municipal Bond Insurance Market

Municipalities and other tax-exempt issuers sold a total of $285 billion (par value) of tax-exempt debt in 2001. This is very close to the all-time high figure of $286 billion in 1998. Of debt sold in 2001, 46% ($132 billion), by dollar value, was insured at *issuance*. A similarly high proportion of municipal debt has been brought to the market in the form of insured bonds in recent years - with 40%, 46%, and 51% of the bond volume insured in 2000, 1999, and 1998, respectively. These figures do not include bond insurance for seasoned bonds purchased independently by investors. The percentage of issues that are sold with insurance has increased significantly from about 3% in 1980 and 26% in 1990 to current levels. The bulk of municipal bond insurance is provided by four AAA-rated insurers.[4]

Municipal bond insurance is a third-party guarantee to pay the coupon and principal in the event of default by the issuer (i.e., failure to pay interest or principal on time). Each guarantee is unconditional, irrevocable, and covers 100% of interest and principal of the issue. The bonds that are insured inherit the AAA-rating of the insurers, though they have historically traded at yields higher than those of bonds that have a natural AAA rating, i.e., without the benefit of insurance. The timing of the payments is maintained under the insurance contracts and the insurer is responsible for making bond payments only as they come due. As discussed in the introduction, this feature of the insurance contract is crucial for the payments made by the insurer to have the same tax status as that of the payments made by the issuer. From an investor's perspective, the tax liability for payments made by the insurer are no different from those made by the original municipal issuer.[5]

Another feature of the insurance process worth noting is that insurers collect the premium upfront for providing insurance for the life of the bond. Only a small portion of the premium is, however, recognized each year as taxable income. This income is offset by losses incurred or loss adjustment expenses recognized in anticipation of losses. The remainder is recognized as an unearned premium reserve.[6] It is estimated that the average insurance premium (total) is around .5% of par value. In addition to the premium reserve, a sufficient amount of shareholder equity is required for capital adequacy requirements. The insurer's assets are largely invested in a diversified portfolio of taxable and tax-exempt fixed income securities.

Historically, defaults among municipal bonds have been less frequent than among corporate bonds.[7] However, default in the municipal bond market is not uncommon. Fitch IBCA's September 1999 special report on municipal default risk indicates that 1.5% of the par value issued prior to 1986 had defaulted by 1999. The reported default rates are subject to some downward bias, since some of the underlying bonds had not matured by 1999. The default rates reported are in line with alternative estimates that indicate that, after 1980, about 2% of the bonds issued in any given year will eventually default.[8] Defaults have been largely concentrated among Revenue bonds in some four sectors. The above default rates are for both investment and non-investment grade bonds. If the analysis is limited to only investment grade bonds, the percentage of bonds that defaulted is about 0.35% by dollar value.

Historical default rates are just one estimate of default probabilities. Another estimate is inherent in the default premium demanded by investors in holding bonds rated less than Aaa. Yawitz, Maloney, and Ederington (1985) develop and test a model that jointly estimates the implied tax rate and the default probabilities from yield spreads of municipal bonds. They estimate default probabilities to be in the range of 1.5% to 2.5%, depending on the rating and maturity of the bond. More recently the yield spreads over Aaa bonds have been on the order of 20, 40, and 60 basis points for Aa, A, and Baa municipal bonds (www.hanover.com). These are of similar magnitude to the yield premia for corporate bonds, possibly indicating anticipated default probabilities of a similar order.

To date, there have been relatively few defaults on insured bonds. To an extent this is attributable to the relatively short period that the issuance of insured bonds has been widespread – with many of the bonds that have contributed to this growth having yet to mature. The 1990s, for the most part, were also years in which state and local revenues grew strongly. Defaults have, however, tended to occur at somewhat higher rates in recent years. This is evident from the losses and the loss adjustment expenses as a ratio of premiums earned for the four largest insurers. This ratio was at an all-time high of 21% in 1998, compared to an average of 10.2% over the last 12 years.[9] In fact, in 1999 MBIA increased its premium by about 20% in light of the losses incurred in 1998.

The bond insurance market exhibits some interesting features with regard to the types of bonds that are insured. First, insurer-provided information suggests that relatively few of the riskiest bonds are insured (those with ratings of BB and below, for instance). Secondly, it appears that longer maturity bonds are more likely to be insured than similar bonds of shorter maturity. In fact, we find several instances in which an offering consists of serial bonds that are issued such that the longer maturity obligations are insured, while the shorter maturity ones are not.[10] These patterns and other issues are explored in our empirical analysis.

II. One-period Model

We first analyze the benefits of insurance in a one-period model, which is later extended to a multi-period setting to examine the role of bond maturity. The issuer, who may be tax-exempt, needs to raise \$1 at the beginning of the period and issues a par-valued bond to raise net proceeds of \$1. The bond is risky and the issuer defaults with an exogenous probability q. In the event of a default, investors may be partially compensated or may receive the promised payments after a significant delay. We denote the value of the payments made in the default state by α, where $\alpha \in [0, 1]$. Hence, while q represents default risk, α denotes the recovery rate in the event of a default. For simplicity, we will assume that investors and other market participants are risk-neutral.

The issuer has the choice of selling an uninsured bond or one that is packaged with third-party insurance with a promised coupon of c_u and c_i, respectively. The insurer is assumed to have sufficient resources to fully guarantee its liabilities. Note that given our assumption of universal risk-neutrality, insurance providers in our model have no inherent advantage in bearing risk. We assume that there is no private information, that insurers are no better than investors at monitoring or at valuing the bonds to be insured, and as is the practice, that the timing of cash-flows is maintained in the event of a default. The above assumptions allow us to focus on the tax consequences of bond insurance. In the discussion below, we allow for the possibility that an insurance provider can extract some rents and make a non-zero profit of $\varepsilon \geq 0$ per dollar of net proceeds raised. The marginal tax rate for the insurance company is denoted by τ_i.

Investors can invest in either taxable securities or tax-exempt municipal bonds and incur a marginal tax rate τ on taxable income. The return on a taxable risk-free security is r. With risk neutrality, the equilibrium expected return on risky taxable securities will also be the same. For every dollar of pre-tax cash flow, investors get $\$(1-\tau)$ of after-tax cash flow, implying that the equilibrium after-tax return required by investors is $\$(1-\tau)\,r$.

The investor's tax rate on a bond's coupon payments depends on the tax status of the issue and is denoted by τ_c. The coupon payments on municipal bonds are exempt from personal income taxes, i.e., $\tau_c = 0$ in this case. For a corporate bond we assume that $\tau_c = \tau$. The tax treatment of capital gains or losses on municipal bonds is, however, similar to that of taxable bonds. The capital gains tax rate is also assumed to be τ.[11] In the event of a default, investors have sufficient taxable income to fully utilize any capital losses to offset tax liabilities.

A. Value Enhancement from Insurance

We first derive the required coupon rate, with and without insurance. The impact of insurance is then analyzed for different tax scenarios.

The Uninsured Bond Case: We consider the case of a \$1 par-valued uninsured bond. In this case, investors receive the face value of the bond (\$1) and the promised pre-tax coupon payment unless there is default. In the default state, investors receive a pre-tax cash flow of \$$\alpha$, signifying a capital loss of $(1-\alpha)$. Thus, the after-tax cash flows received are:

$$\begin{cases} 1 + c_u\,(1-\tau_c) & \text{with probability } (1-q) \\ \alpha + \tau(1-\alpha) & \text{with probability } q. \end{cases}$$

Given that the bond has a par value of \$1 and that $r\,(1-\tau)$ is the after-tax required rate of return:

$$1 = \frac{(1-q)\,(1+c_u\,(1-\tau_c)) + q\,(\alpha + \tau(1-\alpha))}{1+r\,(1-\tau)}.$$

The above equation can be solved to obtain the required coupon payment c_u:

$$c_u = \frac{(r+q)\,(1-\tau)\,(1-\alpha)}{(1-q)\,(1-\tau_c)}.$$

The Insured Bond Case: Let the premium required by the insurance provider for insuring the bond be π. Thus, the issuer has to issue a bond with par-value $(1+\pi)$ to obtain net proceeds of \$1. Consistent with industry practice, the premium payment is made at the time of issuance. For this case the coupon will simply be given by

$$c_i = r\,(1+\pi)\,.$$

The insurance company obtains the premium at the beginning of the period and invests in (risk-free) treasury securities at the interest rate r. The expected after-tax profit, ε, of the insurance company is therefore:

$$\varepsilon = (1-q)\,[\pi\,(1+r)]\,(1-\tau_i) + q\,[\pi\,(1+r) - (1+\pi+c_i-\alpha)]\,(1-\tau_i)\,, \tag{1}$$

where τ_i is the marginal tax rate for the insurer. The two terms in the above expression represent insurer cash flows in states with and without default, weighted by their probabilities.

For a given level of expected profit (ε), the premium charged by the insurance company is given by solving (1) for π to obtain

$$\pi = \frac{\left(\varepsilon \left(1-\tau_i\right)^{-1} + (1+r) - q\alpha\right)}{(1+r)(1-q)} - 1.$$

Tax Implications of Insurance: Given that there is a single promised payment (single period bond), the effect of insurance is easily gauged by comparing promised payments, with and without insurance. The net amount raised by the issuer is kept fixed at \$1. In the default state, the cash paid by the issuer is the same, α, irrespective of insurance. In the solvent state, the issuer of an insured bond pays the higher par value of $(1+\pi)$ instead of \$1 and a lower coupon payment of c_i instead of c_u. Thus, insurance will be preferred by the issuer if and only if

$$(1+\pi+c_i) < (1+c_u).$$

Substituting for π, c_i, and c_u the inequality can be expressed as:

$$\frac{\left(\varepsilon \left(1-\tau_i\right)^{-1} + (1+r) - q\alpha\right)}{(1+r-q(1+rA))}(1+rA) < 1 + \frac{[r+q(1-\alpha)]A}{(1-q)}, \tag{2}$$

where $A = \frac{(1-\tau)}{(1-\tau_c)}$. We use condition (2) to analyze the desirability of insurance both for the taxable and tax-exempt issuers.

Case I: Taxable bond with $\tau_c = \tau$: In this case, $A = 1$. Substituting the value of A, condition (2) simplifies to

$$\frac{\varepsilon}{(1-\tau_i)} + (1+r) - q\alpha < (1-q) + r + q(1-\alpha),$$

which reduces to

$$\frac{\varepsilon}{(1-\tau_i)} < 0.$$

Hence, insurance is value-neutral for taxable bonds if the insurance company makes zero profits. It is, however, value-destroying if the insurer's profits are positive (or if there are any costs of establishing or monitoring the insurance contract).

Case II: Tax-exempt bond with $\tau_c = 0$: Substituting for $A = (1-\tau)$ in (2) and simplifying the condition for the issuer to prefer insurance reduces to

$$\frac{\varepsilon \hat{R}(1-q)}{(1-\tau_i) q\tau} + 1 - q\hat{R} - r^2 (1-\tau) < \alpha \left(1 - q\hat{R}\right), \tag{3}$$

where $\hat{R} = 1 + r(1-\tau)$. At $\alpha = 1$, the above condition can be further simplified to the following:

$$\frac{\varepsilon \hat{R}(1-q)}{(1-\tau_i) q\tau} - r^2 (1-\tau) < 0.$$

Thus, as long as ε is small enough, insurance is value-enhancing for $\alpha = 1$. However, if $\alpha < 1$ then there will exist a threshold $\widehat{\alpha}$, given by (3), such that for all $\alpha > \widehat{\alpha}$ insurance will enhance value. The restriction on $\alpha > \widehat{\alpha}$ is relaxed later in the paper. In fact, we show that insurance is value-enhancing for long maturity bonds irrespective of the value of α. The above discussion can be summarized in the following proposition.

PROPOSITION 1: *For a single-period bond, if the insurer's expected profits are zero, then insurance is (i) value-neutral for a taxable bond and (ii) value-enhancing for a tax-exempt bond for α high enough.*

Notice that the above irrelevance result for a taxable bond is independent of various parameter values. The fact that insurance is value-neutral should probably not be too surprising. Intuitively, this is just the value additivity principle at work. The insurance contract is just another security, and adding a fairly priced security to another fairly priced security (both subject to a similar tax treatment) will not, in general, add value. The same cannot be said for municipal bonds. Insurance on a municipal bond has the effect of changing the size of tax payments, and thus is not value-neutral. Note that in the above discussion, the notion of "value creation" is primarily from the perspective of the bond issuers. Under our current assumptions, the value to the issuers comes directly at the expense of tax authorities in a zero sum game between the two (given that investors and insurers make zero profits).

To understand the interaction between taxes and bond insurance, it is helpful to note that there are essentially two channels by which taxes affect the value from insurance: (i) The tax arbitrage (TA) effect, which corresponds to the increase in probability of getting a subsidy (tax-exempt payments) from the government; and (ii) the capital loss (CL) effect, which reflects the fact that since insured bonds are risk-free, there is no longer the possibility of capital tax losses. The proposition above indicates that the net impact of these two tax effects is neutral for corporate bonds, while it may be non-zero for municipal bonds. Our interpretation of the irrelevance result for taxable bonds is that credit enhancements in the corporate bond market may have little to do with tax savings and exist for reasons, such as investor risk preferences, that are not modeled in the paper.

It is relatively straightforward to understand the TA effect for a municipal bond with $\alpha = 1$. There are no capital losses and only the coupon payment c_u is missed in the event of default. Now, if the municipality sells the bond coupled with third-party insurance, it is effectively packaging another state contingent claim with its bond. This new security (the insurance contract) pays the coupon with probability q. Even though this new security is issued not by the municipality but by the insurance company, the cash flows are still tax-exempt. Thus, *insurance permits the insurance company to issue tax-exempt securities (which pay out when the bond is in a default state) without any restriction on its investment portfolio.* We refer to this added value from municipal bond insurance as the tax arbitrage effect.

It might seem that the TA effect would make bond insurance value-enhancing for any municipal bond. This, however, is not the case. To illustrate this, we discuss an example that compares the impact of insurance on a corporate bond and a similar municipal bond. First, consider a one-period corporate bond with a par value of \$1, and to highlight the difference between the two effects, assume that $r = 0$. This assumption allows us to focus on capital gains and losses. Also assume that $q = 0.5$ and that $\alpha = 0$. Thus, in the event of a default, the investor receives nothing. The coupon for a corporate bond can be calculated to be \$1. To see this, note that with a \$1 coupon, the investor's pre-tax cash flow is \$2 with probability 0.5. The post-tax cash flows are thus $\$1 + \$1(1 - \tau)$ and $\$\tau$, the capital tax loss, with equal probability. The expected after-tax cash flow is \$1, which is consistent with a bond price of \$1 and an expected return of 0. The expected tax payment by the investor is \$0. Now if the bond is insured, the value of the bond will be \$1 and the coupon will go down from \$1 to \$0, while the expected tax payment remains the same (zero). Insurance is value-neutral here since the \$1 increase in the value of the bond is offset by the \$1 cost of paying for the insurance.

This can now be compared to a municipal bond, keeping various parameter values the same. Let the tax rate, τ, be 40%. The coupon for the municipal bond, as we show, will be \$0.60. To verify this, note that the pre-tax cash flow to this bond is \$1.60, or zero with equal probability. However, the post-tax cash-flow is \$1.60 with probability 0.5 and (0.4)\$1 (value of capital loss) with equal probability. The expected post-tax cash flow is therefore \$1 – which is consistent with a price of \$1 and an expected post-tax return of 0. Interestingly, in this example, the municipal bond investor receives an expected (capital loss) tax subsidy of \$0.20. Insuring the bond will, however, eliminate this subsidy. If the bond is insured, its coupon will fall to \$0. However, to raise \$1 the municipality will have to issue a par-valued bond worth \$2 and pay an insurance premium on this bond equal to \$1. The insurance company will pay \$2 with probability 0.5 if it is to break even. Observe that the municipality is worse off as it now has to pay \$2 instead of \$1.60 in the no-default state. Consequently, as far as this capital loss effect is concerned, insurance is value-destroying for municipal bonds. This value destruction is due to the asymmetric treatment of capital losses for municipal bonds: Capital losses for municipal bonds are tax deductible, while the higher coupon payments that are required to compensate investors for the expected capital loss are tax exempt. Corporate bonds, on the other hand, have a symmetric tax treatment as far as capital losses are concerned. We refer to this disadvantage of insurance for the municipal bonds as the capital loss (CL) effect. Thus, whether insurance will add or destroy the value depends on the net impact of the tax arbitrage and the capital loss effects.

III. Multi-period Extension and Bond Maturity

In this section we analyze the effect of bond maturity and show that the results developed for a single-period setting extend to a multi-period setting. An interesting result, which we examine in our empirical analysis, is that the benefits from insurance are increasing in bond maturity.

In the case of the one-period bond, we were able to evaluate the impact of insurance by its effect on the bond's single promised payment, keeping net proceeds fixed. However, for a multi-period bond, assessing the impact of insurance is less straightforward. It would appear that, keeping net proceeds fixed, the impact of insurance would be apparent in terms of, say, its effect on bond yield. The drawback to such an approach, however, is with the different pattern of payments promised by the issuer, for issuing an insured versus an uninsured bond, for the same net proceeds. This difference in promised payments can affect the probability of default (not modeled) and thus make the conclusions doubtful. A more appropriate comparison for multi-period bonds, in our view, is to keep the issuer's promised pattern of payments fixed and to compare the money raised in the insured and uninsured cases.[12] We will, therefore, assume that the bonds are issued at par with an annual coupon payment normalized to $1.

The bonds are risky in that there is an (exogenous) probability q each period that the issuer's cash position will not be sufficient to fully service its outstanding debt.[13] As before, a default state is one in which the issuer can only pay out less than the bond's face value. Specifically, it is assumed that if default occurs, the issuer pays $\alpha \in [0,1]$ fraction of the face value of the uninsured bond; there are no further cash flows made by the issuer.[14] The assumptions on the taxability of bond payments are as in the one-period bond case. Hence, when there is default and bond value goes down, investors have sufficient taxable income from other sources to be able to offset capital losses in the same period. For simplicity, the term structure of interest rates is assumed to be flat and nonstochastic.[15] For expositional ease, we will also assume hereon that competition in the bond insurance market drives the expected profit from insuring municipal bonds to zero.

The Uninsured Bond Case: Let the price of an uninsured par-valued bond of maturity N be P_U. From the assumptions on default probability, in any period n (conditional on no default in the previous $(n-1)$ periods), there are two possible outcomes: The bond pays a pre-tax coupon of $1 with probability $(1-q)$ or defaults with probability q. In the case of default, the price of the bond goes to αP_U and thus investors get a reduction in the tax liability equal to $\tau P_U(1-\alpha)$. The post-tax payoff in period n is the following:

$$\begin{cases} (1-\tau) & \text{with probability } (1-q) \\ \alpha P_U + \tau P_U (1-\alpha) & \text{with probability } q. \end{cases}$$

The price of the uninsured par-valued bond can be written as the present value of future expected after-tax coupon and principal payments, discounted at the after-tax rate required by investors. Note that by assuming the bond to be par valued, we avoid problems having to do with amortization of capital gains over the life of the bond. Thus,

$$P_U = \sum_{n=1}^{N} \left[(1-q)^{n-1} \; \frac{(1-q)\,(1-\tau) + q\,(\tau P_U\,(1-\alpha) + \alpha P_U)}{[1 + r(1-\tau)]^n} \right] + \frac{(1-q)^N}{[1+r(1-\tau)]^N} P_U. \quad (4)$$

Solving the above equation for P_U, the price of the uninsured par-valued bond, is given by:

$$P_U = \frac{(1-q)}{(r + q\,(1-\alpha))} \; .$$

<u>The Insured Bond Case</u>: Instead of an uninsured bond, consider a situation in which the issuer packages the multi-period bond with a third party guarantee and receives a price P_I from the market. As mentioned, we would like to analyze the effect of insurance, keeping the liabilities of the issuer unaffected. A problem, however, is that if the liability of the issuer is assumed to be the same as in the case of the comparison uninsured bond ($1 every period and P_U on maturity), then the insured bond becomes a premium bond. This makes the analysis messy, with tax laws requiring the premium to be amortized over the life of the bond. To simplify the analysis, the insured bond is instead assumed to be par valued, obliging the issuer to make a principal payment of P_I at maturity. We will, however, need to make the net obligation of the issuer at maturity equivalent to P_U, the par value of the comparison uninsured bond. To do this, the issuer is assumed to put in escrow a risk-free zero-coupon (pure-discount) bond, with face value equal to the difference between P_I and P_U and a maturity of N periods. Hence, to determine the effect of insurance, net proceeds from the insured bond are compared to P_U, the proceeds from the comparison uninsured bond. From the discussion above, the net proceeds from the insured bond are obtained by adjusting total proceeds, P_I, by insurance cost (π) and cost of the zero coupon bond in escrow, denoted by P_Z.

Since the insured bond pays \$1 for certain, either from the issuer or the insurance company, the price that investors will be willing to pay is given by

$$P_I = \frac{1-\tau_c}{r(1-\tau)}.$$

The price of a zero coupon bond that pays $(P_I - P_U)$ after N periods is given by

$$P_Z = (P_I - P_U)\left(1 + \frac{1-\tau_c}{1-\tau}\, r\right)^{-N}.$$

The next lemma derives the actuarially fair premium charged by the insurance company.

LEMMA 1: *The insurance premium charged upfront is given by*

$$\pi = \frac{q\left(1 + r\left(1 - \alpha P_U\right)\right)}{r\left(q + r\right)}\left(1 - \frac{\left(1-q\right)^N}{\left(1+r\right)^N}\right) - \frac{\left(1 - \left(1-q\right)^N\right)}{\left(1+r\right)^N}\left(\frac{1}{r} - P_U\right). \tag{5}$$

Proof: See the appendix.

A. Comparing the Impact of Insurance for Taxable and Tax-exempt Issuers

The issuer's advantage from insurance in the multi-period case is represented by the additional money raised at time 0, keeping the future liabilities fixed. Thus, the advantage of insurance (ψ) is given by

$$\begin{aligned}\psi &= P_I - \pi - P_Z - P_U \\ &= (P_I - P_U)\left(1 - \left(1 + \frac{1-\tau}{1-\tau_c} r\right)^{-N}\right) - \pi. \end{aligned} \tag{6}$$

Evaluating the value of ψ for different tax parameters gives us the following proposition.

PROPOSITION 2: *If insurers earn zero expected profits, then, for a multi-period bond:*

1. *Insurance is value-neutral for a taxable bond, that is, $\psi = 0$ for $\tau_c = \tau$;*
2. *Insurance is value-enhancing for a tax-exempt bond for α high enough, that is, $\psi > 0$ for $\tau_c = 0$.*

Proof: See the appendix.

Hence, it has been shown that extending the model to a multi-period setting delivers results similar to the ones obtained in the one-period setup. Specifically, insurance is value-neutral for a corporate bond and may be value-enhancing or value-destroying for the municipal bond. Whether insurance will add or destroy value for a municipal bond depends on the net impact of the tax arbitrage and capital loss effects described earlier. We next show the effect of a bond's riskiness and maturity on the value of insurance.

B. Bond Riskiness and the Benefit from Insurance

The riskiness of the bond is captured in our setting by a higher default probability (q) and a lower rate of recovery in case of default, i.e., a lower α. The effect of α on the value of insurance is unambiguous — the higher the α, i.e., the lower the riskiness, the higher the benefit from insurance. An increase in α reduces the capital loss effect and has no effect on the tax arbitrage effect. Thus, an increase in α increases the value of insurance.

The impact of default probability is not so obvious. An increase in q affects both the tax arbitrage effect and the capital loss effect. The net effect depends on the size of the capital loss effect. In Figure 1 we plot the value of insurance as a function of q for different values of α to illustrate that the relationship between ψ and q is ambiguous. The figure illustrates that for smaller values of α, the capital loss effect is higher than the tax arbitrage effect. In these cases the value of insurance can be decreasing in q. However, if the capital loss effect is small, i.e., if α is close to 1, then an increase in q increases the probability of getting the tax arbitrage effect and hence would increase the benefit from insurance. The next proposition summarizes the above discussion.

(Insert Figure 1 about here.)

Proposition 3: *The value of insurance for a tax exempt bond is: (i) Decreasing in riskiness as measured by a decrease in recovery rate (α); and (ii) increasing or decreasing in the riskiness as measured by the default probability (q) depending on the value of α.*

In the comparative statics above, α and q were assumed to be independent. We now turn to a brief analysis of insurance benefits, when the recovery rate (α) is related to default probability. We show that the effect of riskiness on the value from insurance depends on the relationship between the two measures of riskiness, α and q. This reinforces the earlier observation that the value of bond insurance and bond riskiness need not go hand in hand.

For purposes of this discussion, consider the case in which the recovery rate α is a decreasing function of q.[16] The effect of default probability q on ψ (the net benefit of insurance) can then be expressed in terms of the total derivative:

$$\frac{d}{dq}\psi(q, \alpha(q), N, \tau) = \frac{\partial \psi}{\partial q} + \frac{\partial \psi}{\partial \alpha}\frac{\partial \alpha}{\partial q}.$$

Using the fact that ψ is increasing in α, along with the assumption that α is decreasing in q, we see from the above expression that a sufficient condition for $\frac{d}{dq}\psi(q, \alpha(q), N, \tau) < 0$ is that $\frac{\partial \psi}{\partial q} < 0$. Hence, when α and q are negatively correlated, it follows that $\frac{\partial \psi}{\partial q} > 0$ is a necessary condition for the value of insurance to be increasing in the riskiness of the bond.

We present numerical examples in Figure 2. The figure plots the value of insurance for a specific functional form, $\alpha(q) = \frac{1}{1+\Delta q}$, that characterizes the relationship between α and q. The Δ measures the sensitivity of α to q. The assumed relationship $\alpha(q)$ is decreasing in q and satisfies the boundary condition $\alpha(0) = 1$. We vary the tax rate, interest rate, the maturity, and the sensitivity of α to q in panels A, B, C, and D respectively. For all these parameters the value of insurance is initially increasing and then decreasing in the default probability q. More significantly, for almost all the parameter values plotted, the value of insurance is positive for lower levels of riskiness and negative for higher levels of riskiness. Thus, when the probability and magnitude of the default are related, it is possible for a low-risk bond to be insured while a high-risk bond is not. The next proposition summarizes the above discussion.

(Insert Figure 2 about here.)

PROPOSITION 4: *If α and q are related such that $\frac{\partial \alpha}{\partial q} < 0$, the value of insurance can be non-monotonic in the riskiness (q) and there will exist parameter values for which the value of insurance is positive for low q and negative for high q.*

The prediction above, taken at face value, is contrary to what one might expect from arguments for bond insurance based solely on investor risk tolerance or on the need for reducing information asymmetry. In our model, there are two sources of risk for bond investors. First, if the bond defaults, the investors are worse off. Second, conditional on default, a lower value of α imposes additional penalty on investors. All else being equal, an increase in q or a decrease in α will result in a riskier bond. If investor risk tolerance is the primary factor motivating insurance, one might expect the demand for insurance to be highest for the riskiest bonds. The proposition above indicates that it is possible for the value of insurance to be lower for riskier bonds, even when both sources of risk act in concert.

The result presented in the above proposition is consistent with the observation that though many low-risk bonds (say with ratings of A or higher) are insured, some higher-risk bonds (ratings of C or below) remain uninsured. This relationship is further investigated in our empirical analysis.

C. Bond Maturity and the Benefit from Insurance

The ambiguity about the benefits from insurance disappears for long maturity bonds. We can characterize the relationship between bond maturity and insurance value as follows.

PROPOSITION 5: *For α large enough, the value of insurance is always positive with bond maturity $N \geq 1$. For any $\alpha > 0$, the value of insurance is positive if bond maturity N is large enough. Further, the value of insurance is increasing in N, for N large enough.*

The above proposition indicates that for longer maturity bonds, the benefits from the insurance company making tax-exempt payments (TA effect) will dominate the capital loss (CL) effect. The intuition for the result is straightforward. Recall that in the event of a default, the insurance company maintains the payment stream promised by the issuer. Hence, for a given probability of default in some period t (say), as the maturity of the bond increases, the insurer is effectively committing to providing a longer stream of tax-exempt payments. This increases the tax arbitrage effect. On the other hand, the magnitude of the capital loss effect remains the same. Thus, it is more likely that the default will occur when the present value of the CL effect is dominated by the present value of the benefit from the insurer making tax-exempt coupon payments.

The above result is consistent with the casual observation that the longer maturity series of serial tax-exempt issues appear more likely to be insured than short maturity ones.[17] Kriz (2000) provides evidence supportive of the result presented in Proposition 5. He analyzes a sample of 521 General Obligation bonds issued between 1991 and 1997 and shows that bond insurance is more likely to be issued for long-term debt. In our empirical analysis with a much larger sample, we also provide evidence in support of the proposition.

D. The Economic Significance of Bond Insurance

An important issue that still needs to be addressed is whether the magnitude of the tax-related benefits is large enough to affect the growth of municipal insurance industry. To obtain some (rough) idea about the level of value enhancement due directly to insurance, we calculate the value of ψ for reasonable values for the various parameters. Our finding is that even for relatively safe bonds, the magnitude of the value increase due to insurance can be significant.

For illustration, consider a 30-year par-valued municipal bond with a yield of 4.9% ($r = 8\%, \tau = 39\%$), an annual default probability of 0.1%, and a payout conditional on default equal to 95% of the value of the bond. In this case, the increase in value from insurance is approximately 0.34% of bond value. For a similar bond but with a probability of default of 0.25%, the increase in value is close to 1%. For perspective, note that the value of the municipal bonds that were insured in 2001 was about $132 billion. Thus, a 0.34% increase in value creates an annual surplus of $448 million. This surplus can be compared to the operating expenses incurred by the insurance companies, to gauge whether the tax-related benefits are large enough to cover the costs of insurance provision. As it turns out, the costs of insurance provision appear to be substantially smaller than the potential surplus. For instance, the operating expense of MBIA, which had over a third of the muni insurance market, was only about $40 million in 2001.[18]

The above estimates reflect net increases in value after accounting for the negative impact due to the capital loss effect. If investors are unable to take full benefit of the capital losses, if and when they occur, the above estimates will understate the potential benefits. Further, under a regime where the capital gains tax rate is lower than the ordinary income tax rate, the actual benefit will also be higher than the above estimates.[19] We now turn to an empirical investigation of insured municipal bond offerings.

IV. Empirical Analysis

In this section we examine the empirical implications of the tax-based rationale for the insurance of tax-exempt bonds. As discussed above, the model has two main predictions. First, the model predicts that the benefit of insurance is non-monotonic in the bond's default risk. Specifically, we have shown that there exist parameters for which the benefit of insurance is initially increasing and then decreasing in the default probability. Another implication of the model is that the benefit of insurance is increasing in the maturity of the bond. Thus, we expect a higher fraction of longer maturity bonds to be insured. We provide evidence supportive of these two implications using an extensive sample of municipal bonds issued in 2001.

A. Data Description

We obtain data on tax-exempt bonds issued by all states (not including territories, e.g., Puerto Rico) in 2001 from Bloomberg. Our initial sample consists of 119,674 bonds with a unique CUSIP number. Some observations are dropped due to missing data items. Specifically, we drop observations for which information on maturity, amount issued, price at issue, or insurance status is missing. We also exclude bonds with maturity of less than 13 months. Because these short-term bonds have typically not been insured, including them will, if anything, bias the results in favor of our maturity hypothesis.

Our final sample consists of 108,407 bonds, 54.9% of which are insured. The total market value of the bonds is $225 billion. Although the number of bonds issued is large, most of the bonds are issued in the form of serial offerings that, when combined, comprise an issue. In all, we identify the total number of issues (or series) to be 11,725. Thus, on average a serial offering has about 9 distinct bonds of varying maturities. The bonds in our sample have been issued by 6,812 unique issuers, implying an average number of 16 bonds per issuer. Not all issuers issued multiple bonds and the sample has 666 issuers that issued only one bond. On the other extreme is Douglas County Nebraska Sanitation, which issued 570 bonds with unique CUSIP numbers in 2001.

The rating of an insured bond is not useful for our analysis, as it reflects the credit worthiness of the insurer and is typically AAA. For our analysis we require information on the underlying rating of insured bonds, i.e., the rating the bonds would have received in the absence of insurance. The information on underlying ratings by S&P or Moodys and sometimes by both is available from Bloomberg for many of the bonds in our sample. However, in our sample, 30,312 or 28% of the bonds are not rated by either S&P or Moodys. Specifically, 32.8% of the uninsured bonds are not rated, while 24.1% of the insured bonds do not have a rating for the underlying bond.[20]

For the purpose of our analysis we convert the agency ratings to a consistent numerical score. To get equivalence between the ratings of the two agencies we use the Bloomberg Composite of Moody & S&P Rating Scale. Non-rated bonds are given a score of 1. We create five categories for the rated bonds with the highest rated bonds getting a score of 6. The detailed classification scheme used to obtain the numerical score is provided in Table I. Most of the bonds in our sample have either a single rating or the same numerical score based on the rating from both agencies. However, about 6% of the total number of bonds have a different numerical score as per our classification scheme. For these bonds, we round up the average numerical score.[21]

(Insert Table I about here).

In Table II we report the summary statistics of bonds based on their rating category. As can be seen, the average and the median maturity are quite similar across the various rating categories and similar to the sample maturity values of 10 (mean) and 8.9 (median) years. The percentage of callable bonds is also similar across categories. The most interesting feature for our purposes is the percentage of bonds insured. The highest percentage is in the mid-range categories. More than 80% of the bonds in categories 3 and 4 are insured, while only about 8% of bonds of the highest rated category and about 47% of the non-rated bonds are insured.

This is consistent with the intuition presented in the paper. A chi-square test for equality of the proportion insured across the six rating categories is rejected with a p-value of 0.001.

(Insert Table II about here).

B. Logit Regression Analysis

We now discuss the results from the multivariate logit regression analysis. The benefit from this approach is that it allows us to simultaneously consider the effect of all variables of interest. The logit regression we estimate is based on the following model:

$$I_{Insurance} = f\left(Const, \ln(maturity), I_{Callable}, Rating, Rating^2, \ln(Mkt\ Val)\right),$$

where $f(\cdot)$ is the logit function. The dependent variable is an indicator variable with a value of 1 if the issued bond is insured and 0 otherwise. Based on our model, the coefficient of $\ln(maturity)$ is predicted to be positive. In a similar vein, all else being equal, a callable bond has a smaller expected maturity than a non-callable bond with the same nominal maturity. Thus, we expect the coefficient on the indicator variable $I_{Callable}$ to be negative. The impact of default risk on insurance, as discussed above, is predicted to be non-monotonic.

In estimating the regression models, we control for the total market value of the bond by using $\ln(Mkt\ Val)$ as one of our independent variables.[22] Although not formally modeled, if there are fixed costs to the provision of insurance, this will lower the average cost of insurance for larger offerings. Such fixed costs may result, for instance, from the cost of investigating the bond issuer. With lower average costs for insurance, larger size offerings are more likely to be issued as insured bonds – implying a positive coefficient on the independent variable $\ln(Mkt\ Val)$.

In Table III, we report the results of our logit regressions. The first column provides the regression results when we include only a linear term for the bond rating. Notice that even though the coefficients are statistically significant, relatively little of the variation is explained by the independent variables. Specifically, the adjusted R-square is only 2.4%. This is not surprising given the nonlinear relation between insurance and bond rating. To capture the nonlinearity in bond rating, we introduce the quadratic term on rating. The quadratic model, column 2, is clearly a better fit for the data. The adjusted R-square goes from 2.4% to 20.4%. As predicted by the model, the coefficient on maturity is positive (0.29) and the coefficient on the callability of the bond is negative. Both coefficients are significant at the 1% level.

(Insert Table III about here).

The coefficient on the independent variable $\ln(Mkt\ Val)$ is also positive and significant at the 1% level. This is consistent with the fixed cost argument made earlier. The data are also consistent with the prediction about the riskiness of the bond. To see this we calculate the sum of the two terms that depend on the rating, i.e., *Rating* and $(Rating)^2$. As the rating score goes from 1 to 6 the sum of these two terms is given by 2.43, 3.88, 4.35, 3.84, 2.35, and -0.12, respectively. Notice that as riskiness increases, the likelihood of insurance increases and then decreases.

As a robustness check we repeat our analysis after dropping the highest rating bonds (numerical rating 6). This is to ensure that bonds in this category, less than 8% of which are insured, do not unduly affect our results. We also examine the effect of using indicator variables for each rating category, instead of numerical scores. For example, $I_{R=2}$ is 1 if the bond has rating score of 2 and 0 otherwise. As indicated, the results we obtain are essentially similar to the results with the quadratic model. The coefficients on maturity, callability, and market value have the same sign as before and are similarly significant. The impact of ratings is easier to see in the indicator-variable model. The constant term captures the intercept for the non-rated bonds (rating score =1). As the riskiness decreases, i.e., as the rating score improves, the coefficients on the rating indicator variables first increase and then decrease.

Of the issuers in our data sample, 530 issued both insured and uninsured bonds. In all they issued 18,615 of the bonds in the sample. All other issuers issued only insured or only uninsured bonds in our sample. We refer to these issuers as the partial insurance (PI) issuers. We believe that the partial insurers are of special interest, because they seem to be making a strategic choice about which bonds to insure and which to leave uninsured. These issuers clearly have the ability to place uninsured bonds in the market and also have a relationship with an insurer that reduces any barrier to acquiring insurance. Hence, comparing the choices made by these issuers to those made by other issuers can be useful as a robustness check and may shed additional light on the economics of bond insurance.

The average PI issuer is larger than the typical issuer in our sample. The average number of bonds issued by the PI issuers is 35 compared to an average of 16 for the entire sample. Similarly, the average market value per bond for the PI issuers is $4.66 million compared to an average amount of $2.07 million for the entire sample. The number of insured bonds in the PI sample is a little less than that in the entire sample — 51% compared to 55%. The average maturity in this sample is 11 years, compared to 10 years in the entire sample.

Column 5 in the table presents results from the logit regression restricted to the PI issuers. The results are very similar to those from the entire sample. The coefficients on maturity, market value, and rating are positive while the coefficient on the squared rating is negative. The coefficients on these independent variables are significant at the 1% level. The coefficient on callability becomes insignificant in the subsample, though its sign and magnitude is similar to the coefficient in the full sample. For robustness, we repeat the analysis using indicator variables for each rating category. The results are reported in column 6. The coefficients on maturity, amount, and callability are essentially unchanged. The coefficients on the bond rating categories are smaller in magnitude but follow a pattern similar to the estimated coefficients for the full sample.

V. Conclusion

In the paper we propose a simple model to explain why municipal bonds are often issued with pre-packaged insurance. Our explanation is based on the tax exemption of municipal bonds. We have argued that there are two channels by which taxes affect the benefits from municipal bond insurance. One, the tax arbitrage effect, makes insurance valuable for municipal bonds as it allows the insurer (in a probabilistic sense) to become an issuer of tax-exempt securities. This effectively increases the size of the subsidy from the federal government. However, the tax arbitrage benefit can only be obtained if the payments made by the insurer are also tax exempt. Bond insurance, unlike other methods of credit enhancement, maintains the tax status of payments – irrespective of whether they are made by the issuer or the insurer.

The second channel is the capital loss effect, which recognizes that by insuring a municipal bond, investors are giving up on tax loss benefits and lowering the tax-exempt coupon rate. This effect reduces the benefit of insurance for municipalities. The trade-off between these two effects determines the desirability of insurance for a municipal bond. Interestingly, both effects are individually zero for a corporate bond, when tax rates on ordinary income and capital gains are equal.

We find that, all else being equal, insurance is more beneficial for bonds with longer maturities. The impact of risk on insurance benefits is, however, ambiguous. This suggests that it is possible for insurance to be value-enhancing for some low-risk bonds, while it is value-destroying for other higher risk bonds. We analyze data on insurance patterns in municipal bond offerings to test the model's predictions. Our empirical findings, based on a large sample of municipal offerings in 2001, are generally supportive of the model's predictions.

Given the significant tax benefits associated with municipal bond insurance, it is not entirely clear why the market only developed in recent years. A factor may be that the tax-exempt status of the payments by insurers may not have been fully clarified before the early 1980s. In addition, the increased riskiness of municipal debt in recent times may have increased the benefits from insurance. We hope that future research will shed more light on why the time was ripe for bond insurance.

Appendix: Proofs

Proof of Lemma 1: Let $\{\Pi_n\}_{n=0..N}$ be the unearned premium balance at the beginning of year n, which the insurance company invests in treasuries at the rate of return r. The insurance company's tax revenue recognized in period n is, $[r\Pi_n + (\Pi_n - \Pi_{n+1})]$, where the first term is the return from investment while the second is the earned premium. Assume that in case of default the insurer sets up a pass-through escrow account and funds it with Φ_n (including αP_U), thus, incurring a tax loss of $[\Phi_n - \Pi_{n+1}]$. The expected after-tax profit in period n is

$$\begin{aligned} \varepsilon_n &= \left[r\Pi_n + (\Pi_n - \Pi_{n+1}) - q\left(\Phi_i - \Pi_{n+1}\right)\right](1 - \tau_i) \\ &= \left[\Pi_n (1 + r) - q\Phi_i - (1 - q)\,\Pi_{n+1}\right](1 - \tau_i). \end{aligned} \tag{A1}$$

We assume that the tax law operates in such a way that the premium recognized is actuarially fair for all n. This combined with our zero profit condition implies that the insurance company makes zero expected profits every period. Thus,

$$\Pi_n = \frac{q\Phi_i + (1 - q)\,\Pi_{n+1}}{(1 + r)}. \tag{A2}$$

Now in period N, if the issuer does not default, the insurance company has no further liability, i.e., $\Pi_{N+1} = 0$. Therefore,

$$\begin{aligned} \Pi_N &= \frac{q\Phi_N}{1 + r}, \text{ and} \\ \Pi_{N-n} &= \sum_{j=0}^{n} \frac{(1 - q)^{n-j}\, q\Phi_{N-j}}{(1 + r)^{n-j+1}}. \end{aligned} \tag{A3}$$

We obtain the actuarially fair premium at time 0 by substituting $n = N$ in the above expression:

$$\pi = \Pi_0 = \sum_{j=0}^{N} \frac{(1 - q)^{N-j}\, q\Phi_{N-j}}{(1 + r)^{N-j+1}}. \tag{A4}$$

To calculate Φ_k we can calculate the price of zero coupon treasuries to fully fund the liability. Thus,

$$\Phi_k = 1 + \frac{1}{r}\left(1 - \frac{1}{(1+r)^{N-k}}\right) + \frac{P_U}{(1+r)^{N-k}} - \alpha P_U. \tag{A5}$$

From the above expression,

$$\pi = \frac{q\,(1 + r\,(1-\alpha P_U))}{r\,(q+r)}\left(1 - \frac{(1-q)^N}{(1+r)^N}\right) - \frac{\left(1-(1-q)^N\right)}{(1+r)^N}\left(\frac{1}{r} - P_U\right). \tag{A6}$$

∎

Proof of Proposition 2: For the corporate bond, i.e., $\tau_c = \tau$, we have $P_U = \frac{(1-q)}{(r+q(1-\alpha))}$, $P_I = \frac{1}{r}$, and $P_I - P_U = \frac{q(1+r(1-\alpha P_U))}{r(q+r)}$. Substituting in (5) and simplifying we obtain

$$\pi = (P_I - P_U)\left(1 - \frac{1}{(1+r)^N}\right). \tag{A7}$$

Substituting the above in (6) it is evident that $\psi_{\text{taxable}} = 0$.

For the municipal bond, i.e., $\tau_c = 0$, we have $P_U = \frac{(1-q)}{(1-\tau)(r+q(1-\alpha))}$ and $P_I = \frac{1}{r(1-\tau)}$. Note that the value of insurance (ψ) is continuous in α. We will show by induction that for $\alpha = 1$ the value of insurance is positive. From continuity, it will also be positive for α close enough to 1. Let $\hat{R} = 1 + (1-\tau)\,r$. For $\alpha = 1$, we can see that $\psi^{N=1}$ reduces to $\frac{qr\tau}{(1+r)(1+(1-\tau)r)}$, which is positive. Suppose ψ^N is positive. To prove that it is positive $\forall N$, we need to show that ψ^{N+1} is positive. Substituting in (6) and simplifying we obtain,

$$\begin{aligned}
\psi^{N+1} - \psi^N &= \frac{q}{\hat{R}^{N+1}} + \frac{\tau\left(1-(1-q)^{N+1}\right) - q}{(1-\tau)\,(1+r)^{N+1}}, \\
&> \frac{q}{(1+r)^{N+1}} + \frac{\left(\tau\left(1-(1-q)^{N+1}\right) - q\right)}{(1-\tau)\,(1+r)^{N+1}}, \\
&= \frac{\tau\,(1-q)\left(1-(1-q)^N\right)}{(1-\tau)\,(1+r)^{N+1}} > 0.
\end{aligned} \tag{A8}$$

∎

Proof of Proposition 5: Differentiating (6) with respect to N we obtain

$$\frac{\partial}{\partial N}\psi = (P_I - P_U)\frac{\ln(1+(1-\tau)r)}{(1+(1-\tau)r)^N} + \frac{\left(P_U - \frac{1}{r}\right)\ln(1+r) - Z(1-q)^N(\ln(1+r) - \ln(1-q))}{(1+r)^N},$$
$$> \frac{(P_I - P_U)\ln(1+(1-\tau)r) + \left(P_U - \frac{1}{r}\right)\ln(1+r) - Z(1-q)^N(\ln(1+r) - \ln(1-q))}{(1+r)^N}, \tag{A9}$$

where $Z = P_U - \frac{1}{r} + q\frac{1+r(1-\alpha P_U)}{r(q+r)}$. Now,

$$(P_I - P_U)\ln(1+(1-\tau)r) + \left(P_U - \frac{1}{r}\right)\ln(1+r),$$
$$= \left\{\frac{\ln(1+(1-\tau)r)}{(1-\tau)r} - \frac{\ln(1+r)}{r}\right\} + P_U\left(\ln\left(\frac{1+r}{1+(1-\tau)r}\right)\right) > 0. \tag{A10}$$

The first term is positive as $(1+x)^{\frac{1}{x}}$ is decreasing in x for $x < 1$. If $Z < 0$ then $\frac{\partial}{\partial N}\psi$ is always positive. However, we show below that that is not the case.

$$Z = P_U - \frac{1}{r} + q\frac{1+r(1-\alpha P_U)}{r(q+r)},$$
$$= \frac{1}{(q+r)}\left[\frac{(1-q)}{(1-\tau)(r+q(1-\alpha))}(q(1-\alpha)+r) - (1-q)\right],$$
$$= \frac{(1-q)}{(q+r)}\left[\frac{1}{(1-\tau)} - 1\right] > 0. \tag{A11}$$

The numerator of the expression in (A9) is increasing in N. Thus, if it is positive for some N, then it is positive for all higher N. However, if the numerator is negative for some small N, then, ignoring the integer problem, there has to exist some N_L such that the numerator is equal to zero at $N = N_L$. This is due to the continuity of the above expression in N combined with the fact that for $N \to \infty$, the above expression is positive. Thus, for all $N > N_L$, $\frac{\partial \psi}{\partial N}$ is positive. ∎

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Table I
Classification of Bond Ratings

Bond ratings are converted to a consistent numerical score. To get equivalence between the ratings of the two agencies we use the Bloomberg Composite of Moody & S&P Rating Scale. Non-rated bonds are given a score of 1. We create five categories for the rated bonds with the highest rated bonds getting a score of 6.

S&P Ratings	Moodys' Ratings	Numerical Rating
Not rated	Not rated	1
Below BBB+	Below Baa1	2
A-, BBB+	Baa1, A3	3
A+, A	A, A1, A2	4
AA, AA-	Aa2, Aa3	5
AA+, AAA	Aa, Aa1, Aaa	6

Table II
Summary Statistics on Rating Categories

Shown here are descriptive statistics on bonds classified by the rating categories as per Table I. Maturity is the bond's time to maturity in years; Total market value is the sum of the market value of the bonds at the time of issue in billions; Percent Callable and Percent Insured is the fraction of bonds callable and insured respectively.

Rating Category	Average Maturity	Median Maturity	Std. Dev. Maturity	Number of Bonds	Percent Callable	Total Market Value	Percent Insured
1	9.6	8.3	6.3	30,312	47.8%	30.6	47.0%
2	11.0	9.5	7.3	1,915	45.6%	5.3	63.8%
3	9.9	9.0	6.1	10,040	42.6%	19.0	83.9%
4	9.9	8.8	6.2	26,683	44.9%	47.7	82.1%
5	10.2	9.1	6.3	25,242	42.5%	76.9	49.8%
6	10.7	9.2	7.3	14,215	45.4%	45.3	7.97%
Total	10.0	8.9	6.5	108,407	45.0%	224.8	54.9%

χ^2 test for equality of the proportion insured is rejected at p=0.001

Table III
Logistic Regressions on Likelihood of Insurance

The dependent variable has a value of 1 if the issued bond is insured and 0 otherwise. The independent variables are: *Ln(Maturity)*, the log of the bond's time to maturity in years; *Callable*, which is 1 if the bond is callable and 0 otherwise; *Rating*, a numerical score between 1 and 6 as per Table I; *(Rating)*^{2}, the square of variable *Rating*; *Ln(Mkt. Val.)*, log of the market value of the bond at the time of issue; and $I_{R=j}$, which is 1 if the bond has a numerical rating score of j as per Table 1 and 0 otherwise. Equation (3) is estimated excluding bonds in rating category 6. Equations (5) and (6) are estimated using bond issues where the issuer has issued both insured and uninsured bonds in the sample (partial insurance).

	1	2	3	4	5	6
Constant	-1.62	-5.66	-5.84	-3.27	-1.77	-0.82
	(0.05)**	(0.07)**	(0.07)**	(0.06)**	(0.15)**	(0.13)**
Ln(Maturity)	0.25594	0.2897	0.2846	0.30	0.36	0.37
	(0.013)**	(0.015)**	(0.015)**	(0.015)**	(0.03)**	(0.033)**
Callable	-0.40	-0.44	-0.47	-0.46	-0.04	-0.04
	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.05)	(0.05)
Rating	-0.18	2.92	2.87		1.01	
	(0.00)**	(0.02)**	(0.03)**		(0.05)**	
(Rating)^2		-0.49	-0.49		-0.20	
		(0.00)**	(0.01)**		(0.01)**	
Ln(Mkt. Val.)	0.16	0.22	0.24	0.23	0.07029	0.06
	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**
$I_{R=2}$				0.52		-0.41
				(0.05)**		(0.11)**
$I_{R=3}$				1.62		0.04
				(0.03)**		(0.07)
$I_{R=4}$				1.49		-0.17
				(0.02)**		(0.05)**
$I_{R=5}$				-0.21		-0.79
				(0.02)**		(0.05)**
$I_{R=6}$				-2.76		-2.44
				(0.03)**		(0.06)**
Pseudo R^2	0.0244	0.2042	0.1157	0.2074	0.1002	0.1059
Observations	107,460	107,460	93,354	107,460	18,615	18,615

Numbers in parentheses are standard errors. $p < 0.01$:**; $0.01 < p < 0.05$:*

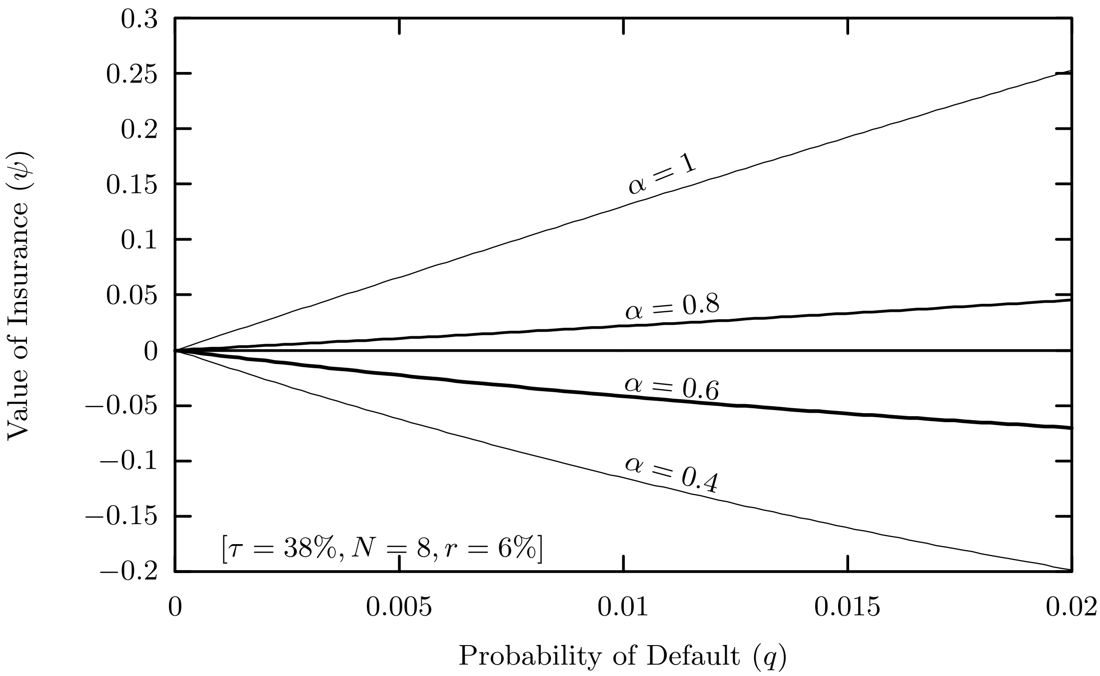

Figure 1. Value of insurance as a function of q (with α constant). The figure plots the value of insurance as a function of the probability of default, q, holding the recovery rate, α, constant at 0.4, 0.6, 0.8, and 1.0, respectively. The parameter values used are as follows: The tax rate is 38%, maturity is 8 years, and the pre-tax rate of return is 6%.

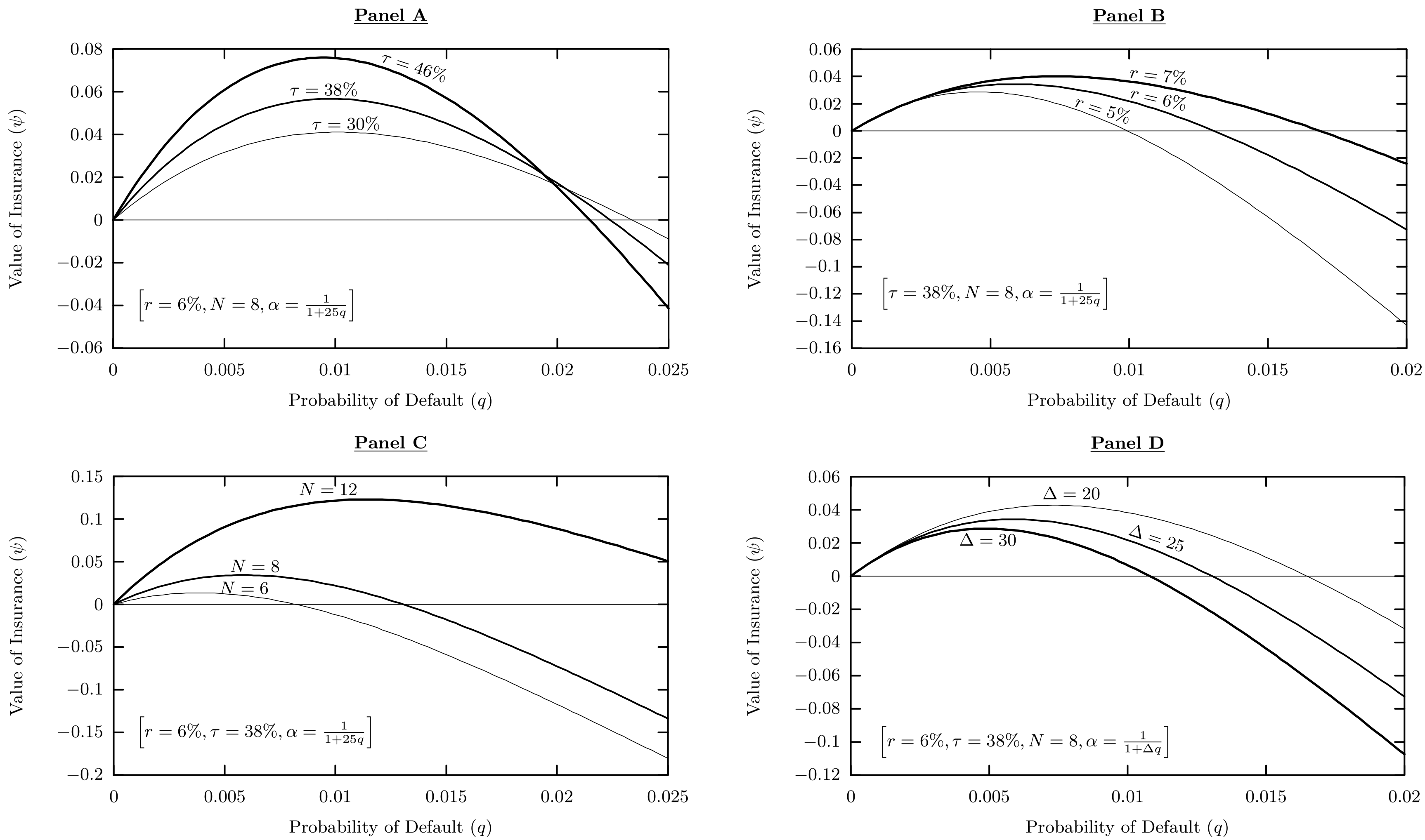

Figure 2. Value of insurance as a function of q (with $\alpha = \frac{1}{1+\Delta q}$). The figure plots the value of insurance as a function of the probability of default, q, with the recovery rate, α, dependent on q. Specifically, $\alpha = \frac{1}{1+\Delta q}$. The tax rate is varied in Panel A, the pre-tax rate of return is varied in Panel B, the maturity is varied in Panel C, and the dependance of α on q is varied in Panel D. All parameters kept constant are specified in each panel.

Notes

[1]Cash flows from credit derivatives and other forms of credit enhancement will not be tax-exempt, as they generally do not maintain the timing of the bond's promised cash flow (Miller (2002)).

[2]While insured bonds are typically rated AAA, information on the bond's underlying rating is available for many of the insured bonds.

[3]Our discussion on these alternative explanations draws upon Angel (1994). Much of the other existing work on the subject has focused on determining the magnitude of the issuer's savings from bond insurance. For example, see Bland (1987), Braswell, Nosari, and Browning (1982), Hsueh and Chandy (1989), Kidwell, Sorensen, and Wachowics (1987), Nathans (1992) and Quigly and Rubinfeld (1991).

[4]The insurers are Ambac Assurance Corp., MBIA Insurance Corp., Financial Guaranty Insurance Co., and Financial Security Assurance.

[5]As stated in the boilerplate disclosure form provided by Ambac Assurance: "Upon payment of the insurance benefits, the insurer becomes the owner of the obligation, appurtenant coupon, if any, or right to payment of principal or interest on such obligation and will be fully subrogated to the surrendering holder's rights to payment."

[6]When a bond is refinanced or advance refunded, the issuer is immediately able to earn the entire unearned premium.

[7]There are some spectacular stories of default in the municipal market as there are in the corporate market. For example, Heartland Advisors' municipal bond fund lost about 70% of its value in October 2000 when it was discovered that 27 bonds in its portfolio of 54 bonds had either defaulted or were close to doing so (Joe Mysak (11/30/2000), Online column, Bloomberg.com).

[8]From the Bond Investors Association of Miami Lakes, FL, as reported in the *Cincinnati Post*, December 20, 1994. For studies of default rates, see Cohen (1989), Fons (1987), Yawitz, Maloney, and Ederington (1985) and Yavitz (1977). Cirillo and Jessop (1993), in a well-known study, show that of all the tax-exempt bonds that were issued from 1980 to 1991, about 2.12% of the total dollar amount had defaulted up to 1991. If the sample were restricted to only rated bonds the percentage is only 0.27%. However, the study has two major shortcomings in our view. First, it does not allow sufficient time for bonds issued in later years to age. The default rate for the bonds issued from 1980 to 1986 is significantly higher than for those issued from 1987 to 1991. Second, the study does not include any of the insured bonds that defaulted during the period and the insurance company took over the payments. Thus, the default rate is biased downward.

[9]The source for this is the Fitch IBCA special report on municipal default risk, September 15, 1999.

[10]A serial bond is very similar to a bond with a sinking fund. It is in effect a series of bonds that, while issued together, have different maturities, identified by their serial numbers. An instance is that of the $110 million serial bond issue: The City of Seattle, Washington Water System Revenue Bonds, 1999, Series B. In this offering, bonds with maturities greater than 15 years were insured, while the rest were not. We provide additional examples in footnote 17.

[11]This assumption is consistent with the tax rates in effect during the years (1986 to 1994) in which the size of the insured-municipal-bond market grew rapidly. In recent years, the capital gains tax has once again been lowered. It can be shown that a reduction in the capital gains tax rate can only increase the value of insurance.

[12]Either approach yields equivalent results for the one-period case.

[13]The constant probability of default makes the analysis tractable, but does not capture elements that one may wish to model, e.g., if one wanted to model the probability of default as increasing with the age of the bond.

[14]An equivalent assumption would be that in a default, the value of the bond falls to $\$\alpha P_U$ and there are no further defaults.

[15]The assumption of a flat and nonstochastic interest rate makes the model quite tractable. If the interest rate process is assumed to be stochastic, this should not affect the qualitative nature of our results. Previous work has identified that the term structure of municipal bonds exhibits some special properties. For example, it is always upward sloping, and the implied tax rates on the longer maturity bonds are significantly smaller than those implied by short-term bonds. For a model explaining this phenomenon and other related literature, see Green (1993).

[16]There is, for instance, empirical support for such a relation between default probability and recovery rates in the case of corporate bonds (Altman et al. (2002)).

[17]For example, all series maturing from 2001 to 2016 of the City of Seattle, Water System serial Revenue Bonds issued in October 1999 were left uninsured, while all bonds maturing in 2017, 2019, 2023, and 2029 were insured by FGIC. A similar arrangement was made by the City of Seattle for their October 1999 Drainage and Wastewater Revenue bonds (MBIA) and the June 1999 Water System Revenue bonds (FGIC). State of Nevada provides another example of only long-term bonds being insured in its $129 million par value serial GO bonds (November 1995 issue), which had maturities ranging from 1997 to 2025. Of these, only $40 million of bonds maturing in 2025 were insured by FGIC to get a AAA rating. The rest were left uninsured and got a rating of AA (S&P) and Aa (Moody's).

[18]The total operating expense of the financial guarantee division was $80 million. Less than half of the business of this division was in insuring municipal bonds. The company claims that the operating expenses for its international insurance business are proportionately higher.

[19]The estimates will also be higher if a range of possible default types are considered and the likelihood of a long term default is small relative to short-term defaults (as is the likely case for munis).

[20]It is interesting to note that a larger fraction of insured bonds have an underlying rating compared to the uninsured bonds, even though the bonds are insured at issuance. We speculate

that the insurers might be using the rating to set insurance premiums. If indeed that is the case, it diminishes the importance of certification as a rationale for insurance.

[21]As a robustness check, we repeat the analysis by using the lower and higher rating and get qualitatively similar results.

[22]The results are robust to using par value in place of bond market values.