The municipal puzzle: a review of the literature

By

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S.B. Economics, Massachusetts Institute of Technology, 1997

Submitted to the Sloan School of Management in Partial Fulfillment of the Requirements
for the Degree of

Master of Business Administration

at the

Massachusetts Institute of Technology

June 2002

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ABSTRACT

Numerous papers have explored the pricing of municipal bonds relative to taxable instruments. An emerging theme of this literature is the persistently steep municipal term structure, and its incompatibility with prevailing notions of capital market equilibrium. This contradiction is known as the Municipal Puzzle.

In this thesis, we critically assess the various theories advanced so far to explain the municipal puzzle. After considering the evidence, we identify the tax avoidance theory as being on balance the most likely candidate. The thesis then develops a helpful variation on the original tax avoidance view developed by Green. In addition, we propose a theoretical framework to overcome the apparent incompatibilities between the opportunity for tax avoidance and overall asset market equilibrium.

Thesis Supervisor: John C. Cox
Nomura Professor of Finance
Acknowledgements

“We see no upside in furthering the education of a future competitor.”

Head trader, municipal swap desk

I would like to acknowledge the helpful attitude of the bank’s municipal swap desk. Their refusal to provide data has simplified my work tremendously.

On a more serious note, I would also like to extend thanks to my all my friends and family. Their warmth and support have sustained me throughout my work. Lastly and most importantly, I am indebted to Prof. Cox, my thesis advisor. Without his interest, insight, and patience, I would not have taken on this project, let alone brought it to fruition.
Introduction

The municipal bond market is a natural setting in which to examine the effect of taxes on the pricing of financial assets, in particular the pricing of fixed income securities. While the literature on this topic ranges from the highly theoretical to the completely empirical, almost every author takes as his starting point Merton Miller’s seminal 1977 paper “Debt and Taxes”. In it, Miller lays out the first coherent theoretical framework that connects the relative pricing of taxable and tax exempt bonds to the economy’s overall asset market equilibrium. In particular, he focuses on how taxable firms and individuals, through their value maximizing behavior, drive relative asset pricing. Most of the subsequent literature concerning the relative pricing of municipals has focused on testing the implications of Miller’s paper against empirical facts. While the evidence is not uniform, most authors find that long-term municipal yields are much higher than what Miller’s framework would predict, relative to taxable yields. This discrepancy, while well documented, remains without a definitive explanation and has come to be referred to as the “municipal puzzle”.

The goals of this paper’s goal are to (1) review the theory and empirical evidence that give rise to the muni puzzle (2) review and evaluate the various explanations that have been offered (3) offer a synthesis of existing knowledge and some suggestions for further research.

In our first section, we review the theoretical framework laid out in the Miller paper. We cover this in some detail as we wish to convey to the reader just how
intuitively and theoretically appealing Miller’s model is. The model’s coherence and intuitive appeal makes it clear why it remains the basic theoretical tool for analyzing the municipal term structure, despite its inability explain some basic empirical facts.

In the second section, we review what the basic empirical evidence tells us about Miller’s hypothesis. The contradiction between some of this empirical evidence and the Miller model has fueled much of the subsequent literature.

In the third through seventh section, we review and evaluate various explanations offered to resolve the muni puzzle. We have sorted these hypotheses into broad categories while also trying to roughly follow the literature’s chronological development.

The eighth section argues the tax avoidance hypothesis is the most likely candidate for explaining the muni puzzle. The ninth section attempts to overcome some of the difficulties of fitting this hypothesis into overall asset market equilibrium. The conclusion proposes a synthesis and suggests directions for future research.

1 Miller Paper Summary

Merton Miller’s seminal “Debt and Taxes” paper, written in 1977, is the starting point for most of the literature on the pricing of municipal bonds relative to taxable instruments.

Miller sets out to resolve a corporate finance problem arising from the Miller-Modigliani framework he helped create. In the process of explaining this problem
however, he finds that corporate financing decisions are intimately related to equilibrium spreads between taxable and tax exempt debt.

In the original Miller Modigliani framework, capital structure is irrelevant to firm valuation. This is a powerful result, but it relies on some unrealistic assumptions, first and foremost being the absence of taxes. Once corporate taxes enter the picture, it is apparent that debt financing will be cheaper than equity on an after tax basis. The gains from leverage are offset by the potential costs of reorganization in bankruptcy. The resulting equilibrium is one where each firm determines its optimal capital structure based on the idiosyncratic characteristics of its reorganizations costs. There are no obvious interactions between firm’s individual corporate financing decisions and the spread between taxable and tax exempt debt.

Miller’s argument adds personal taxes to the overall framework for understanding the interaction between corporate financing decisions and asset market equilibrium. A firm with $1 of operating income (income net of all operating expenses, but not of financing costs) can choose between two ways to distribute this income to its capital providers.

If the $1 is distributed in the form of interest payments to bondholders, then net proceeds to the capital provider will be:

\[ $1 \left(1 - \tau_p \right) \]; where \( \tau_p \) is the personal tax rate of the bondholder
Note this outcome is a direct result of the deductibility of interest payments for corporate income tax purposes. Interest payments allow corporations to move $1 from the corporate income tax return to the individual's income tax return.

If, instead of paying out the $1 to bondholders, the corporation chooses to "earn" that income and distribute it subsequently to shareholders, the net proceeds to shareholders will be:

\[ $1 \left( 1 - \tau_c \right) \left( 1 - \tau_e \right) \]\n
where \( \tau_c \) is the corporate income tax rate and \( \tau_e \) is the tax rate paid by individuals on equity income.

Note that while \( \tau_c \) is relatively straightforward (it would currently equal 35% for almost all reasonably sized corporations), \( \tau_e \) is ambiguous because the rate at which equity income is taxed depends on how and when it is distributed to shareholders. Distribution through current dividends results in \( \tau_e = \tau_p \), whereas distribution through capital gains (or share repurchases) implies a far lower value for \( \tau_e \). Not only is the statutory tax rate for capital gains much lower than the statutory tax rate on dividends, but because capital gains taxes need only be paid when realized, the effective tax rate on equity income realized through capital gains can be considerably below the already less onerous statutory tax rate on capital gains. Miller and most of those following him therefore assume that the effective tax rate on equity income is zero. If we believe this to be true, then the value of a $1 of equity income will be:

\[ $1 \left( 1 - \tau_c \right) \]
If the above assumptions fully and accurately describe the differences between debt and equity financing, debt will be the cheaper source of capital as long as the following holds true.

\[(1 - \tau_p) > (1 - \tau_c)\]

In other words, additional debt financing is optimal so long as bondholders face a lower tax rate than the corporation itself. In a world of progressive personal income taxes, bondholders will of course face different personal tax rates, so what will matter in practice will be the tax rate faced by the marginal bondholder. In equilibrium therefore, it must be the case that:

\[(1 - \tau_p) = (1 - \tau_c),\] so the marginal bondholder is the one whose personal income tax rate equals the corporate income tax rate.

How does all this tie into the spread between tax exempt and taxable interest rates? Thus far, we have examined the situation from the perspective of the corporation, which obtains capital from the source with the lowest marginal after tax cost.

We now consider the situation from the perspective of an investor, who allocates his dollars to the asset class with the highest marginal after tax return. This investor faces the following options when investing in taxable vs. tax-exempt securities:
The net return from investing in taxable bonds is $r_T (1 - \tau_p^i)$, where $\tau_p^i$ is the personal tax rate of investor $i$, and $r_T$ is the pretax yield on taxable instruments.

The net return from investing in tax-exempt bonds is $r_M$, where $r_M$ is the yield on municipal (i.e. tax exempt) instruments.

Thus, the rate that needs to be paid to entice investor $i$ into the taxable market is given by:

$$r_T^i = \frac{r_M}{1 - \tau_p^i}$$

The marginal investor, $m$, will set overall equilibrium such that:

$$r_T^m = \frac{r_M}{1 - \tau_p^m};$$

hereafter, we refer to $\tau_p^m$ as the implied tax rate (ITR), which is calculated as the yield ratio of otherwise identical par\(^1\) taxable and tax exempt bonds.

We saw earlier that debt financing is optimal for corporations so long as the tax rate of the marginal bondholder is below the tax rate of the corporation. Combining this fact with the equation above, we can see that if there is to be an equilibrium in the taxable market, it must be the case that:

$$\tau_p^m = \tau_c$$

where $\tau_p^m$ is the tax rate faced by the marginal holder of taxable bonds.

\(^1\) Using par bonds allows us to ignore complicating factors, such as the tax treatment of discounts and premia on municipal bonds
Given a market equilibrium situation, the pricing of taxables versus tax-exempt bonds will be given by the equation below:

\[ r_T = r_M / (1 - \tau_c) \]

The yield ratio between taxables and tax-exempts is thus fully determined by the corporate tax rate, and is independent of supply/demand effects. In essence, corporations, through their capital structure decisions, arbitrage away any difference between their own income tax rate and that of their marginal bondholders.

While this model excludes many potentially important risks (notably default) and transactions costs (notably issuance related agency costs), it has the advantage of describing municipal yields in the context of overall asset market equilibrium. Even those authors who try to disprove some of the model's predictions use the basic notions developed by Miller. In particular, the notion that, in the absence of transaction costs, the ratio of taxable to tax-exempt yields will reflect the tax rate of the marginal bondholder is a common thread in almost every subsequent paper.

2 Basic Empirical Facts

2.1 Intermediate and long term yield ratios

Trzcinka (1982) examines the yield ratio of long term corporate and municipal bond indices, and finds that it is nowhere close to what the Miller hypothesis suggests. The corporate tax rate at the time was 48%, suggesting a yield ratio of 52%. In fact, over his 1970-1979 sample period, Trzcinka's observes yield ratios that vary between 40 and 30%. He also notes that the implied tax rate falls uniformly with maturity. While
Trzcinka’s indices may only imperfectly adjust for maturity and risk differences between municipals and corporates, the preliminary evidence is not encouraging for the Miller hypothesis’ ability to explain intermediate or long term yield ratios. Van Horne (1978) finds similar, though less systematic results for yield ratios in earlier sample periods.

2.2 Short term yields

Jordan and Pettway (1985) focus their attention on computing the implied marginal tax rate for short term yields. Specifically, they compare yields on taxable and tax exempt money market funds. Although the funds have somewhat different maturities and risk profiles, due to investment policy restrictions, the authors find that without making any adjustments, the implied marginal tax rate (44%) is very close to the prevailing corporate tax rate at the time of the study (46% during 1982-1983). After adjusting for risk through better data selection, they find an implied tax rate that is almost identical (46.3%) to what Miller’s theory would suggest.

3 Market Segmentation by Maturity

Preliminary evidence suggests that while the Miller model does a good job of explaining short term yield ratios, implied marginal tax rates at longer maturities are much lower than the model would suggest. A natural response to this difficulty is to posit a form of market segmentation where investor groups that are marginal at longer maturities face lower tax rates than those investors that are marginal for short term bonds. This is precisely the approach taken by Kidwell & Koch (1983) and many others. They propose a model of market segmentation where the supply of municipals is fixed in each maturity band, irrespective of yield differentials. They justify this assumption by pointing
out that most municipalities are obliged to operate on a balanced budget. In other words, while they can issue short-term debt in anticipation of short-term revenue (such as real estate tax payments), short term paper cannot be used to fund long-term projects. Conversely, long-term debt cannot typically be used to fund operating budget deficits without a constitutional amendment or referendum.

These restrictions effectively segment the supply of municipal debt into distinct maturity buckets. However, as the authors point out, segmentation must be effective on both the supply and demand side of the market for equilibrium prices to respond. If only supply is segmented, security purchasers will simply shift their portfolios to take advantage of (and correct) yield discrepancies as they arise. Kidwell & Koch argue that commercial banks have a strong preference for short-term issues, because of their need to match the duration of their assets with the duration of their mostly short-term liabilities. Hence, the authors argue, commercial banks incur interest risk when investing in long-term municipals, and consequently require a large risk premium to hold these securities. In this framework, the quantity bonds purchased by banks at intermediate/long maturities is very inelastic, and they are non-marginal investors. Instead, the marginal investors are individuals, who purchase the residual amount of bonds not bought by commercial banks. Because the amount of municipals purchased by commercial banks falls with maturity, yields must rise with maturity in order to induce individuals with lower and lower tax rates to enter the municipal market. This situation produces a profile of ITRs that falls with maturity.
While this argument may have had some validity in the 1980's, prior to the development of the swap market, it is difficult to see how it applies today. Indeed, banks can manipulate the duration of their liabilities through the derivatives market, so that it matches the duration of whatever asset they wish to purchase. As term premia in the taxable swap market have almost always been lower than the term premia of the municipals curve (Brooks, 2001), it cannot be argued that the costs of this hedging operation would be sufficient to discourage banks from undertaking it. Thus, it seems Kidwell & Koch’s market segmentation hypothesis cannot explain the persistence of low implied tax rates at long maturities in the context of today’s more liquid hedging markets. While their paper finds descriptive relationships that are compatible with market segmentation, we believe these are not strong enough to outweigh the model’s theoretical shortcomings.

4 Differential Default Risk

Trzcinka (1982), in addition to noting the unexpectedly low long term implied tax rates, develops an explanation for this puzzle which relies on systematic risk differences between municipals and corporates. He argues that municipal bonds are intrinsically riskier than corporates of the same rating. Rating agencies, he contends, do not attempt to measure default risk uniformly across municipals and corporates, but instead focus on maintaining rating comparability only within these categories. As evidence, he cites the fact that events that should have lowered default risk for all municipals (such as the Revenue Sharing Act of 1972) did not provoke a wholesale upgrade of municipal issuers. In this particular instance, the Act caused an observable decline in the yields of municipal
bonds within a given rating category, suggesting that ratings were not adjusted to reflect the reduced likelihood of default. Admitting the possibility of a systematic risk difference, the author goes on to argue that tax exempts are likely to be riskier than comparably rated corporates because (1) municipal assets cannot be seized in bankruptcy, (2) municipal financial statements are less informative than corporate ones and (3) the political factors that influence a municipal borrower are more difficult for bondholders to understand than the shareholder wealth maximization motive that guide a corporate debtor.

The author undertakes testing this hypothesis by regressing municipal yields on comparably rated taxables. The estimated equation is:

\[ r_M^t = \alpha^t + \beta^t r_T^t + \varepsilon^t \]

Trzcinka's basic hypothesis is that the intercept represents the premium required to compensate investors for the additional risk of municipals relative to similarly rated corporates of a particular maturity. Assuming this risk premium follows a random walk, he estimates the slope coefficient using a random intercept technique. The estimated slope coefficient represents the marginal tax rate facing investors for maturity t. The estimates of \( \beta \) are generally close to 52%, and in no case is the author able to reject the \( \beta = 52\% \) null hypothesis at the 5% confidence level. He also finds that estimates of \( \alpha^t \) rise with maturity. These results are generally supportive of the Miller model. However, the paper's theoretical grounding appears in need of some clarification. It is not obvious, for example, why the muni/corporate risk gap should rise with maturity. In addition,
subsequent authors call into question the very premise that municipals should be in
general riskier than similarly rated corporates.

In this vein, Skelton (1983) attempts to directly compare the risk of high grade
municipals relative to similarly rated corporates. The author's first approach is to simply
compare the standard deviations for similar municipal and corporate indices. This
analysis shows that municipal returns are, if anything, slightly less volatile than corporate
bond returns. The author carefully notes that standard deviation of returns focuses on the
returns of an asset held in isolation, and may fail to capture the actual marginal
contribution of municipals to an investor's aggregate risk portfolio. In order to compare
the relative risk contribution that municipals and corporates make to an existing portfolio,
Skelton regresses their respective return series on the returns of a common stock index.
He compares the resulting "betas"\(^2\) with each other, and finds again that there is no
consistent pattern suggesting municipals are riskier to hold than corporates. Thus, neither
of Skelton's results support Trzcinka's theory that municipals carry higher risk relative to
corporates. While this evidence is not sufficient to conclusively eliminate the differential
default risk hypothesis, it highlights the difficulties of properly adjusting for relative risk
when comparing two classes of defaultable bonds.

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\(^2\) The term beta should, strictly speaking, only be applied to the covariance of an asset with the whole
market. This is clearly not what Skelton does. However, if most of the variance in an investor's portfolio
comes from stocks, rather than bonds, Skelton's "betas" will be good approximations of the true betas.
Differential Default Risk: Interaction of Tax and Default Risk

The Trzcinka paper modeled the supposedly higher risk of municipal bonds as a simple risk premium that investors demand for holding these securities relative to corporates. His very general specification does not take into account the structure of bond returns (either full return of principal or default), and might therefore be improved on by more careful modeling of the default process. Yawitz, Maloney and Ederington (1985) develop a structural model of bond returns (the YME model hereafter) that assumes risk neutral bond pricing and a Poisson process for defaults. They show that in that setting, the following equation will describe the return of risky tax-exempt bonds relative to default free taxables.

\[ r_M = \frac{(1 - P)(1 - \alpha \tau^m_p)}{P} + \frac{(1 - \tau^m_p)}{P} r_r \]

In this equation, \( P \) is the instantaneous, and time independent (Poisson) probability that a particular bond will NOT default in any given period. \( \alpha \) is the fraction of principal losses that are deductible from ordinary income in the event of default\(^3\).

The authors note that although their model still implies a linear relationship between taxable and tax exempt yields, the interpretation of the coefficients is now different. Recall than in the Trzcinka model, the intercept represented the risk premium demanded by investors to compensate them for holding municipals, while the slope coefficient represents the tax rate of the marginal (yield setting) investor. This

\(^3\) It turns out the authors findings are largely insensitive to most realistic choices of alpha
straightforward interpretation of coefficients is flawed if we admit that, while still containing some simplifications, the YME model is a more accurate description of reality\(^4\) than Trzcinka's equation. We can see from the equation that simply taking the slope as an estimate of the marginal investor's tax rate will produce an estimate that is biased upwards. The relationship between default risk and marginal tax rates on the one hand with the equation's slope and intercept on the other is non-linear and non-separable.

The authors use numerical methods to circumvent these problems, estimating \(P\) and \(\tau_p^m\) for bonds that vary by tax status, maturity and quality. This approach appears more theoretically correct than the Trzcinka model, and its key qualitative results appear intuitively plausible:

1. Estimates of \(P\) fall with the rating of municipal bonds used to estimate the equation. Estimated annual default rates range from 1.5% to 3.1%, depending on the grade and maturity of bonds used.

2. Estimates of \(P\) and estimates of the marginal tax rate appear to have no systematic relationship.

3. Estimates of the marginal tax rate consistently fell with maturity, from approximately 62% for 1 year bonds to 50% for 20 year securities.

While the first two points serve to confirm the model is at least qualitatively correct, the third one is most relevant to the muni puzzle proper. It suggests that

\(^4\) The key element of realism captured by YME model is the risk of default on principal. If it were the case that only the coupons were at risk, we could simply gross up the required return by the probability of default and continue to interpret the intercept and slope as in Trzcinka's model.
introducing default risk explicitly into our framework will produce higher estimated marginal tax rates across the curve. What is more, these estimated tax rates are generally close to what the Miller hypothesis would suggest.

However, some aspects of these results are rather unsatisfactory. First, the estimated default probabilities seem implausible: they are 3 to 6 times higher than historical experience. Second, we note that estimated default probabilities tend to rise with the maturity of the bonds used to estimate them. These cross maturity differences in default probability are in many cases larger than the cross quality differences, casting further doubt on the validity of the estimates.

Even accepting these default probabilities as accurate, it is still difficult to consider the YME model estimates as fully supportive the Miller hypothesis. While the overall level of implied tax rates certainly looks closer to Miller’s predictions (although it is now too high), the pronounced downward slope of ITRs is inconsistent with the Miller model.

The authors suggest that falling ITRs may be due to differences in call risk between municipal and treasury bonds. Because most long term municipal issues are callable, and because the YME framework does not take into account this risk, the model will understate tax rates when call risk is significant. The significance of this downward bias will increase with the value of the embedded call option, which, other things being equal, will be higher for longer dated bonds. Thus, unaccounted for call risk may help

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5 Default probability estimates will be strongly biased up if investors in fact regard this risk as systematic.
explain the falling ITRs we observe in both the unadjusted and default adjusted term structures.

6 Directly Eliminating Differential Call and Default Risk

We saw in the previous section that it is difficult to adequately control for default risk when estimating implied marginal tax rates. In some sense, this is not unexpected: any test of a differential risk hypothesis that relies on an explicit model of risky bond pricing is likely to be of low power, because it is in fact a joint test of both the model’s validity and the level of marginal tax rates at various maturities. Fortunately, Kochin and Parks (1988) eschew multi-factor models of bond pricing, and instead attempt to directly eliminate differential call and default risk from their yield comparisons. They do this by selecting 6 very high quality, non-callable, state-issued, general obligation bonds. Because these bonds are issued in series of various maturities, they provide what is essentially a par, call free, quasi-riskless municipal curve. Instead of simply comparing these bonds’ yield to maturity with those of similar term treasuries, they develop a more sophisticated measure of market implied marginal tax rates. Recall that in the taxable market, we can, starting from the par treasury curve, derive the series of forward taxable interest rates. Starting from a par municipal curve, we can derive a similar series of forward tax exempt rates. Kochin and Parks develop the notion of implied forward tax rates (IFTRs), which they define as:

\[ \text{IFTR}_t = (1-(fr_M^t / fr_T^t)) \]

6 There are no recorded defaults of state issued general obligation bonds
Where the \( f \) prefix denotes the forward rate derived for a particular maturity \( t \). Because the par municipal curve the authors use has some gaps, the forward rates and IFTRs they derive should be interpreted as averages of forward tax rates for a particular maturity interval. We reproduce their results below:

**IFTRs by maturity interval**

<table>
<thead>
<tr>
<th>State/Date</th>
<th>0-1</th>
<th>1-2</th>
<th>2-5</th>
<th>5-10</th>
<th>10-20</th>
<th>20-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 9/71</td>
<td>0.461</td>
<td>0.461</td>
<td>0.409</td>
<td>0.232</td>
<td>-0.178</td>
<td>N/A</td>
</tr>
<tr>
<td>ME 10/71</td>
<td>0.432</td>
<td>0.414</td>
<td>0.435</td>
<td>0.224</td>
<td>-0.142</td>
<td>N/A</td>
</tr>
<tr>
<td>NJ 4/71</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.111</td>
<td>-0.101</td>
<td>-0.194</td>
</tr>
<tr>
<td>CA 3/82</td>
<td>0.475</td>
<td>0.411</td>
<td>0.259</td>
<td>0.136</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ME 3/82</td>
<td>0.458</td>
<td>0.395</td>
<td>0.259</td>
<td>0.136</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>NJ 5/82</td>
<td>N/A</td>
<td>N/A</td>
<td>0.202</td>
<td>0.055</td>
<td>-0.374</td>
<td>N/A</td>
</tr>
</tbody>
</table>

These figures, while interesting, seem to deepen the muni puzzle rather than help resolve it. Obviously, the IFTRs presented above are generally far from the corporate tax rate predicted by the Miller hypothesis. The slope of IFTRs is also very pronounced, going from something close to the corporate tax rate at the short end, to zero or negative values at the long end. Although these results are very troubling, they are also difficult to invalidate, because the risk differences traditionally invoked to explain abnormally high municipal yields (higher default and call risk) are unlikely to be significant here. We might think that these results are artifacts of the particular bond issues selected by the
authors, however, they find similar results when using broader indices as their municipal yield proxy.

The authors, while noting some interesting arbitrage opportunities created by the negative implied tax rates, do not offer a theoretical framework to explain their existence. Despite this limitation, their paper uncovers some key stylized facts that any credible theory of the municipal term structure must contend with:

1. IFTRs fall dramatically with maturity
2. Long term IFTRs are consistently very low, or even negative
3. Differences in Call and Default risk do not seem to explain these low IFTRs

Clearly, the traditional market segmentation arguments, which rely on low tax individuals as the marginal holders of long term munis will be insufficient to explain these results. Indeed, one would be hard pressed to identify plausible marginal investors in long term municipals whose marginal income tax rate is low enough to explain the results.

Given how surprising these findings are, it is worth reviewing another paper that confirms them using a rather different approach. In his aptly titled “Default Risk Cannot Explain the Muni Puzzle” paper, Chalmers (1998) examines municipal bonds whose

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7 Negative IFTRs are not present in every period, but near zero IFTRs appear to be quite a common occurrence.
8 Feenberg and Poterba (1991) show that individual holders of municipals are almost exclusively upper income households.
payments have been secured with U.S. Treasury bonds. This situation arises when an issuer wishes to cancel a liability, but cannot realistically tender for the bonds, either because of legal restrictions, or because the securities' dispersal among many retail accounts makes the transaction costs of a tender prohibitive. Instead, the issuer places treasury securities sufficient to cover all interest and principal payments on the original municipal bond in an irrevocable escrow account.

It would be fair to consider that municipal issues refunded in this way are free of any default risk. In addition, the prerefunding process essentially eliminates the issuer's call option, because the treasury portfolio is designed to cover coupon and principal payments to final maturity. Thus, Chalmers' analysis is in the same spirit as Kochin and Parks, because it attempts to directly eliminate default and call risk from the municipal bonds used to estimate the tax-exempt curve. In his model, Chalmers chooses a linear regression specification because he can safely ignore default risk. Municipal yields are a linear function of both the risk free government yields and a muni specific term premium. If the Miller hypothesis is correct, we would expect (1) the estimated intercept term to be zero, (2) the estimated muni specific term premium to be zero and (3) the coefficient on government yields to equal the prevailing corporate tax rate.

The statistical tests reject all but the last of these hypotheses. The estimated intercept term is positive and significant, indicating the presence of a risk premium in the yields of even default free short-term municipal bonds. The coefficient on the muni specific term premium is also positive and significant. Encouragingly, however the coefficient on government yields is very near \((1 - \tau_c)\), as predicted by the Miller model. In
addition to these results, the author also notes that at various points in time, the ITR calculated on long bonds was in the 5% range, much too low to be attributed to an individual investor's marginal tax rate. While Chalmers does not focus specifically on ITRs, his results should be viewed as very similar to and supporting the basic conclusions we drew from Kochin and Parks' paper:

1. ITRs fall consistently with maturity
2. Long term ITRs are very low
3. Default and Call risk cannot explain 1. and 2.

In addition to providing further confirmation for these puzzling facts, Chalmers raises some interesting points, which to our mind at least, suggest another potential explanation for low ITRs. When comparing prerefunded bonds (carrying no default risk) with "Prime" bonds (carrying some default risk) he finds that yields are higher for the default free bonds. How can this be the case? One possibility is that while the prerefunded bonds show generally good marketability (because of their homogenous collateral), they are not as liquid as the "Prime" bonds. It seems likely therefore, that liquidity may play a large role in the determination of municipal yields. If liquidity differences can lead to significant yield spreads within the municipal bond asset class, then it would be reasonable to expect liquidity differences to have an even larger impact on spreads across the boundary of the municipal bond asset class. This would be

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9 As defined by Salomon Bros.
especially true when comparing municipals with other, vastly more liquid instruments such as U.S. Treasuries. Further research in this area seems very much warranted.

7 Differential Risk: Consumption Hedging

Piros (1987) shows that taxable bonds may provide a valuable consumption hedge to their holders. Municipal bonds, which lack this valuable feature, must compensate investors with a higher yield. The intuition behind Piros' model can quickly be grasped using a simplified, two state economy. In the good state, consumers have high incomes, and because of the progressive tax code, face relatively high marginal tax rates. In the bad state, the opposite is true. Because investors' marginal tax rates rise and fall with the state of the economy, risk free taxable bonds have higher after tax returns in the bad state than in the good state. When the economy is in the bad state, investors have lower labor income, and therefore a higher marginal utility of consumption. The converse is true in the good state. Therefore, taxable bonds provide their highest returns when the marginal utility of consumption is highest. This useful property raises the attractiveness of taxable relative to tax-exempt bonds.

In essence, this argument is a variation on the differential risk theme, although in this story, the driving force is the negative correlation between investors' human capital and the after tax return on taxable bonds. While this model can theoretically explain higher observed yields on municipal bonds, it needs some additional assumptions to address the issue of falling ITRs. There are some reasonable justifications for a higher systematic risk premium on longer municipal bonds. We find one particularly
convincing. Only a municipal bond’s coupons are tax-advantaged, and therefore only the coupons should carry the additional risk premium. Because the fraction of a bond’s price represented by the coupons rises with maturity, we would expect to see higher risk premia (and lower ITRs) the longer the term of the bond.

Chalmers’ goal is to test the Piros hypothesis by measuring, then comparing the levels of systematic risk in portfolios of municipal and taxable bonds. Drawing on the experience of prior researchers, Chalmers eschews direct measures of consumption and instead uses various asset price measures as proxies for consumption.

The author starts with straightforward regressions of after tax government and municipal bond returns on the value weighted NYSE. Drawing on his earlier work, he uses a portfolio of prerefunded bonds to proxy for the municipal market. Chalmers then tests whether the difference between municipal and taxable betas is significantly positive. A positive beta difference would imply significantly higher systematic risk in municipal bond returns compared to taxable returns. Using his data, the author is in fact unable to reject the “zero beta difference” null hypothesis at any point on the term spectrum. This aspect of the Chalmers’ findings essentially replicates --with cleaner data-- Skelton’s (1983) work. We note however that Chalmers point estimates of the beta difference are consistently positive across all maturity buckets.

Chalmers rightly notes that what investors really care about is not the correlation of bond returns with the equity market, but rather with the total market. The author uses a value-weighted average of the equity, government and municipal bond markets as his total market. He then essentially repeats the paired regression procedure to create a new
series of estimated beta differences. Again, none are significantly different from zero. In addition, the point estimates' sign varies inconsistently across maturity buckets.

Taken together, these empirical findings lend no support to the notion of higher systematic risk for municipals relative to taxables, further reinforcing the point made by Skelton in 1983. Most importantly, Chalmers' results undermine yet another version of the differential risk hypothesis.

8 Tax Avoidance Mechanisms

So far, we have noted the inadequacy of various frameworks for explaining the muni puzzle. Market segmentation seems unlikely on theoretical grounds, in addition the very low IFTRs uncovered by Kochin and Parks cast further doubt on the existence of individual marginal investors facing sufficiently low tax rates. The differential call and default risk hypotheses, while intuitively appealing, cannot explain the results of Kochin and Parks, or those of Chalmers. Liquidity differences may be a promising area, but have received limited attention so far. Systematic risk differences other than call and default risk are also rejected by Chalmers' latest working paper.

8.1 Tax avoidance obtained through portfolio design

Green (1993) proposes a theory that can explain the term structure of ITRs, while relying on a single investor population facing a single tax rate on interest income. He does not directly address the question of which tax rate (individual, corporate...) is the determining one, but his work nonetheless casts much needed light on why the taxable and tax-exempt yield curves seem to converge at long maturities. The fundamental idea
driving his model is that taxable investors can construct tax-advantaged portfolios that lower their effective tax rate on long-term bonds. The intuition behind Green’s model is best understood through an example he provides. Suppose an investor can enter into the following positions:

1. Short 1 par 10% taxable bond with maturity T

2. Long 2 discount 5% taxable bonds with maturity T

The combination of these two positions will result in no net coupon payments. The upfront cost of the strategy is \( P^T = 1 - 2B_{5\%} \), where \( B_{5\%} \) is the cost of the 5% discount bond. At maturity, the investor will receive a net pretax cash flow of $1. His capital gain will be the discount amount on the two 5% bonds: \( 2 - 2B_{5\%} \). In keeping with the assumption of a single tax rate, Green calculates the net after tax proceeds from this position to be:

\[
1 - \tau (2 - 2B_{5\%}) \text{ which can be rewritten as } 1 - \tau (1 - P^T). \]

In effect, the investor has purchased a pure discount bond that is not taxed until maturity\(^{10}\). To a taxable individual, this “synthetic zero” is clearly attractive relative to an actual coupon payment received on

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\(^{10}\) Readers should note that this strategy relies on the existence of bonds, which, while issued at par, now trade at a discount. Had the two bonds in this example been issued at a discount, tax rules for OID (original issue discount) bonds would apply, and our hypothetical investor would have to make tax payments on imputed interest prior to receiving cash returns.
the same date\textsuperscript{11}, but unattractive relative to a principal payment. The value of the synthetic zero today must be equal to its discounted after tax value:

\[ p^T = [1 - \tau (1 - P^T)] d^T; \text{ where } d^T \text{ is the after tax discount factor for period } T \]

This expression can be rewritten to explicitly calculate \( p^T \), the value today of a pre tax dollar received in period \( T \):

\[ p^T = [(1 - \tau) d^T] / (1 - \tau d^T) \]

This expression makes the tax advantaged nature of our synthetic zero relative to pure coupon payments more obvious:

\[ p^T > [(1 - \tau) d^T] \]

We now imagine a portfolio of these synthetic zeros (SZs) that replicates the pretax payments of a par taxable bond. It is clear that the after tax coupon payments of the synthetic par bond will be higher than the after tax coupon payments of the actual par bond. It is also clear that the after tax principal payments of the synthetic par bond will be lower than after tax principal payments of a normal par bond. As we make this comparison at longer and longer maturities, the coupon stream will make up an increasing fraction of the bond's value. As this happens, a larger and larger fraction of the bond's value will be made up of tax-advantaged cash flows, and the average tax rate on

\textsuperscript{11} In fact, Green's model probably understates the tax advantage of the synthetic zero relative to coupons, because it ignores the fact that the accrual of principal is taxed at the lower capital gains rate.

28
the bond's cash flows will fall. Intuitively, we would therefore expect the taxable and tax-exempt yield curves to move closer together at longer maturities.

Green goes beyond this intuitive argument and shows formally that in any environment with positive forward rates, the ratio of taxable to tax-exempt par yields will fall with maturity. He also shows that at the very short end of the curve, this ratio will approach \((1 - \tau)\), exactly as is observed in reality. While this model is appealing, it does rely crucially on one assumption. It assumes that arbitrage by dealers and tax-exempt institutions dominates the pricing of pre tax cash flows relative to each other. While an individual may prefer principal payments to coupon payments, because the former are tax-exempt, a dealer treats both as identical. Green assumes that dealer arbitrage dominates individual arbitrage and therefore eliminates price gaps between portfolios of securities with identical pre tax cash flows\(^\text{12}\). While other researchers have found that there are some tax effects in the pricing of fixed income securities\(^\text{13}\), these effects are generally small enough to consider Green's model a reasonable approximation of reality.

Green first tests the model informally during a period of relative stability in the tax code: 1988-1990. He does this by graphically comparing the relative yields predicted by his model to those prevailing in reality. Overall, his model performs well, especially when compared to the alternative of simply multiplying yields across the curve by a single tax rate. Green then proceeds to more formal statistical tests using the Generalized Method of Moments to deal with the model's non-linear nature. While the model is rejected at conventional significance levels when estimated over the entire 1950-1990

\[^{12}\text{Individual arbitrage would tend to equate the value of portfolio with the same after tax cashflows.}\]
period, this is not surprising (as the author argues), given the radical changes undergone by the tax code during this period. For 1987-1990, the period when the actual tax code most closely resembles the stylized one of Green's model, the tests fail to reject his hypothesis. For all periods under consideration, his model is a much better predictor of yields than the standard constant yield multiple relationship.

8.2 Tax avoidance obtained through organizational form

In the previous section, we saw how investors can lower their effective tax rate on long-term bonds through the use of specialized portfolios that facilitate tax deferral. The value of tax deferral grows with maturity, leading naturally to a downward sloping ITR term structure.

Having considered this explanation for the municipal term structure, it is natural to consider other forms of tax avoidance, in particular those allowing investors to lower their effective tax rates through tax deferral. There are a number of such vehicles available to individual investors. We focus here on 401(k) accounts and single premium deferred annuities (SPDAs). In terms of tax treatment, both allow investors to hold fixed income instruments and accrue interest that will be untaxed until liquidation. At the time of liquidation, investors pay tax on the investment’s net return. Mathematically, the after tax accumulation\(^{14}\) can be written as:

\[
ATA_{\text{def}} = 1 + [(1 + r_T)^n - 1] (1-\tau_p) = (1-\tau_p) (1+ r_T)^n - 1 + \tau_p
\]

\(^{13}\) See for example Elton and Green (1998)

\(^{14}\) Following earlier convention, our expression for after tax accumulation assumes an identical tax rate for income and capital gains. This understates the true tax advantage available to investors who use these privileged organizational forms.
Assuming investors consider this investment a substitute for municipal bonds, both will have to earn the same ATA.

\[(1 - \tau_p) (1 + r_T)^{(n)} + \tau_p = (1 + r_M)^{(n)}\]

It can be shown that the tax-deferred instrument’s ratio of after- to pre-tax returns rises monotonically with \(n\), and converges to \((1 - \tau_p)\) for a sufficiently large \(n\). The instrument’s after tax yield likewise grows with \(n\), and converges to the pre tax yield (Scholes and Wolfson 1992). This shows that in a world where investors are on margin deciding between tax-exempt and tax-deferred (rather than fully taxable) bonds, we should not be surprised to see ITRs fall with maturity, and gradually converge to zero for very long bonds. This leaves open the question of whether investors actually are on margin choosing between tax-deferred and tax-exempt investments. While more research is clearly needed here, it is worth noting that there are few obstacles to investors obtaining tax deferral for their longer term investments. In particular, we note that while 401(k) contributions are limited by IRS regulations, SPDAs can be purchased without restriction\(^{15}\).

The existence of tax deferral strategies is to our mind the most convincing explanation for the relative shape of the taxable and tax-exempt yield curves. Contrary to the market segmentation hypothesis, it does not rely on marginal investors having implausibly strong maturity preferences and low tax rates. Unlike the differential risk hypothesis, it can explain the puzzling facts relating to prerefunded bonds. In fact, if we

\(^{15}\) Investors who surrender an SPDA prior to age 59.5 must pay an additional 10% excise tax.
combine the municipal market's probably large liquidity premia with the taxable
market's income deferral opportunities, it may even be possible to explain the negative
IFTRs observed by Kochin and Parks.

Despite many attractive features, tax avoidance explanations of the muni puzzle
are difficult to integrate into an overall picture of asset market equilibrium. Our next
section examines some of these theoretical problems in more detail, and proposes some
tentative solutions.

IITR Term Structure, Asset Market Equilibrium, and Corporate Financing

Decisions

Recall Miller's basic argument: corporations, by consistently choosing the lowest
cost source of capital, arbitrage away any difference between their own tax rate $\tau_c$ and
that of their marginal bondholder, $\tau_p^m$. If Green's model is correct, then bondholders face
tax rates that decline with debt maturity. Why then, would corporations issue any
securities other than long-term debt? Recall that firms will issue debt over equity so long
as the following inequality holds:

$$(1 - \tau_p) > (1 - \tau_c) (1 - \tau_e),$$

which can be rewritten as $r_M / r_T > (1 - \tau_c) (1 - \tau_e)$
So even if we assume equity income escapes taxation, it must still earn a rate of return that makes up for its inferior tax treatment at the corporate level. With corporate tax rates at 35%, and long term ITRs often below 10%, it is hard to see why any equity gets issued. Note that this apparent paradox arises precisely because tax avoidance explanations do not rely on differential risk to justify low long term ITRs. In a differential risk model, we would simply argue that the true, risk adjusted, yield ratio is close to $(1 - \tau_c)(1 - \tau_e)$.

Should we reject the tax avoidance story because it predicts long-term debt dominates other securities? While it may not have been their original intention, Buser and Hess (1986) propose a version of the Miller model that could resolve some of the difficulties pointed out above.

Buser and Hess develop a simple framework for understanding how transaction costs affect the Miller equilibrium. Denoting the deadweight costs of security issuance as $d_E$ and $d_T$ for equity and debt respectively, they note that in equilibrium:

\[ r_E + d_E (1 - \tau_c) = (r_T + d_T) (1 - \tau_c) \]

\[ r_M = r_E (1 - \tau_c) \]

Denoting the difference in deadweight costs between debt and equity as $d = d_T - d_E$, the authors re-arrange terms to obtain:

\[ r_M = (r_T + d) (1 - \tau_c) (1 - \tau_e) \]

we can re-write this in terms of the taxable to tax-exempt yield ratio:
\[ \frac{r_M}{r_T} = (1 + d/r_T) (1 - \tau_s) (1 - \tau_e) \]

While Buser and Hess’ focus is not the muni puzzle, and their paper concerns short term bonds only, we find their framework helpful when thinking about how to integrate the ITR term structure implied by Green’s model into an overall picture of capital market equilibrium.

The revised expression shows that other things being equal, municipal yields rise with the differential deadweight costs of debt over equity issuance. It seems natural then, that when trying to explain the steepness of the tax-exempt yield curve, we should look for a similar rising pattern in the term structure of differential issuance costs (DICs).

Differential issuance costs between debt and equity form a key component of the “pecking order” theory of capital structure proposed by Myers (1984). In this framework, equity issuance costs stem from the information asymmetry between market participants and the corporation’s managers. Investors know managers have superior information regarding the value of the firm’s assets and projects relative to the market value of its equity. As a result, the market for new issue shares suffers from adverse selection, because shareholders interpret issuance as a signal that the firm’s equity is currently overvalued.

In order to circumvent this problem, firms can issue “safe debt” whose value is independent of any private information and therefore does not give rise to transaction costs when issued. In a footnote to his paper however, Myers notes that his theory assumes that “managers and shareholders agree on the variance rate” of the firm’s assets.
Clearly, if this is not the case, a “lemons market” problem, similar to the one plaguing new equity issues, will also affect debt issuance.

Measuring a firm’s asset volatility is non-trivial, and measuring the degree of information asymmetry between managers’ and other market participants on this topic is even more difficult. Despite these difficulties, it seems reasonable to guess that this information asymmetry increases with the horizon of the variance estimate. That is to say, while the market’s estimate of a firm’s bankruptcy risk over the next year may be as good as management’s estimate, it is likely that at longer horizons, management has a significant informational advantage, as certain projects’ risks may not be apparent for some time. Higher information asymmetry at long horizons will lead to higher agency costs for issuing long-term debt compared to issuing short-term debt. We should also note that at longer horizons, moral hazard will also come into play, significantly raising agency costs in the debt market. Managers interested in maximizing shareholder wealth will be tempted to substitute risky assets for existing ones after long-term debt is issued, thus raising the value of the firm’s equity at the expense of its bondholders. Thus, there are good reasons to expect the agency costs of debt to increase with maturity.

What matters in the Buser and Hess framework however is not the absolute level of issuance costs, but rather the differential costs between debt and equity issuance. Agency costs for equity issuance are constant, as equity has no fixed term. We would

\[\text{footnote}{Leland 1996, examines the moral hazard issue in more detail. Interestingly, his model also included a tax advantage for long term debt relative to short term debt, albeit for very different reasons than those outlined in our thesis.}\]
therefore expect the differential agency costs of debt to equity to rise with the maturity of the debt being issued.

Returning to our equation expressing the yield ratio, we see that it is now quite possible to accommodate Green’s model into overall asset pricing equilibrium. All that is required is for differential issuance costs to rise with debt maturity, which seems very likely. In this revised framework, the genuine tax advantages of long-term debt are offset by its higher agency costs.

Conclusion

In this thesis, we showed the apparent contradiction between theory and facts that is the municipal puzzle. Next, we examined the market segmentation hypothesis, which argues that investors in different tax brackets have different maturity preferences, because of asset/liability matching requirements. This seemed unlikely given the strong incentives for investors to find alternate duration management tools. The various differential risk hypotheses we examined essentially argue that while there is an apparent contradiction between Miller’s model and the market’s yields, appropriately risk-adjusting yields eliminates this contradiction. We consider the work of several authors who persuasively invalidate the differential risk hypothesis. The final explanation we examine is also the most convincing to our mind. Tax deferral opportunities, whatever their form, allow investors to lower the effective tax rate they face on long-term cash flows. While attractive, the tax deferral hypothesis seems incompatible with a situation where firms issue securities other than long term debt. Our paper closes by showing that
this problem can be resolved if the contracting costs of debt relative to equity rise with debt’s maturity, which seems very likely.

We believe that tax deferral offers a compelling and comprehensive solution to the municipal puzzle. Future empirical research should focus on more complete tests of the Green’s tax deferral hypothesis. It would also be valuable to test other tax deferral hypotheses (such as the one suggested here) against empirical data. This would help answer the question of what kind of tax deferral is at work for the marginal investor. Further theoretical work might explore the question of how maturity dependant tax rates are compatible with the existence of short-term securities. In particular, it may be interesting to estimate the size of the contracting costs necessary to for such an equilibrium to hold.
References


