Journal of Financial Services Research 8:243-256 (1994)

The Determinants of Bond Call Premia: A Signalling Approach

EDUARDO S. SCHWARTZ
Anderson Graduate School of Management, University of California, Los Angeles, 405 Hilgard Avenue, Los Angeles, CA 90024-1481

ITZHAK VENEZIA
The Hebrew University, Jerusalem

Abstract

A signalling model is presented that provides an additional explanation for the determination of call premia on corporate bonds. It is shown that firms may signal their exclusive information about their probability of default by the choice of their call premia. Stockholders of safer firms (i.e., those that have a lower probability of bankruptcy) have a higher incentive for providing a low call premium. This occurs because the call option will be valuable only if the firm survives by the first call date. This event, however, is more likely for the safer firm. The safer firm will therefore be more willing to sacrifice some current revenues (or equivalently, to provide a higher coupon than it would otherwise have to pay in order to sell the bond at par) by determining a lower call premium. The model therefore predicts a negative correlation between safety and call premia, a correlation that has been empirically confirmed by Fischer, Heinkel, and Zechner (1989). This correlation provides support to the signalling theory vis-à-vis the alternative explanation of taxes determining the call premia. Another contribution of this model is that it ties the call premium decision with expectations of future interest rates. Such expectations are considered important by practitioners, but were rarely considered in previous research.

1. Introduction

Call price premia are prevalent for callable corporate and municipal bonds, yet there are relatively few studies that attempt to explain how firms and municipalities determine these call premia.[1] Potential explanations for the existence of call premia fall into one of four categories: institutional considerations, agency theory, signalling theory, and tax induced reasons.

The institutional considerations suggest that the call provisions allow the firm to replace its debt if some of its covenants become expost (i.e., after the issue) too costly. Thus the call provisions allow the firm more flexibility, and decisions to call will not be made solely in light of a consideration of falling interest rates or an improvement in credit rating (which reduces the firm's cost of refinancing). Agency theories for the existence of call

The authors would like to thank Gonzalo Cortazar, Robert Heinkel, Haim Reisman, Salvador Zurita, participants at seminars at INSEAD and the Jerusalem Conference in Finance, and two anonymous referees for helpful comments and suggestions.

premia were suggested by Bodie and Taggart (1978), Barnea, Haugen, and Senbet (1980), and Fischer, Heinkel, and Zechner (1989). They demonstrate that call provisions (and maturity structure) can be rationalized as a means of resolving the agency problems of debt associated with infomational asymmetry, risk incentives, and Myers's (1977) type of foregone growth opportunities.[2] Some of the implications of this theory have been tested by Allen, Lamy, and Thompson (1987), Marr and Ogden (1989), Mitchell (1991), Ogden (1988), and Thatcher (1985).

Tax rationale for the existence of call premia has been provided by Marshall and Yawitz (1978, 1980), Boyce and Kalotay (1979), and Finnerty, Kalotay, and Farrell (1988). Call premia are taxed as capital gains of bondholders, but are deducted as regular expenses of issuers. If bondholders have lower marginal tax rates than issuers, a rationale for the existence of call premium is established. These tax theories, however, have been challenged by Brick and Wallingford (1985), and by Mauer, Barnea, and Kim (1991). A signalling explanation for the existence of call provisions has been suggested by Robbins and Schatzberg (1986). Their model, however, consists of a very specific numerical example, and it does not consider the variability of interest rates, and therefore the option characteristics of the call feature. In addition, in their example, the call price is lower than the face value of the bond, contrary to usual practice.

The purpose of this article is to provide a more general signalling model which explains the call premium decision. Whereas practitioners maintain that interest rates expectations are important in the call premium decision, the extant literature does not explain why and how these expectations affect this decision. In this article, a model is developed that shows how the firm determines its call premium as a function of expected future interest rates and the firm's risk of default. We also explore some of the empirical implications of the above mentioned tax theories, and compare them with those of the signalling model.[3]

The intuition of the model is the following: The call option is valuable to the issuers if interest rates decline, because then they can refinance at a lower interest cost. The lower the call premium the higher the chances the issuers will refinance and hence the higher the expost (i.e., after the bond issue has been sold) transfer of wealth from bondholders to stockholders in case of a cell. This does not imply however that lowering the call premium represents such an exante transfer of wealth. In an efficient capital market the bond price will reflect any possible future transfers of wealth.[4] The costs of lowering the call premium are borne by the firm at the time of issue either in the form of lower proceeds from the bond issue (since bondholders will pay less for the issue foreseeing the higher possibility of call) or, more often, in the form of a higher coupon rate needed to sell the bond issue at par. The benefits from lowering the call premium may come only after the call protection period. Whether or not the firm will actually benefit from the call option depends on whether interest rates will sufficiently fall, and on whether or not the firm will survive until the first call date and beyond. Information asymmetries between bondholders and the firm, at the time of issue, concerning future interest rates, are unlikely.[5] Such asymmetries however are much more likely to exist concerning the probability of bankruptcy of the firm. The firm (actually managers working on behalf of stockholders interests) may have more accurate information about the probability of bankruptcy. In this case firms may be able to signal their quality by their choice of the call premium.[6] Firms with a low probability of bankruptcy will be more willing to lower the call premium, because they are more likely to benefit from the call provision (since they are more likely to survive by the time of the end of the call protection period). Lower bounds for the call premia will exist, however, since there are transaction costs associated with refunding debt, i.e., the costs of calling the old debt and issuing new debt. These costs, it will later be shown, deter the lower quality firms from mimicking the higher quality ones.

A multiperiod model, which shows how a signalling equilibrium is reached under the above scenario, is presented. The optimal call premium of the issuing firm is derived as a function of the unknown (to bondholders) probability of bankruptcy, the parameters of the distribution of future interest rates, and the transaction costs associated with refunding debt. It is shown that the equilibrium call premium is negatively correlated with the safety of the firm, a correlation that was confirmed empirically by Fischer, Heinkel, and Zechner (1987).[7] This negative correlation is also consistent with the common practice in the corporate bond market of tying the call premium to one year's coupon interest. As a result, firms with a greater default risk, and thus a higher coupon, have a higher call premium.

The article is organized as follows. In section 2 the model is presented. Some comparative statics results are provided in sectiion 3. The effects of taxes are analyzed in section 4, and concluding remarks are given in section 5. The appendix contains the more technical proofs.

2. The model

Consider a new firm that has a single project whose success or failure will determine the viability of the firm. As the only source of external financing, the firm issues callable debt. Without loss of generality, suppose the firm decides to issue callable bonds with a face value of \$1 and r as its coupon rate.[8] Given the face value and the coupon rate, the firm must then determine the optimal call premium.[9] The bond issues are perpetuities with a call protection period of one period. At the end of the first period, the firm may decide to call the issue. If the bond is called, a new issue of debt will be issued for the same amount of the retired debt. For ease of exposition, it will be assumed that the new debt will be noncallable, and that its market valuation as well as the valuation of current debt are done under risk neutrality in a world without taxes (the effect of taxation will be investigated in section 4).

At the time of issue, there is a probability $(1 - P)$ that the firm will go bankrupt during period 1. If this occurs the bondholders will receive nothing. If the firm survives through the end of period 1, it will not go bankrupt later on. The probability P of survival is known to the firm but unknown to the bondholders. It is assumed that the firm cannot communicate P to the bondholders without moral hazard. The one-period interest rate at the time of issue is assumed to be zero.[10] The interest rate to prevail at the second period is random and denoted by $\tilde{x}$. It is assumed that the realization of the interest rate x wil remain fixed from period 2 on.

At the end of period 1, the firm can decide whether or not to refund the debt.[11] If it does, it will have to pay the bondholders $1 + k$, where k is the call premium. In addition, it will incur transaction costs of m when issuing the new debt. The refunding decision will be made as follows: the costs of replacing the existing debt are $1 + k + m$, assuming that the new debt will be fairly priced. The discounted net present value of the existing debt at the end of period 1 is r/x, (the value of a perpetuity of r discounted at the rate of x). It therefore follows that the firm will refund its debt if:

$$r/x > 1 + k + m \tag{1}$$

or equivalently,

$$x < \frac{r}{1+k+m}. \tag{2}$$

The sequence of events and decisions is presented in figure 1.

Based on the above refunding strategy, the proceeds of the firm from its bond issue are given by

$$\beta(k) = \pi[r + (1 + k)F(\alpha) + \int_{\alpha}^{x_{max}} \frac{r}{x}\, dF(x)], \tag{3}$$

where π is the bondholders estimate of P, $F(x)$ is the cumulative distribution function of $\tilde{x}$, x_{max} is the maximum possible value of x, and

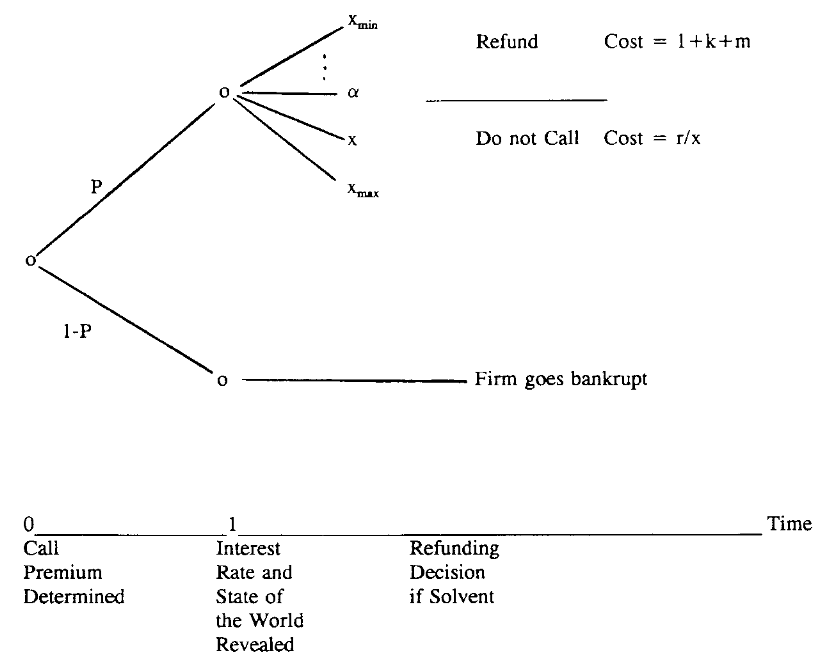

Figure 1. Sequence of events and decisions for signalling model of call premia determination.

$$\alpha \equiv r/(1 + k + m).$$

The rationale behind (3) is that the bondholders will pay, assuming risk neutrality, the discounted expected future value of future receipts. The bondholders expect to receive nothing with probability $(1 - \pi)$, i.e., if the firm goes bankrupt. If the firm survives they will receive r for the first coupon. In addition they will receive $(1 + k)$ if the firm refunds the debt, with probability of $F(\alpha)$, and r/x should the interest rate turn out greater than α and the firm does not refund the debt. In the latter case, the bonds which they hold are valued at r/x. This value should be integrated over all possible values of x above α.

Note that since $\beta(k)$ represents the proceeds to the firm from the bond issue, the effective coupon rate, $c(k)$, paid by the firm for the first period is given by:

$$c(k) = (1 + r)/\beta(k) - 1.$$

The net present value of this financing decision is given by the difference between the proceeds from the bond issue and the present value of the expected payments in the future:

$$V(k) = \pi[r + (1 + k)F(\alpha) + \int_{\alpha}^{x_{max}} \frac{r}{x}\, dF(x)] - P[r + (1 + k + m)F(\alpha) + \int_{\alpha}^{x_{max}} \frac{r}{x}\, dF(x)]$$

$$V(k) = (\pi - P)H(k) - PmF(\alpha), \tag{4}$$

where $H(k)$, the expected payments to the bondholders in the survival state, is given by:

$$H(k) \equiv r + (1 + k)F(\alpha) + \int_{\alpha}^{x_{max}} \frac{r}{x}\, dF(x). \tag{5}$$

$V(k)$ is the difference between the proceeds from the bond issue and the expected payments to the bondholders and the expected transaction costs (which occur in the event of a bond refunding in period 2). The managers of the firm use the true probability of default P in their valuation, and the bondholders use their own estimate π of P.

It will next be shown that when the value of P cannot be communicated without moral hazard, this value can be signaled by the firm's choice of k. For this, assume there are many similar firms with probabilities of survival P over the support $[P_{\min}, P_{\max}]$. The following proposition will establish the existence of an informational equilibrium:

Proposition 1: There is a decreasing signalling function $k(P)$ such that each firm with a probability of survival P chooses a call premium $k(P)$. Bondholders beliefs concerning P are given by the inverse function of $k(P)$, $\pi(k) = k^{-1}(P)$. In equilibrium, for each P, $\pi[k(P)] = P$.

Proof: Assuming that bondholders beliefs are indeed formed by observing k, (4) can be rewritten with $\pi(k)$ replacing π. That is:

$$V(k) = [\pi(k) - P]H(k) - PmF(\alpha). \tag{6}$$

Managers of the firm striving to maximize the value of stockholders' equity will determine k so as to maximize (6). The First Order Condition (FOC) for this maximum is given by

$$V'(k) = \pi'(k)H(k) + [\pi(k) - P]H'(k) - P\alpha'(k)mf(\alpha) = 0, \tag{7}$$

where $f(\alpha)$ is the density of $F(\alpha)$. Using the fact that $\alpha'(k) = -r/(1 + k + m)^2$, (7) can be rewritten as

$$V'(k) = \pi'(k)H(k) + [\pi(k) - P]\, H'(k) + \frac{Prmf(\alpha)}{(1+k+m)^2} = 0. \tag{8}$$

Anticipating the existence of a fully revealing equilibrium, i.e., that $\pi(k) = P$, the second term in the right hand side of (8) vanishes, and the FOC becomes:

$$\pi'(k)\, H(k) = -\pi(k)\, \frac{rmf(\alpha)}{(1+k+m)^2} \tag{9}$$

or

$$\frac{\pi'(k)}{\pi(k)} = \frac{d \ln \pi(k)}{dk} = -\frac{rmf(\alpha)}{(1+k+m)^2\, H(k)} \equiv T(k). \tag{10}$$

The above equation is an ordinary differential equation whose solution requires the integration of $T(k)$ under the appropriate initial conditions. These conditions are inferred from the following reasoning. Since, in equilibrium, the true chances of survival of all firms will be truthfully revealed, firms with the lowest chance of survival would not want to incur any cost of signalling. They will therefore choose a call premium that does not allow a call. If a call were possible this would reduce the proceeds from the issue without providing any benefit (because, in equilibrium, the true "quality of the firm" will be known). From the set of all call premia that guarantee that the bonds will not be called, we assume that the lowest quality firms will choose the smallest possible value, which will be the smallest upper bound of all call premia. This yields the following boundary condition:

$$\pi(k_{\max}) = P_{\min}, \tag{11}$$

where $k_{\max}$ is the lowest k ensuring no refunding in period 2, i.e.,

$$k_{\max} = r/x_{\min} - m - 1. \tag{12}$$

Since $f(\alpha)$ and $H(k)$ are positive, it follows that $\pi(k)$ is a decreasing function of k. $\pi(k) = k^{-1}(P)$ will represent a reactive signalling equilibrium (see, e.g., Riley (1979)) if some regularity conditions are satisfied (see appendix 1) and if the marginal expected benefits of signalling (i.e., decreasing the value of k) are higher for higher quality firms (i.e., those with higher P). Since it is shown in appendix 1 that these conditions indeed are satisfied, the proof is complete.[12] QED

The above proposition establishes that call premia may serve as a signalling device. The lower the call premium, the lower is the probability of bankruptcy of the firm. The solution of (10) with boundary condition (11) provides the call premium as a function of the probability of survival. Firms with the lowest probability of survival choose the highest call premium $k_{\max}$, which is the minimum call premium for which these firms will never call the issue. Firms with a survival probability P in the open interval $(P_{\min}, P_{\max}]$ choose a lower k. A firm with a probability of survival P in that interval chooses a k so that $\pi(k) = P$. Safer firms will signal their quality by choosing a lower call premium.

3. Comparative statics

Having established the main result of the article, that is, the existence of a signalling equilibrium and the inverse relation between the call premia and the quality of the issuing firm, we now proceed to discuss some additional comparative statics results.

The main parameters affecting the signalling function are the parameters of the distribution function of future interest rates, the costs of refunding, and the coupon rate.

In earlier studies, it was sometimes suggested that when interest rates were expected to fall, firms would choose lower call premia. A lower call premium would allow the firm to benefit more from possible future refunding of the bond issue (see, for example, Elton and Gruber, 1971). If expectations about future interest rates are homogeneous between bondholders and managers of the firm, however, the benefits from more likely refunding in the future should be priced out at the time of issue. In the present model, even though homogeneous expectations about interest rates are assumed, these expectations do matter in the choice of the call premium, because they affect the signalling equilibrium.

There are three effects of lower expected future interest rates on the choice of call premium. First, if interest rates are expected to be lower, the benefits from calling the bond will be higher. Second, the higher likelihood of calling will increase the expected refunding costs. Third, if lower expected interest rates are a consequence of a shift in the support of the distribution of interest rates, the call premia for the lowest quality firms will increase, shifting up the signalling function. This occurs, because a lower minimum possible value of the interest rate implies that there is more risk for the lowest quality firms in signalling, and therefore they would choose a higher call premium. The net of these three effects will depend on their relative magnitudes, which, in turn, will depend on the probability distribution of interest rates and the parameter values.

To get further insights into the implications of the model concerning the effect of the above effects, consider the uniform distribution. Assume that $\tilde{x}$ is uniformly distributed over the interval $[R_0 - h, R_0 + h]$. R_0 is the mean of the distribution. In this case the condition for equilibrium (10) becomes:

$$\frac{d \ln \pi(k)}{dk} = -\frac{\frac{rm}{2h}}{(1+k+m)^2 H(k)}, \tag{13}$$

where

$$H(k) = r + (1 + k)\frac{\alpha - (R_0 - h)}{2h} + r\frac{\ln}{2h}\left[\frac{R_0 + h}{\alpha}\right]. \tag{14}$$

From (12) the initial condition in this case is:

$$k_{\max} = \frac{r}{R_0 - h} - m - 1. \tag{15}$$

Numerical integration of (13) subject to (15) shows that as R_0 increases (i.e., if expectations of interest rates increase) the signalling function shifts to the left. That is, for the uniform distribution, increases in future expectations will cause firms to lower their call premia. In the following section, some observations are made on the effect of taxes on call premia determination.

4. Tax effects

When bonds are called, the call premium paid by the firm is treated as a capital gain for bondholders but as a regular expense for the issuing firm (see, e.g., Finnerty, Kalotay, and Farrell, 1988; Van Horne, 1980). Marshall and Yawitz (1980) and Yawitz and Anderson (1977) argue that differential taxation can provide a rationale for the existence of call provisions.[13] In this section, the effect of this differential taxation on the determination of the call premium is analyzed, assuming that there is no asymmetric information between bondholders and the firm about its probability of survival.[14]

Let the marginal tax rate on the capital gains be denoted by t_s, and the corporate income tax by t_c. Further assume that $t_c > t_s$. This agrees with most traditional analyses of differential taxation of capital gains and ordinary income (see e.g., Miller, 1977; Miller and Scholes, 1978). In this case the after-tax proceeds for the bondholders at the time of call[15] is given by

$$1 + k(1 - t_s). \tag{16}$$

The after-tax costs for the firm will be:

$$1 + k(1 - t_c) + m. \tag{17}$$

The firm will then call its bonds if

$$1 + k(1 - t_c) + m < r/x,$$

i.e., if

$$x < \frac{r}{1 + k(1 - t_c) + m} \equiv \alpha. \tag{18}$$

Including the above tax assumptions in the model and abstracting from any information asymmetries between bondholders and the firm, (4) becomes:

$$V(k) = PH(k, t_s) - PH(k, t_c) - PmF(\alpha), \tag{19}$$

where now the function $H(k)$ is replaced by $H(k, t)$ defined by:

$$H(k, t) = r + \int_{x_{min}}^{\alpha} [1 + k(1 - t)]dF(x) + \int_{\alpha}^{x_{max}} \frac{r}{x}\, dF(x), \qquad \text{for } t = t_s, t_c. \tag{20}$$

After some rearrangement of terms, (19) can be written as:

$$\begin{aligned} V(k) &= Pk \int_{x_{min}}^{\alpha} (t_c - t_s)\, dF(x) - PmF(\alpha) \\ &= PF(\alpha)[k(t_c - t_s) - m]. \end{aligned} \tag{21}$$

Differentiating $V(k)$ with respect to k one obtains:

$$V'(k) = PF(\alpha)(t_c - t_s) - Pf(\alpha) \frac{(1 - t_c)}{[1 + k(1 - t_c) + m]^2} [k(t_c - t_s) - m]. \tag{22}$$

If there is no differential taxation, it is easy to see from (22) that $V'(k)$ is always positive, implying that the call premium should be infinite, i.e., the bond would be noncallable. It is clear that, in this framework, if there is no asymmetric information, it will never be worthwhile to incur refunding costs. However, if $t_c > t_s$, then a finite positive k may be obtained that maximizes $V(k)$ and that provides a positive likelihood of refunding. In what follows, the comparative statics implications of this tax model[16] are discussed and compared with those of the previous section.

The effect of survival probabilities on the optimal call premium k^*, for a given P, can be inferred by noting that: sign $(\partial k^*/\partial P)$ = sign $[\partial^2 V(k)/\partial k \partial P]$. Differentiating (22) with respect to P, one obtains:

$$\frac{\partial^2 V}{\partial k \partial P} = F(\alpha)(t_c - t_s) - f(\alpha) \frac{1 - t_c}{[1 + k(1 - t_c) + m]^2} [k(t_c - t_s) - m)]. \tag{23}$$

The sign of $\partial^2 V/\partial k \partial P$ can be either positive or negative depending on the value of the parameters, which implies that the optimal call premium can increase or decrease with the probability of survival. It is easy to show, however, that under reasonable assumptions this derivative will be positive, implying, for the tax model, a positive relation between the call premia and safety, which is opposite to the prediction of the signalling model. For example, looking only at the last square bracket in equation (23), this term would be negative for average call premia of 0.03, refunding costs of 0.01, and tax differential of 0.20, implying a positive derivative.

Under the above reasonable assumptions about the tax rates and refunding costs, the implication of the tax model is, therefore, that call premia increase with safety, the opposite conclusion of the signalling model.[17] Under the tax model, the higher is the call premium, the greater are the potential tax benefits. Also, the higher is the survival probability, the greater are the chances of obtaining these benefits. Safer firms will therefore tend to choose a higher call premium in order to capture more of these benefits. It has been found, however, by Fischer, Heinkel, and Zechner (1989) that there is a negative correlation between call premia and safety, suggesting that the signalling effects more that offset the tax effects.

5. Conclusion

A signalling model has been developed that provides an additional explanation for the determination of call premia. Under this model, firms signal their higher quality (lower probability of bankruptcy) by choosing a lower call premium. Firms may choose other variables to signal quality. For example, Flannery (1986), has shown that (short) term to maturity can also be used as a signal. Firms, however, will prefer using call premia as a signal when tax advantages to call premia exist, when lowering maturity will cause an undesired mismatch between asset and debt life, and when expectations of falling interest rates will make shortening durations too costly.

The negative correlation between quality and call premia is also predicted by the agency theory models of Bodie and Taggart (1978), Barnea, Haugen, and Senbet (1980), and Fischer, Heinkel, and Zechner (1989), and was empirically corroborated by the latter authors. Since our theory introduces expectations of interest rates as an explanatory variable, whereas the extant literature does not, this variable may be used to differentiate between the theories. It is left, however, for future research to determine whether interest rate expectations or some other variables can either separate between the theories or conclude that they may coexist.

Appendix 1: Proof that Riley's conditions hold

For Riley's (1979) reactive equilibrium to hold, the following conditions must be met:

(A1) The unobservable attribute must have an increasing distribution function with bounded support.
(A2) The value function should be twice differentiable in P and k.
(A3) The optimal k should be unique for each P.
(A4) The marginal expected benefits of increasing $(-k)$ should be increasing in P, i.e.,

$$\frac{\partial^2 V}{\partial k \partial P} < 0.$$

Proof: (A1) to (A3) are technical conditions and are assumed to hold. To show (A4), which is the crucial condition, differentiate equation (4) with respect to P, obtaining:

$$\frac{\partial V}{\partial P} = -[H(k) + mF(\alpha)].$$

Differentiating this with respect to k, recalling the function $H(k)$ from equation (5) gives:

$$\frac{\partial^2 V}{\partial k \partial kP} = -F(\alpha) - \alpha'(k)f(\alpha)(1 + k + m) + \alpha'(k)f(\alpha)\frac{r}{\alpha} = -F(\alpha) < 0,$$

where the last equality follows the definition of α. QED

Appendix 2: The signalling model with taxes

In this appendix, we show that the signalling effect of call premia exists even when taxes are integrated into the model of section 2 (see note 15).

If bondholders pay taxes at a rate t_s and the firm pays taxes at a rate t_c, then the value function $V(k)$ in 6 is replaced by

$$V(k) = \pi(k)H(k, t_s) - PH(k, t_c) - PmF(\alpha), \tag{A5}$$

where $H(k, t)$ is defined in (20). The FOC for this equation is given by:

$$V'(k) = \pi'(k)H(k, t_s) + \pi(k)H'(k, t_s) - PH' + (k, t_c) + \frac{Pmf(\alpha)}{(1+k+m)^2} = 0. \tag{A6}$$

Anticipating the existence of a fully revealing equilibrium, i.e., that $\pi(k) = P$, the FOC becomes:

$$\frac{\pi'(k)}{\pi(k)} = - + [H'(k, t_c) - H'(k, t_s)]. \tag{A7}$$

Differentiating (20) with respect to k, one obtains that:

$$H'(k, t) = -t\,F(\alpha), \qquad t = t_s, t_c. \tag{A8}$$

Substituting (A8) into (A7), the latter equation becomes:

$$\frac{\pi'(k)}{\pi(K)} = -\frac{Pmf(\alpha)}{(1+k+m)^2} - F(\alpha)(t_c - t_s). \tag{A9}$$

Since it is assumed that $t_c > t_s$, it follows that $\pi'(k) < 0$, and the negative relationship between call premia and safety is proved. □

Notes

1. In a sample of 278 observations taken at random from the files of Wilshire Associates, of nonconvertible bonds issued during the years 1987–1990, it was found that the call premia ranged from 0 to 10.5 percent with a mean of 2.65 percent, and a standard deviation of 2.79 percent.
2. See also Narayanan (1987), Narayanan and Lim (1989), and Aivazian and Callen (1980), who discuss some limitations of the agency theory approach.

3. Flannery (1986) considered a signalling model that explains the choice of maturity, a variable that has some common features with the call premium. Our article, however, provides a direct, rigorous, theoretical linkage with the observed empirical fact. In addition, unlike Flannery, we tie the signalling decision to interest rate expectations, and analyze the tax implications of call premia.
4. The effect of call premia on the yields has been investigated by Ferri (1978, 1979), Jen and Wert (1967, 1968), Kidwell (1976, 1977), Kidwell and Hendershott (1978), Laber (1979), Spivey (1989), and Van Horne (1980).
5. See, however, Elton and Gruber (1971) who rationalize call premia on the basis of such asymmetries. This, however, was challenged by Myers (1971).
6. Here quality or safety is modelled by the probability of survival. Lower volatility could be considered as an alternative measure of safety. The high correlation between bankruptcy and volatility suggests, however, that similar results are expected with both measures of safety.
7. In their theoretical analysis, Fischer, Heinkel, and Zechner (1989) identify risk with volatility. In their empirical tests, however, they proxy it by Moody's corporate bond rating, which is a measure of probability of survival (or bankruptcy).
8. This is a simplified version of the world. Usually the firm will determine how much money it wants to raise, and then will determine the other variables such as the call premium, call protection period, sinking fund, and coupon rate. We decided to make the above assumption in order to simplify the exposition.
9. A large enough call premium guarantees that the bonds will not be called. Noncallability is therefore a special case of the present model. A large enough negative call premium ensures that the bond will be called after one period (the bond in this case is actually a short-term bond). Theoretically therefore, short term bonds can be considered a special case of this model. In practice however, negative call premia are never used, and hence the analysis is confined to long-term bonds only.
10. The results of this article remain intact if we assume an interest rate r_1 for the period until the end of the protection period and $\bar{x}$ from then on. This will, however, just complicate the mathematics without adding new insights.
11. The refunding decision depends also on the possible changes in the quality of debt. However, since future quality can take on only two values (bankruptcy or complete safety), the refunding decision relates to future quality in the following special way. If quality deteriorates to bankruptcy, the firm obviously does not refund. If the quality improves, the firm will refund only if the interest rates fall sufficiently.
12. Note that the NPV of the bond issue is negative, $-PmF(\alpha)$. This, however, does not violate the participation principle, since it is assumed that all firms must finance the project with debt. The need to use debt may stem from tax reasons, or other reasons. This article abstracts, however, from these issues in order to separate the signalling effect of call premia from other effects of financial decisions.
13. See, however, Brick and Wallingford (1985) and Mauer, Barnea, and Kim (1991), who disagree with the tax explanation of call premia.
14. In appendix 2, we show that the results of section 2 remain intact even when taxes are integrated into the model. We found it, however, more instructive to analyze each model separately in this section.
15. We are only considering taxes on the call premium and not taxes on interest payments in order to isolate the call premium decision.
16. This model is similar to Marshall and Yawitz's (1980), except that here a chance of bankruptcy has been added as well as transaction costs, and some simplifying assumptions were also made in order to obtain comparative statics results which Marshall and Yawitz did not provide.
17. It can be shown that the negative correlation between quality and risk premia is maintained even when the above tax assumptions (of lower capital gains tax rates than corporate rates) are integrated into the model of section 2.

References

Aivazian, V., and J. Callen. "Future Investment Opportunities and the Value of Call Provisions on a Bond: Comment." *Journal of Finance* 35 (September 1980), 1051–1056.

Allen, D. S., R. E. Lamy, and G. R. Thompson. "Agency Costs and Alternative Call Provisions: An Empirical Investigation." *Financial Management* 16 (Winter 1987), 37–44.

Barnea, A., R. A. Haugen, and L. W. Senbet. "A Rationale For Debt Maturity Structure And Call Provisions in The Agency Theoretic Framework." *Journal of Finance* 35 (December 1980), 1223–1234.

Bodie, Z., and R. A. Taggart, Jr. "Future Investment Opportunities and the Value of the Call Provision on a Bond." *Journal of Finance* 33 (September 1978), 1187–1200.

Boyce, W. M., and A. J. Kalotay. "Tax Differentials and Callable Bonds." *Journal of Finance* 34 (September 1979), 825–838.

Brick, I. E., and B. A. Wallingford. "The Relatiave Tax Benefits of Alternative Call Features in Corporate Debt." *Journal of Financial and Quantitative Analysis* 20 (March 1985), 95–105.

Elton, E. J., and M. Gruber. "Dynamic Programming Applications in Finance." *Journal of Finance* 26 (May 1971), 473–506.

Ferri, M. G. "How Do Call Provisions Influence Bond Yields?" *Journal of Portfolio Management* 5 (Winter 1979), 55–57.

Ferri, M. G. "Systematic Return Risk and the Call Risk of Corporate Debt Instruments." *Journal of Financial Research* 1 (Winter 1978), 1–13.

Fischer, E. O., R. Heinkel, and J. Zechner. "Dynamic Recapitalization Policies and the Role of Call Premia and Issue Discounts." *Journal of Financial and Quantitative Analysis* 24 (December 1989), 427–446.

Flannery, M. J. "Asymmetric Information and Risky Debt Maturity Choice." *Journal of Finance* 41 (March 1986), 19–37.

Haugen, R. A., and L. W. Senbet. "Resolving the Agency Problems of External Capital Through Options." *Journal of Finance* 34 (June 1981), 629–647.

Jen, F. C., and J. E. Wert. "The Effect of Call Risk on Corporate Bond Yields." *Journal of Finance* 22 (December 1967), 637–651.

Jen, F.C., and J. E. Wert. "The Deferred Call Provision and Corporate Bond Yields." *Journal of Financial and Quantitative Analysis* 3 (June 1968), 157–169.

Kidwell, D. S. "The Inclusion and Exercise of Call Provisions by State and Local Governments." *Journal of Money, Credit and Banking* 8 (August 1976), 391–398.

Kidwell, D. S. "The Ex-ante Cost of Call Provisions on State and Local Government Bonds." *Journal of Economics and Business* 30 (Fall 1977), 73–78.

Kidwell, D. S., and P. H. Hendershott. "The Impact of Advanced Refunding Bond Issues on State and Local Borrowing Costs." *National Tax Journal* 31 (March 1978), 95–100.

Laber, G. "How do Call Provisions Influence Bond Yields?: A Comment." *Journal of Portfolio Management* 5 (Summer 1979), 70–72.

Marr, M. W., and J. P. Ogden. "Market Imperfections and the Choices of Maturity and Call Provisions in Corporate Debt." *Journal of Business Research* 19 (August 1989), 17–31.

Marshall, W., and J. Yawitz. "Optimal Terms of the Call Provision on a Corporate Bond." *Journal of Financial Researach* 3 (Fall 1980), 203–211.

Mauer, D. C., A. Barnea, and C. Kim. "Valuation of Callable Bonds under Progressive Personal Taxes and Interest Rate Uncertainty." *Financial Management* 20 (Summer 1991), 50–59.

Miller, M. "Debt and Taxes." *Journal of Finance* 33 (May 1977), 261–276.

Miller, M., and M. Scholes. "Dividends and Taxes." *Journal of Financial Economics* 7 (December 1978), 333–364.

Mitchell, K. "The Call, Sinking Fund, and Term-To-Maturity Features of Corporate Bonds: An Empirical Investigation." *Journal of Financial and Quantitative Analysis* 26 (June 1991), 201–222.

Myers, S. "Discussion." *Journal of Finance* 26 (May 1971), 538–539.

Myers, S. "Determinants of Corporate Borrowing." *Journal of Financial Economics* 6 (November 1977), 138–147.

Narayanan, M. P. "On the Resolution of Agency Problems by Complex Financial Instruments: A Comment." *Journal of Finance* 42 (September 1987), 1083–1095.

Narayanan, M. P., and S. P. Lim. "On the Call Provision in Corporate Zero-Coupon Bonds." *Journal of Financial and Quantitative Analysis* 24 (March 1989), 91–103.

Ogden, J. P. "A Rational for the Sinking-Fund Provision in a Quasi-Competitive Corporate-Bond Market." *Journal of Business Research* 16 (May 1988), 197–208.

Riley, J. "Informational Equilibrium." *Econometrica* 47 (March 1979), 331–359.
Robbins, E. H., and J. D. Schatzberg. "Callabale Bonds: A Risk-Reducing Signalling Mechanism." *Journal of Finance* 41 (September 1986), 935–949.
Spivey, M. F. "The Cost of Including a Call Provision in Municipal Debt Contracts." *Journal of Financial Research* 12 (Fall 1989), 203–216.
Thatcher, J. S. "The Choice of Call Provisions Terms: Evidence of the Existence of Agency Costs of Debt." *Journal of Finance* 40 (June 1985), 549–561.
Van Horne, J. C. "Called Bonds: How does the Investor Fare?" *Journal of Portfolio Management* 6 (Summer 1980), 58–70.
Yawitz, J., and J. Anderson. "The Effect of Refunding on Shareholders Wealth." *Journal of Finance* 32 (June 1977), 1738–1746.