Are Taxes Capitalized in Bond Prices?  
Evidence from the Market for Government of Canada Bonds*

Stuart Landon **
Department of Economics
University of Alberta
Edmonton, Alberta
Canada T6G 2H4

14 May 2008

Abstract

This paper investigates the extent to which corporate and personal income taxes are capitalized in the prices of Government of Canada bonds. This is important to both purchasers and issuers of bonds since the degree of tax capitalization has implications for market bond yields and after-tax investment returns. The extent of the capitalization of taxes in bond prices may also affect estimates of the term structure, has implications for tax incidence and can identify the marginal investor in the bond market (or whether one exists). The results indicate that the taxes paid by financial-sector corporations were almost completely capitalized in bond prices during the period 1986-1993. This suggests that, during this period, the marginal investor was a financial-sector corporation, rather than an individual, a non-financial corporation or a tax-exempt entity, and that bond prices moved in response to changes in corporate tax rates. For the period 1994-2006, the capitalization of corporate and personal income taxes in bond prices is estimated to be near zero, implying that the marginal investor in this period faced a zero tax rate. The change in the pattern of tax capitalization in the early 1990s occurred at a time when there were institutional and regulatory changes in the market for Government of Canada bonds that augmented market liquidity, increased transparency, and lowered transactions costs.

*The author thanks Bev Dahlby and Ergete Ferede for providing the corporate income tax rate data. Helpful comments were provided by Constance Smith and seminar participants in the School of Economics and Finance at Victoria University of Wellington.

**Author email: Stuart.Landon@ualberta.ca
1. Introduction

The degree of tax capitalization in bond prices has implications for bond yields and after-tax investment returns, so an understanding of the impact of taxes on bond prices is of fundamental importance to purchasers of bonds, such as private investors and portfolio managers, and to bond issuers, such as governments and corporations. As noted by Pye (1969) and Robichek and Niebuhr (1970), the capitalization of taxes in bond prices (and, thus, bond yields) can have important consequences for estimates of the term structure. An accurate specification of the term structure is an important component of models developed in recent years to explain credit spreads and to price credit risk derivatives and other contingent claims. The impact of tax changes on bond prices is also important to tax incidence and can be used to identify the marginal investor in the bond market and, thereby, to clarify the role of different types of market participants in the determination of bond prices. Since tax rates generally differ across investor types, if bond prices reflect the tax position of one particular type of investor, this could create profitable trading opportunities for other investor types (Green and Ødegaard (1997)). “Which group ultimately determines prices is an empirical issue” (Green and Ødegaard (1997, 611)) about which no clear consensus has been reached (Chalmers (1998), MacKay, Prisman and Tian (2000)).

This paper presents empirical evidence on the degree of tax capitalization in Government of Canada bond prices. In so doing, it makes several contributions. Unlike much of the literature, it incorporates data on both corporate and personal income tax rates and explicitly examines whether, and to what extent, these taxes have been capitalized in bond prices. As a result, the analysis can assess whether a particular type of tax has been capitalized in bond prices. This makes it possible to determine whether a marginal investor exists and, if so, to identify which of the three principal types of investors in bonds – individuals, corporations or non-taxed entities – is the marginal

---

1 MacKay, Prisman and Tian (2000) suggest that managers of fixed income portfolios have generally ignored the potential effect of taxes on the term structure even though small changes in the term structure can have potentially large effects on the value of fixed income portfolios.
investor. The use of actual tax data also means that it is possible to directly estimate the degree of tax capitalization. Previous studies tend to estimate implied tax rates (either in a single period or averaged over multiple periods) rather than incorporate tax rate data directly. The use of implied tax rates makes it more difficult to relate estimates of tax capitalization to a particular tax type and to measure the degree of tax capitalization.²

The empirical analysis utilizes data on bond pairs, which makes it unnecessary to estimate the entire yield curve.³ Much of the literature uses an empirical methodology that involves joint estimation of the term structure and implied tax rates (see, for example, McCulloch (1975), Jordan (1984), Litzenberger and Rolfo (1984a), Ehrhardt, Jordan and Prisman (1995), Green and Ødegaard (1997), Elton and Green (1998), Elton, Gruber, Agrawal and Mann (2001), Liu, Shi, Wang and Wu (2007)). Misspecification of the term structure could potentially affect estimates of the degree of tax capitalization. Further, to estimate the entire term structure, a large number of observations is required at each point in time.

Following Green and Ødegaard (1997), the estimation methodology used here employs a non-linear specification of the bond pricing formula. An alternative approach, used by Litzenberger and Rolfo (1984a) and MacKay, Prisman and Tian (2000), for example, employs a

² It is possible to use implied tax rates to identify the marginal investor type, but the process often becomes quite complicated. For example, Litzenberger and Rolfo (1984a) estimate implied interest income tax rates associated with different pre-specified capital gains tax rates, where these capital gains tax rates are the rates that apply to different types of taxpayers. Litzenberger and Rolfo then compare their estimates of the implied interest income tax rate to the rates faced by actual taxpayers for each pre-specified capital gains tax rate. If the estimated rate is close to that of an actual investor type, Litzenberger and Rolfo conclude that this type of taxpayer is likely to be the marginal investor. An alternative that does not use actual tax rate data or estimate implied tax rates is employed by MacKay, Prisman and Tian (2000). They specify four hypothetical tax brackets, one of which corresponds to tax-exempt investors, while another is close to the tax bracket faced by corporations in Canada. Using Canadian bond price data, MacKay, Prisman and Tian (2000) estimate after-tax yield curves for each of these four hypothetical tax brackets. If the yield curve estimated for a particular tax bracket can explain actual bond prices, they conclude that this is the tax bracket of the representative investor. The results of MacKay, Prisman and Tian show that there exists a representative investor, but the tax bracket associated with this investor does not correspond to an actual tax bracket.

³ Another strand of the literature which also does not require estimation of the term structure of interest rates uses bond triplets (three bonds from the same issuer with the same maturity date, but different coupons) and arbitrage tests. See Litzenberger and Rolfo (1984b), Ronn and Shin (1997), Elton and Green (1998) and MacKay, Prisman and Tian (2000), for example. The applicability of this methodology is limited by the small quantity of data available for bond triplets. For example, there are only four triplets included in the data set used in the present study.
linear version of the pricing equation that incorporates the capital gain term as an explanatory variable. Since the capital gain term is a function of the bond price, this linear procedure necessitates the use of an instrumental variables estimation technique. A problem with this instrumental variables procedure is that the identification of appropriate instruments is likely to be difficult, and the parameter estimates may depend on the choice of instruments (Jordan (1984)).

The analysis employs a relatively large previously unused panel dataset of Government of Canada bond prices. An advantage of Canadian data is that the tax code, as it pertains to fixed-income assets, is less complicated than that of the US (MacKay, Prisman and Tian, 2000). This greatly simplifies the empirical analysis and makes it easier for the empirical specification to accurately reflect tax policy. Further, with a simpler tax system, it is easier for investors to determine the tax implications of different investments, so pricing errors based on tax confusion are less likely. In addition, Government of Canada bonds are traded in a well developed secondary market with significant liquidity (Gravelle (1999)). Finally, the sample incorporates 21 years of monthly data, a sample period that is longer than the samples used in most other studies and which includes relatively large movements in tax rates.

It is typical in the literature to estimate separate implied tax rates for each point in time (generally each day or each month) without taking into account that taxes in adjoining periods are likely to be linked (for example, tax rates rarely change during a year). Period-by-period estimation also makes it more difficult to examine the impact of changes in tax policy on bond prices and to test whether there have been significant shifts in behaviour. The current study differs from most of the literature in that it uses time series data. The use of a time series of bond price data, in conjunction with explicit data on tax rates, recognizes that taxes may not always change from one

---

4 Outstanding Government of Canada bonds and debentures totaled C$87.4 billion in 1986 (17 percent of GDP), were C$272.7 billion in 2006 (19 percent of GDP), and peaked at C$320.1 billion in 2001 (29 percent of GDP).

5 Green and Ødegaard (1997) and Chittenden and Hein (1999) also both employ time series data. The latter use cointegration analysis to examine the relationship between the yields on taxable and tax-exempt bonds, while Green and Ødegaard (1997) estimate a structural model of the term structure.
period to the next, makes it possible to estimate the degree of tax capitalization across the whole sample as well as for sub-periods, facilitates tests of structural changes in bond market behaviour, and uses the variation in tax rates to identify the extent of tax capitalization.

The existing evidence on the impact of taxes on bond prices and yields is mixed. A number of studies find that taxes affect bond yields, although this effect is often small and, when the degree of capitalization can be identified, capitalization is typically found to be less than complete (see, for example, McCulloch (1975), Van Horne (1982), Litzenberger and Rolfo (1984a), Heuson and Lasser (1990), Ehrhardt, Jordan and Prisman (1995), Green and Ødegaard (1997) for the pre-1986 period, and Elton and Green (1998)). Other authors identify significant tax effects, but find that the estimates of the magnitudes of these effects are quite variable (Jordan (1984), Gay and Kim (1991)). In contrast to these studies, Green and Ødegaard (1997), for the post-1986 period, show that taxes do not have a significant impact on U.S. Treasury bond prices.

The relationship between corporate bond yields and taxes has received far less attention than the relationship between taxes and either U.S. Treasury or U.S. municipal bond yields. In one of the first studies of the relationship between corporate bond yields and taxes, Elton, Gruber, Agrawal and Mann (2001) find, using US data for 1987 through 1996, that a large proportion of state corporate taxes are capitalized in corporate bond yields, and that the tax effect is more important than default risk. In a recent study, Liu, Shi, Wang and Wu (2007) confirm the findings of Green

---

6 Rather than analyzing tax capitalization as it relates to national government bonds or corporate bonds, many of the studies that examine the relationship between taxes and bond prices (yields) have done this by addressing the US municipal bond “puzzle”. This “puzzle” is the small spread between the yields on bonds that earn taxable interest and the yields on US municipal bonds which are tax exempt for some groups of taxpayers, so that the after-tax returns on the tax-exempt municipal bonds are greater than the after-tax returns on taxable bonds. See Green (1993), Chalmers (1998), Chittenden and Hein (1999), and the papers cited therein. The “muni bond puzzle” is a phenomenon that is peculiar to the US tax system and the US municipal bond market is quite different from other bond markets in that the majority of US municipal bonds are held by individuals (70 percent according to Ang, Bhansali and Xing (2007)), a far greater proportion than for most other types of bonds. Explanations for the municipal bond puzzle involve restrictions on arbitrage, transaction costs, and differences in default risk (see Chalmers (1998) and Erickson, Goosbee and Maydew (2003), for example).

7 Guenther (1994) provides evidence of a tax effect on the pre-tax yields of US Treasury bills (rather than bonds) in an analysis of the major US tax changes of 1981 and 1986. However, the magnitude of the estimated effect is small relative to the effect that would have been expected if the marginal taxpayer had been an individual taxpayer.
and Ødegaard (1997) with respect to the absence of tax effects in the US Treasury bond market, but find that US corporate bonds with larger coupons earn higher returns than low coupon corporate bonds, signifying a significant tax effect, although the estimated effect is small.

Several studies have examined tax capitalization in bond yields for non-US markets. The multi-country study of Litzenberger and Rolfo (1984a) shows that taxes have a significant impact on the prices of bonds in Germany, Japan and the UK (as well as the US) and that the implied tax rates reflect the tax status of the major holders of government bonds (corporations in Germany, Japan and the US, individuals in the UK). In a cross-country study, Eijffinger, Huizinga and Lemmen (1998) find that withholding taxes have a significant impact on government bond yields in industrialized countries. An early study by McCallum (1973) shows that the announcement of the introduction of a capital gains tax in Canada raised bond yields, as would be expected if taxes are capitalized in bond prices. However, using Canadian data for 1964-1976, Brennan and Schwartz (1979) find that the effect of personal income taxes on bond yields is slight. MacKay, Prisman and Tian (2000) confirm the results of Brennan and Schwartz, but find that, after 1976, taxes induce a segmented equilibrium with clientele effects, especially between 1981 and 1986 (when their sample ends). MacKay, Prisman and Tian (2000) attribute the change in the latter part of their sample to the introduction of the capital gains tax in 1972, large interest rate movements, and deficit financing.

---

5 Clienteles form when different sub-sets of investors, such as investors belonging to different tax brackets, hold different sub-sets of bonds, implying that investors are not indifferent across all bonds (Schaefer (1982)). Dybvig and Ross (1986) distinguish two types of clientele effects – those in quantities and those in prices and quantities. Clienteles effects in quantities arise when there is at least one marginal investor who holds (or is indifferent between) all bonds, but other types of investors hold only a subset of bonds. Clienteles effects in prices and quantities occur when no investor type is indifferent between all bonds, so there is no price vector for which some investor would be willing to hold positive quantities of all bonds. In this case, there does not exist a marginal investor. If a marginal investor exists, the term structure is determined by the demand of that investor type. In the absence of a marginal investor, an estimate of the term structure using all bond prices will not reflect the demand of any single type of investor. Implied tax rates estimated in this case may not apply to any particular type of investor (Jordan (1984)) and so may be of little use. Arbitrage in this type of equilibrium must be imperfect due, for example, to restrictions on short selling. Prisman and Tian (1994, 303) note that, in Canada, short sales “are difficult and costly to implement and may constitute the frictions needed to support an equilibrium with clientele effects.”
by the Canadian government which led to an increase in the supply of government bonds and
attracted more investors from diverse tax brackets to the bond market.

The results presented below indicate that financial sector corporate income taxes were
almost fully capitalized in the prices (and yields) of Government of Canada bonds from 1986 (when
the sample begins) to the early 1990s. Although movements in corporate and personal income tax
rates are correlated to some extent, the results suggest that personal income taxes, unlike corporate
taxes, were not fully capitalized in bond prices. This result is not surprising as it is consistent with
the much larger share of Government of Canada bonds held by corporations than by individuals.
Further, as suggested by Green and Ødegaard (1997), individuals are less likely to be the marginal
investor as they face higher transaction costs.

For the period 1994 through 2006, the evidence implies that neither corporate taxes nor
personal income taxes are capitalized in bond prices. This result is consistent with the marginal
investor during this period being an entity that pays no tax. The change in the identity of the
marginal investor and the degree of tax capitalization does not appear to correspond to movements
in bond holdings. However, in the early 1990s, the financial industry and the Bank of Canada
introduced institutional reforms to the operation of the market for Government of Canada bonds
aimed at improving market liquidity, efficiency and transparency. These reforms are expected to
have reduced the risk and transaction costs of trading in this market and, as a consequence, may
have induced investors not subject to tax to trade more actively. This is consistent with the
suggestion of Shleifer and Vishny (1997) that arbitrage in financial markets may be less constrained
when there is less risk.

The results obtained suggest that there is a “marginal investor” who is indifferent between
holding all Government of Canada bonds, although not all types of investors would want to hold all
bonds. In the terminology of Dybvig and Ross (1986), there exists a clientele in quantities, but not
in prices and quantities. For both the 1986-1993 and 1994-2006 periods, the results indicate that the marginal investor can be identified with a particular type of investor subject to a particular type of tax – a financial sector corporation in the first period and a non-taxpaying entity in the second.

The next section outlines the empirical methodology employed, while Section 3 describes the data. Section 4 presents the results and indications of the robustness of the estimates. The final section provides a discussion of the results.

2. Empirical Methodology

The price \( P_{At} \) in period \( t \) of bond \( A \), a bond with a par-value of 100, coupon \( C_A \) and \( M \) periods to maturity, is given by:

\[
P_{At} = C_A(1 - \beta_i \tau_{it}) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_{it}) + 100d_i(t_M, \beta_i \tau_{it}) - (100 - P_{At}) \beta_i \tau_{it} \quad \text{(1)}
\]

where \( \tau_i \) and \( \tau_g \) are the tax rates on interest income and capital gains, respectively, the \( \beta_i \) parameter represents the degree to which taxes are capitalized in the bond price, and \( d_i(t_m, \beta_i \tau_{it}) \) is the after-tax discount factor in period \( t \) for the \( m^{th} \) period in the future (the price at time \( t \) of an after-tax claim of one dollar to be delivered \( m \) periods in the future), so, when \( r_m \) is the \( m \)-period pre-tax market yield,

\[
d_i(t_m, \beta_i \tau_{it}) = \frac{1}{(1 + r_m(1 - \beta_i \tau_{it}))^m}. \quad \text{(10)}
\]

The only difference between equation (1) and the standard bond pricing formula used in the

---

9 In some jurisdictions, such as Canada, the capital gains tax rate is expressed as a fraction, \( \phi_g \), of the ordinary income tax rate, so \( \tau_g = \phi_g \tau_i \), and the two tax rates are not independent.

10 Note, as is common in the literature, it is assumed that the tax system treats capital gains and losses symmetrically, that taxes are imposed when income is received, and that tax rates are known and constant through time. This last assumption is consistent with the assumption in Shiller and Modigliani (1979, 300) “that tax rates and tax laws relating to capital gains are, and are expected to be, unchanging.” Shiller and Modigliani contend that the alternative of modeling the time path of expected tax rates is simply too difficult. Further, as in other studies that examine the impact of taxes on bond yields, the specification given in equation (1) assumes that investors plan to hold bonds to maturity and so ignores the whole issue of tax-timing options as discussed in, for example, Constantinides and Ingersoll (1984). Equation (1) is consistent with the taxation of bonds in Canada in that coupon payments and capital gains are both taxed when the corresponding income is received. However, it ignores the possible differential tax treatment of premium and discount bonds. In Canada, the capital loss associated with a premium bond can only be used to write off a capital gain earned on another asset, not coupon income.
literature, such as that of Robichek and Niebuhr (1970) or Green and Ødegaard (1997), is the addition of the parameter $\beta_i$. An advantage of estimating $\beta_i$, rather than implied tax rates as is done in much of the literature, is that, when using time series data, the estimation takes advantage of the information contained in observed movements in tax rates through time.

Re-writing equation (1), so that the bond price appears only on the left-hand side, yields:

$$P_{At} = \frac{C_A(1 - \beta_i \tau_{it}) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_{it}) + 100(1 - \beta_i \tau_{gt}) d_i(t_M, \beta_i \tau_{it})}{1 - \beta_i \tau_{gt} d_i(t_M, \beta_i \tau_{it})}. \quad (2)$$

Using this specification, along with data on bond prices, coupons, tax rates, and the discount factors, it would be possible to estimate $\beta_i$ and determine the extent to which taxes are capitalized in bond prices. A problem with this approach is that it requires data on the discount factors associated with the entire yield curve (the $d_i(t_m, \beta_i \tau_{it})$). An alternative, used in much of the literature is to simultaneously estimate the tax effects and an approximation to the yield curve. A shortcoming of this methodology, as mentioned above, is that any errors in the estimation or specification of the yield curve may bias the estimates of the tax capitalization parameters.

It is not necessary to have information on the entire yield curve at every point in time if there is a second bond (Bond B) with the same maturity date and risk characteristics as Bond A, but a different coupon. Following equation (2), the price of this second bond would be given by:

$$P_{Bt} = \frac{C_B(1 - \beta_i \tau_{it}) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_{it}) + 100(1 - \beta_i \tau_{gt}) d_i(t_M, \beta_i \tau_{it})}{1 - \beta_i \tau_{gt} d_i(t_M, \beta_i \tau_{it})}. \quad (3)$$

Since both bonds are discounted by the same discount factor, it is possible to use equation (3) to substitute for $\sum_{m=1}^{M} d_i(t_m, \beta_i \tau_{it})$ in equation (2). This yields:

\[ \]}

11 It is easy to modify the pricing equations to incorporate accrued interest. However, this modification adds little to the model as the accrued interest terms cancels out of equation (4).
Equation (4) incorporates only one point on the yield curve for each bond pair, rather than the entire yield curve, which greatly simplifies estimation.\footnote{Van Horne (1982) also uses pairs of bonds with “similar” maturities. He chooses pairs so that one of the bonds in each pair sells near par (and the other sells at a discount) and uses the yield to maturity on the par bond as the discount rate in the pricing equation for the discount bond. Heuson and Lasser (1990) use pairs of bonds with the same maturity date, but have data covering only five years. They employ a grid search to calculate the marginal tax rate that equates the after-tax yield-to-maturity on each pair. Chittenden and Hein (1999) examine the yields on bonds with the same maturities, but use different types of bonds, so the risk characteristics of the bonds in each pair are unlikely to be the same.}

**Application to Canada**

Equation (4) can be used to estimate the extent of tax capitalization in the prices of Government of Canada bonds. There are three principal types of bondholders in Canada – individuals, financial corporations and non-taxed entities (pension funds and government agencies), all of whom are taxed differently. Individuals pay tax rate $\tau_i$ on coupon income and tax rate $\tau_g$ on capital gains, with $\tau_g$ set as a proportion $\phi_g$ of $\tau_i$ ($0 < \phi_g < 1$). Financial corporations pay the same rate of tax ($\tau_c$) on coupon income and capital gains,\footnote{The corporate tax rate is generally different from the tax rates paid by individuals on either interest income or capital gains. Non-financial sector corporations (corporations who do not trade in bonds as part of their business) pay tax rate $\tau_c$, but pay only a fraction $\phi_g$ of this rate on capital gains (the same proportion as paid by individuals). See Canada Revenue Agency (1984) for a detailed description of the differences between financial and non-financial corporations.} while non-taxed entities pay no tax on both capital gains and coupon income.

If a marginal investor exists, bond prices will reflect the tax rates faced by that investor. Thus, if the marginal investor is an individual subject to personal income taxation, so the personal income tax rates $\tau_g$ and $\tau_i$ are capitalized in bond prices, $\beta_i$ in equation (4) would equal one. Alternatively, if financial-sector corporations are the marginal investor, bond prices would reflect corporate tax rates. In this case, it is necessary to modify equation (4) so that $\tau_g$ and $\tau_i$ are replaced with $\tau_c$ and $\beta_i$ is replaced by $\beta_c$, the corporate tax capitalization parameter. With full corporate tax capitalization, $\beta_c$ would equal one. On the other hand, if the marginal investor is a tax exempt entity
(such as a pension fund), the tax capitalization parameters, $\beta_i$ and $\beta_c$, would both be zero as individual and corporate tax rates would have no impact on bond prices. In the absence of a marginal investor, there is a segmented equilibrium in which subsets of taxpayers hold only subsets of bonds. In this case, different subsets of bond prices will reflect different subsets of tax rates and the estimates of $\beta_i$ and $\beta_c$ are likely to lie between zero and one.

As in Green and Ødegaard (1997), an error term is added to the bond pricing equations (equations (2) and (3)). The addition of an error is justified because “bond price data typically contain noise (bid-ask spread, thin trading, and measurement error). . . . Such observation errors tend to be random and have zero mean in a large sample” (MacKay, Prisman and Tian (2000, 255, 263). Elton and Green (1998) also note that errors in bond pricing are common. The addition of an error to equations (2) and (3), and the generation of equation (4) from these two equations, causes the errors associated with equation (4) to be heteroscedastic. It is also possible that the errors for the time series of observations for each bond pair will be correlated as might the errors associated with the observations common to each time period. As a result, the reported standard errors are adjusted for two-way clustering (by bond pair and by time period) and heteroscedasticity. This is done using the methodology proposed in Cameron, Gelbach and Miller (2006) and Thompson (2006).

3. Data

In order to estimate equation (4), price and coupon data are required for bond pairs, where each pair consists of two bonds that have different coupon rates, but are identical in terms of risk and date of maturity. To ensure that all the data are characterized by similar risk characteristics, bond price data for a single default risk free issuer – the Government of Canada – are employed.

---

14 Rather than cluster by bond pair and observation (month), since tax rates generally remain constant for an entire year, it is possible to estimate the standard errors while clustering by bond pair and year, which allows the errors of all the observations in a particular year to be correlated. This procedure increases the magnitude of the estimates of the standard errors, but not by enough to alter any of the conclusions.
These data are taken from *Canadian Bond Prices* and *FP Bonds—Canadian Prices*, both published by the Financial Post Corporation.\(^{15}\) The sample consists of 2190 last-business-day-of-the-month observations on the bid prices of 94 bonds that can be combined to form 49 bond pairs.\(^{16}\) As is typical in the literature, only bonds with more than 12 months to maturity are included in the sample.\(^{17}\) All bonds in the sample are not callable, are denominated in Canadian dollars, are not real return bonds, are not extendable or exchangeable, and pay interest on a semi-annual basis. The bonds in each pair may differ in terms of amount issued and issue year.\(^{18}\) As they are taxed in a different fashion than coupon bearing bonds, strip bonds and zero-coupon bonds are not included in the data set.

The span of the data is from 1986 to 2006, although some of the bonds matured during the sample period, while others were newly issued, so the bond price data form an unbalanced panel.\(^{19}\) The number of monthly observations for each bond pair has an average of just under 45, but ranges from 2 to 112. The number of observations per year varies from 45 to 203, and averages 104. The average coupons of the high and low coupon bonds in each pair are just under 12 and 8 percent, respectively, so the average difference between the coupons of the bonds in each pair is approximately 4 percentage points. (See Appendix A for additional descriptive statistics.)

As the identity of the marginal investor is not known *ex ante*, two types of tax data are used

---

\(^{15}\) The characteristics of the bonds (for example, amount issued, issue year, callability, etc) are given in the Financial Post publications: *Government Bond Record* and *FP Bonds – Government*.

\(^{16}\) Ninety-four bonds can be used to construct 49, rather than 47, bond pairs because there are four cases in which three bonds share the same maturity date, and so, for each of these cases, two separate pairs can be formed from the observations on three bonds.

\(^{17}\) This is consistent with the definition of “fixed-rate debt . . . as debt with a remaining term to maturity of more than one year” (Harvey, 1999, 29n). Heuson and Lasser (1990), Elton and Green (1998) and Elton, Gruber, Agrawal and Mann (2001) also, for example, do not use data for bonds with less than one year to maturity. As in Elton, Gruber, Agrawal and Mann (2001), a small number of observations with obvious pricing (data entry) errors were eliminated. For example, five observations were not used because the reported price and yield data gave inconsistent predictions (by a small number of basis points) with respect to whether the bonds were trading at a discount or a premium.

\(^{18}\) The issues of risk differentials and differences in callability, which have been cited as being important in the US muni-bond-puzzle literature (Chalmers (1998)) are not relevant here as the bond price data employed correspond to bonds that are issued by one issuer and are not callable.

\(^{19}\) While observations on bond prices are available from 1983, the Bank of Canada term structure data used for \(r_M\) begins only in 1986.
to estimate the degree of tax capitalization, data on personal income tax rates, $\tau_i$ and $\tau_g$, and data on
corporate tax rates, $\tau_c$. The tax rates, $\tau_i$ and $\tau_g$, are set equal to the highest personal tax rates on
interest income and capital gains, respectively, for a resident of Ontario, while the combined federal
and Ontario general corporate tax rate is used for $\tau_c$. The rationale for using the highest marginal
tax rate for $\tau_i$ and $\tau_g$ is that high income individuals are most likely to invest in bonds. The tax rates
applicable in Ontario were employed because Ontario is the largest province in terms of both GDP
and population. Since the federal government collects the major share of both personal and
corporate income taxes, the choice of province of residence is likely to have little impact on the
results.

The tax rate data are presented in Table 1 and plotted in Figure 1. The tax rate on interest
income changed 14 times during the 21 year period from 1986 to 2006. Since $\tau_g$ equals $\phi_g \tau_i$, a large
number of the 16 changes in the capital gains tax rate, $\tau_g$, were due to movements in the tax rate on
interest income, $\tau_i$. However, the capital gains tax as a proportion of the tax rate on interest income
($\phi_g$) also changed four times during the sample period, so the simple correlation between the two
tax rate series is only .599. From a peak in 1994, the personal income tax rate on capital gains fell
by 42 percent by 2001, while the personal tax rate on interest income fell by only 13 percent over
the same period. The correlation coefficient between the corporate tax rate and the personal tax rate
on interest income is .68, while the correlation with the capital gains tax rate is only .43.

To estimate equation (4), it is necessary to associate each observation for each bond pair
with one point on the zero-coupon yield curve ($r_M$). The values for $r_M$ were proxied using estimates

---

20 The personal income tax rate data were taken from the actual Canadian federal and Ontario income tax forms for each
year. These forms can be accessed at http://www.cra-arc.gc.ca/formspubs/t1general/allyears-e.html on the website of
the Canada Revenue Agency. The corporate income tax rate data were provided by Bev Dahlby and Ergete Ferede.
They obtained these data from various issues of The National Finances and Finances of the Nation, both published by
the Canadian Tax Foundation.
generated by the Bank of Canada. To ensure that the data for \( r_M \) and the bond prices are not contemporaneous, the value for \( r_M \) employed is for the business day prior to the business day on which the bond prices are recorded.

4. Results

Table 2 reports estimates of the tax capitalization parameters, \( \beta_i \) and \( \beta_c \). Estimates of the parameter \( \beta_i \) are derived by estimating equation (4) using the personal capital gains (\( \tau_c \)) and interest income (\( \tau_i \)) tax rates. The \( \beta_c \) parameter is estimated by replacing \( \tau_i \) and \( \tau_g \) in equation (4) with the corporate tax rate, \( \tau_c \), and replacing \( \beta_i \) with \( \beta_c \). As noted in Section 2, if the marginal investor is a personal income taxpayer, the individual tax capitalization parameter, \( \beta_i \), would equal one. On the other hand, if the marginal taxpayer is a financial-sector corporation, the tax capitalization parameter associated with the corporate income tax rate, \( \beta_c \), would equal one. If the marginal taxpayer in the bond market is an entity that pays no tax, such as a pension fund or government agency, the coefficients on the tax capitalization parameters will equal zero, so \( \beta_i = \beta_c = 0 \).

Finally, in the absence of a marginal investor, so no single type of investor is indifferent between all bonds, the prices of sub-sets of bonds will reflect the tax rates of sub-sets of investors. In this case, one would expect the estimates of both \( \beta_i \) and \( \beta_c \) to differ from both zero and one.

Table 2 presents estimates of the tax capitalization parameters using data for the whole sample, 1986 through 2006, as well as for two sub-periods – 1986-1993 and 1994-2006. In his

---

21 Downloaded 1 June 2007 from http://www.bankofcanada.ca/en/rates/yield_curve.html. For a description of the methodology used to generate these data, see Bolder, Johnson and Metzler (2004). To minimize the possibility of tax-induced distortions, these yield curve estimates exclude observations for bonds that trade at high deviations from par (Bank of International Settlements, 2005, xi, 3). For the sample period employed, the Bank of Canada provides zero-coupon yields for every maturity from 3 months to 300 months at three month intervals. The maturity chosen to represent \( r_M \) for each monthly observation is the maturity that is closest to the \( M \) for that observation.

22 This is consistent with the assumption that bond traders use only bond price data from the previous day to generate estimates of the discount rate. Note that the bonds that form the bond pairs in the sample used here are, most likely, only a fraction of the bonds used to estimate \( r_M \), since \( r_M \) is estimated using all the available bond data (with the exception noted in the previous footnote), not just data on bond pairs.
study of the Government of Canada yield curve, Johnson (2004-05, 19) notes that “the period between the late 1980s and the early 1990s had very different characteristics from the late 1990s and early 2000s.” Some evidence suggests that this change was caused by institutional reforms to the operation of the market for Government of Canada bonds introduced by the financial industry and the Bank of Canada in the early 1990s. In the earlier period, it has been suggested that many bonds were not liquid, that there was a lack of transparency in the bond market, and that traders used “rules of thumb” and “idiosyncratic” bond pricing formulas. The prevalence of these characteristics declined after the reforms (Whittingham (1996-97) and Johnson (2004-5)). As the period following the early 1990s may have been characterized by different behaviour or institutions than the earlier period, it may not be appropriate to treat the entire sample as a single period. For these reasons, estimates are provided for the two sub-periods as well as for the full sample.

As shown in Part A of Table 2, over the whole sample, the estimates of the personal income tax capitalization parameter, $\beta_1$, is .1809. This parameter estimate is both significantly different from zero and one. The full sample estimate of the corporate tax capitalization parameter given in Part B of Table 2 is .5350, which is closer to one than the individual parameter, but also significantly different from both zero and one. These results suggest that no single type of investor is the marginal investor for the entire sample period.

As can be seen from Table 2, the results for the two sub-samples differ strongly from each

---


24 Johnson (2004-5) suggests that the exact point at which to split the sample is unclear. The choice of break point used here was made based on an examination of the institutional evidence as well as on the fact that market yield differentials between bonds with the same maturity date, but different coupons, averaged less than 10 basis points (with a standard deviation of less than 3 basis points) for the years in the latter period, but averaged 28 basis points (with a standard deviation of up to 25 basis points) in the years of the earlier period. If the break point between the two sub-samples is moved one year in either direction, the values given in Table 2 are generally less than one standard error from the new estimates and never more than two standard errors. Altering the two sub-samples by one year in either direction would not cause any of the conclusions to change, so the precise point at which to split the sample is not critical.
other as well as from the estimates for the whole sample. For the earlier sub-sample, 1986 through 1993, the personal income tax capitalization parameter, $\beta_i$, is .3190, which is larger than the estimate for the whole sample, but still significantly different from both zero and one. On the other hand, the corporate tax capitalization parameter ($\beta_c$) is estimated to be .9193. This estimate is insignificantly different from one as well as significantly different from zero (and is also significantly different from the estimate for $\beta_i$). These estimates suggest that, in the earlier period, financial-sector corporations were the marginal investor in the bond market, so that changes in the corporate tax rate caused movements in bond yields during this period.

Estimates of the two tax capitalization parameters ($\beta_i$ and $\beta_c$) for the sub-period 1994 through 2006 imply that neither corporate nor personal income taxes are capitalized in bond prices. Both estimates of the tax capitalization parameters are near zero (and negative) and, for each parameter, a test strongly rejects the hypothesis that the tax capitalization parameter equals one. These results suggest that, in the more recent period, the marginal investor in the bond market is neither a corporation nor an individual. Rather, the results imply that the marginal investor is an investor facing a zero tax rate, such as a pension fund or government agency.

4.1 Annual Estimates of the Tax Coefficients

As an indication of the robustness of the tax capitalization parameter estimates presented in Table 2, annual estimates of the implied personal and corporate tax rates are generated by estimating equation (4) separately for each year of the sample. Since the tax rates $\tau_i$ and $\tau_c$ are

---

25 A test that the estimated parameters are the same over the two sub-samples rejects the hypothesis of parameter constancy for both parameters. The t-statistics for the structural change tests of the individual and corporate tax capitalization parameters, $\beta_i$ and $\beta_c$, are 12.63 and 8.32, respectively.

26 Green and Ødegaard (1997) find negative estimates of implied tax parameters for the US in the post-1986 period and also interpret these estimates as implying the absence of tax capitalization in bond prices.

27 It is typical to estimate implied tax rates for each observation (month). While we have monthly data, we do not have enough observations to estimate the model for each month. On the other hand, since neither $\tau_i$ nor $\tau_c$ change during any year of the sample, it may be more efficient to estimate the implied tax rates for each year than for each month.
constant during each year, this procedure yields estimates of the implied capitalized tax rates, $\beta_i \tau_i$ and $\beta_c \tau_c$, rather than the tax capitalization parameters $\beta_i$ and $\beta_c$, as the latter cannot be identified separately when tax rates are constant.\(^{28}\) The annual estimates of $\beta_c \tau_c$ and $\beta_i \tau_i$ are illustrated in Figures 2 and 3, respectively.

If a corporate taxpayer is the marginal taxpayer, the estimate of the implied corporate tax rate ($\beta_c \tau_c$) for each year should be insignificantly different from the actual corporate tax rate ($\tau_c$) for the same year. The estimates presented in Figure 2 indicate that, for six of the eight years from 1986 through 1993, the estimated implied corporate tax rate is close to the actual corporate tax rate and five of these estimates are insignificantly different from the actual rate.\(^{29}\) From 1994 onwards, all the estimates of the implied corporate tax rates are close to zero, and all are significantly different from the actual tax rate. Thus, the results in Figure 2 are generally consistent with the results of Table 2 which imply that corporate taxes were capitalized in bond prices in the pre-1994 period, but had little impact on bond prices in the post-1993 period.\(^{30}\)

As can be seen in Figure 3, the estimates of the implied personal income tax rate ($\beta_i \tau_i$) all fall below the actual individual tax rate ($\tau_i$), and are generally less than half of the actual rate. In all cases, the estimated implied tax rate is significantly different from the value of the actual tax rate. As with the implied corporate tax rate, there is a distinct fall in the estimated implied individual tax rate in the early 1990s, and a subsequent stabilization of the estimates of these rates near zero.

\(^{28}\) By using data on $\phi_g$, and noting that $\tau_c = \phi_g \tau_i$, it is only necessary to identify one implied tax rate for individuals, $\beta_i \tau_i$, rather than both $\beta_i \tau_i$ and $\beta_i \tau_g$ because $\beta_i \tau_g = \phi_g \beta_i \tau_i$. It is the use of the data for $\phi_g$ which allows the year-by-year estimates of the “corporate” and “individual” implied tax rates to differ.

\(^{29}\) Note that the estimates presented in Figures 2 and 3 are generated for each year individually and, as a consequence, each estimate is derived using far fewer observations (a minimum of 45 and a maximum of 203) than the estimates in Table 2. The variability of the estimates could be due to the small number of observations in each period (Green and Odegaard (1997)). The standard errors illustrated in Figures 2 and 3 are generated using two-way robust-clustering, the same method used to generate the standard errors in Table 2.

\(^{30}\) The low estimated implied tax rates for 1989 and 1990 correspond with a temporary spike in short term interest rates as well as a temporary decline in the percentage of outstanding Government of Canada marketable bonds held by chartered banks, near-banks, life insurance companies and other financial institutions. This percentage fell from an average of 20 percent in 1986-1988 to 17 percent in 1989 and 1990, before rising to 20 and 24 percent in 1991 and 1992, respectively.
These annual estimates are consistent with the estimates of Table 2 in that they imply that individual taxpayers were not the marginal investor in the Government of Canada bond market. The implied tax rates of approximately zero for the post-1993 period in both Figures 2 and 3 indicate that the marginal investor during this period had a tax rate of zero.

4.2 Robustness of the Estimates

To assess the robustness of the results, several alternatives to the estimation methodology are considered. Branion (1995, 14) and Jones and Fabozzi (1992, 180) note that the most actively traded Government of Canada bonds are of intermediate maturities, in the range of 3 to 10 years, so the model was estimated using only bonds with from 36 to 120 months to maturity. While this reduces the number of observations over the whole sample and in each of the two sub-periods by almost half, the new estimates of the tax capitalization parameters and standard errors differ very little from those presented in Table 2 (generally the estimates differ by less than one standard error) and none of the conclusions would change.

The tax capitalization parameters, $\beta_i$ and $\beta_c$, were also re-estimated using observations from only one month in each year, since tax rates generally do not vary during a year and, as a result, there may be little additional information generated by using more than one observation for each calendar year. Observations for the month of June were chosen ex ante since government budgets are usually announced in March or April (near the government fiscal year-end of March 31) and, thus, tax rate changes should be known by June. Using June observations only, the estimates of the parameters and standard errors are very similar to those reported in Table 2 (none of the parameter estimates change by more than two standard errors) and cause none of the conclusions to change.

The marginal personal income tax rates used to generate the results in Table 2 include both

---

31 This section presents a summary of the robustness results. The estimates underlying this summary are available from the author.

32 There are 183 June observations in the full sample, 1986-2006, and 105 and 78 observations in the 1986-1993 and 1994-2006 sub-periods, respectively.
provincial and federal surtaxes. Since these surtaxes may be paid by only a small number of high income taxpayers, the model was re-estimated using the highest tax rate *exclusive* of federal and provincial government surtaxes as the personal income tax rate.\(^{33}\) This change yielded parameter estimates that were extremely close (all within one standard error) to those reported in Table 2, indicating that the results are not particularly sensitive to the personal income tax rates employed.

In 1985, the Canadian government introduced a lifetime capital gains deduction for individuals. This deduction was capped at $100,000 in 1988 and eliminated in 1994 (Zeng (2002)), but could have had an impact on the demand for bonds and, thus, on the estimates of the individual tax capitalization parameter ($\beta_i$) for the earlier sample sub-period. To determine whether the capital gains deduction has important implications for the results, the parameter $\beta_i$ is estimated for the period 1986 through 1993 with the capital gains tax rate set to zero, as would be the case if individual taxpayers were not constrained by the cap on the lifetime capital gains deduction. While this change causes the estimate of $\beta_i$ to fall, it is still significantly different from both zero and one.

Non-financial corporations pay tax at the corporate rate, but, unlike financial corporations, pay tax on only a proportion $\phi_g$ of capital gains (the same proportion as paid by individuals). Estimates of equation (4) using the appropriate tax rate for non-financial corporations yields estimates of the tax capitalization parameter that are very close to those presented for individuals in Table 2.\(^{34}\) This result implies that, as with individuals, non-financial corporations are not the marginal investor in the market for Government of Canada bonds. This is not surprising as non-financial corporations hold only one percent of outstanding marketable Government of Canada bonds (Table 3).

The sample employed includes both on-the-run and off-the-run bonds. There may be differences in the market liquidity and transactions costs associated with these two types of bonds.

---

\(^{33}\) The combined federal and provincial personal income surtax averaged a little over 5 percentage points during the sample period and varied from approximately 2 to 9 percentage points.

\(^{34}\) For the non-financial corporations case, equation (4) is modified by replacing $\tau_i$ with $\tau_c$ and $\tau_g$ with $\phi_g \tau_c$. 
These differences may be reflected in the price data and this could have affected the estimates. To test if the mixture of on-the-run and off-the-run bonds in the sample is important to the results, the tax capitalization parameters were re-estimated with data only for bonds with an issue date that was at least two years in the past. The new parameter estimates are almost identical to the estimates given in Table 2 (which is not surprising as only a small percentage of the observations in the sample correspond to bonds issued in the previous two years).

Finally, to allow for possible mis-pricing and liquidity effects, the specification of the estimating equation is modified to allow the bond price to differ from the present discounted value of bond income in three alternative ways – by a constant parameter; by a constant parameter and a linear function of the log of the issue amount of each bond; and by a constant parameter and a linear function of the number of years since the bond was issued. (See Appendix B for a derivation of the modified estimating equation.) This specification is more flexible in that it allows for the systematic over- or under-pricing of bonds as well as the dependence of prices on issue amount and years since issue, both potential proxies for bond liquidity. If the bid prices employed are systematically biased, this bias should be reflected in the estimated constant term. Elton and Green (1998) suggest that prices may also differ from the present value of payments due to transaction costs. In addition, they argue that illiquid bonds should offer higher yields and find that liquidity is a significant (although not very large) determinant of the relative prices of US Treasury bonds.

For the whole sample, and in both sub-samples, the estimates of $\beta_i$ and $\beta_c$ for these three variants of the model are similar to those presented in Table 2 and in not a single case would there be a change in the general conclusions with respect to the degree of tax capitalization. Thus, the magnitude of the estimates reported in Table 2 do not appear to be the result of a failure to account for errors in bond pricing or liquidity effects.

---

35 The number of years since issue as a proxy for liquidity is suggested by Green and Ødegaard (1997).
5. Concluding Comments

This paper examines the extent to which corporate and personal income taxes are capitalized in Government of Canada bond prices. Tax capitalization effects are important to investors since they can affect investment returns as well as estimates of the term structure used to price other assets. Tax capitalization effects may also be informative for policymakers as they provide information about tax incidence and the role of different market participants in the determination of bond prices.

The findings described above indicate near complete capitalization in bond prices of the financial sector corporation income tax during the period 1986-1993. While the estimates are also consistent with partial capitalization of personal income taxes, this partial capitalization may follow simply from the positive (but not perfect) correlation of corporate and personal tax rates. That our evidence suggests that the marginal investor paid corporate taxes, rather than personal taxes, during the period 1986-1993 is perhaps not surprising given the relatively small share of Government of Canada bonds held by personal income taxpayers (see Table 3).

For the period 1994-2006, the tax capitalization parameter estimates fall to near zero, which suggests that the marginal investor faces a zero tax rate, the tax rate of pension funds and government agencies. In both sub-periods, there appears to be a marginal investor type, which suggests the absence of tax-clienteles except in quantities. The different tax treatment of investor-types, and the existence of a single-type of marginal investor, implies that there are frictions that inhibit arbitrage in the Canadian bond market. As individual investors are not found to be the marginal investor in either period, changes in personal income taxes are unlikely to have affected bond yields or equilibrium bond market prices.

The failure of bond prices to capitalize either personal or corporate taxes in recent years means that after-tax bond returns for individuals and corporations will change as tax rates change,
so the entire burden of tax changes is borne by the non-tax exempt holders of bonds, as opposed to bond issuers. As a result, tax changes should not affect government financing costs through the tax capitalization channel.

The estimated degree of tax capitalization also has implications for estimates of the yield curve. Tax-related coupon effects are considered to be of sufficient importance that Bank of Canada estimates of the Government of Canada yield curve exclude observations for bonds that trade at large deviations from par (Bank of International Settlements, 2005, 21). The results presented here indicate that, in the recent past, there has been little tax capitalization and so pre-tax yields are largely insensitive to movements in corporate or personal income tax rates. As a result, at least since the mid-1990s, yield curve estimates are unlikely to depend on tax rates or the coupons of the bonds included in a particular sample.36

One possible explanation for the decline in the degree of tax capitalization after 1993 is an increase in the proportion of bonds held by tax-exempt bondholders. However, the percentage of Government of Canada marketable bonds held by trusteeed pension plans and social security funds actually fell, on average, from 21.8 percent in 1986-1993 to 20.7 percent during 1994-2006, as shown in Table 3. Further, the holdings of non-residents, a group that may also be less subject to domestic taxes, fell by an even larger amount between the two periods, while the holdings of banks and other taxable financial institutions actually rose. This evidence suggests that the change in the degree of tax capitalization was not caused by changes in the distribution of bond holdings across investor types.

36 This is consistent with the suggestion of Elton and Green (1998, 1557, 1561): “The inconsequential tax and liquidity effects that we find suggest that more bonds can be included in term structure estimation. Market participants commonly narrow the pool of bonds they consider when estimating the term structure in order to use bonds they believe are unaffected by tax and liquidity effects. Our evidence implies that a larger sample of bonds can be used to estimate the term structure, which could lead to smaller estimation error. . . . The lack of substantial tax and liquidity effects in the relative prices of bonds has important implications for . . . practitioners deciding which bonds to include in their term structure estimations for use by traders.”
A second possible explanation for the change in the extent of tax capitalization is that an increase in the quantity of outstanding Canadian government debt made the market more liquid, which facilitated arbitrage. Green and Ødegaard (1997, 628) suggest that one of the reasons for the disappearance of tax capitalization in the US during the mid-1980s was that “the number of bonds and the range of maturities issued by the U.S. Treasury increased dramatically. The higher degree of market completeness this affords also makes it easier to construct arbitrage positions and to exploit quasi-arbitrage opportunities.” However, rapid increases in Canadian Federal government debt began in the mid-to-late 1980s, long before the decline in the estimates of the tax capitalization parameter.37

It is also possible that changes to the extent of competition in the fixed-income market could have altered the degree of tax capitalization as a more competitive market may lower the cost of arbitrage. However, the fixed income market does not appear to have become more competitive in the early 1990s. As recently noted by the Bank of Canada, “Standard measures of market concentration suggest that the secondary market for government securities, along with other sectors of the domestic fixed-income market, is highly concentrated” (Bank of Canada, 2004, 8). The average market share of the five largest dealers in the secondary market for Government of Canada bonds decreased somewhat in the late 1990s relative to the early 1990s, but rose sharply in recent years (Anderson and Lavoie (2004)) with no change in the implied tax rate (as indicated by Figures 2 and 3).

An alternative explanation for the fall in the degree of tax capitalization is that there was a major change in tax policy which affected behaviour in the bond market. For example, in the US bond market, Green and Ødegaard (1997) found that implicit tax rates were positive in the pre-1986

---

37 From a base of C$87 billion in 1986, the quantity of Government of Canada bonds outstanding rose to C$185 billion in 1993, a rise of C$14 billion per year on average, with the increase in each year exceeding C$10 billion.
period, but fell to zero following the 1986 US tax reform. However, in Canada there were no large
tax policy changes at the time of the decline in the degree of tax capitalization in the early 1990s.

It has also been suggested that large interest rate movements may make it more difficult to
detect tax effects in asset markets (MacKay, Prisman and Tian (2000)). However, the estimated
decline in implied tax rates does not correspond to a change in the pattern of interest rate
movements, as interest rates were relatively stable from 1992 through 1996. In fact, interest rates
were much more variable in the pre-1994 period for which a significant tax capitalization effect is
identified.

While none of the explanations cited above can explain the shift in the degree of tax
capitalization in the early 1990s, at approximately the same time as the downward shift in the estimates of the tax capitalization parameters there were many institutional changes that affected the market for Government of Canada bonds, changes that likely reduced transactions costs and increased both transparency and liquidity. For example, the introduction of benchmark-bond issues in the early 1990s increased liquidity in the government bond market (Harvey, 1999). Also, the government moved in the early 1990s to increase the proportion of marketable debt in the form of bonds, which increased liquidity in the bond market (Gravelle (1999)). The government also moved to an all auction format for bond issues in fiscal 1992-93 and adopted a regular bond auction calendar (Branion, 1995). These changes are likely to have made price discovery in the bond market easier and more transparent. The June 1993 change in regulations that facilitated the reconstitution of strip bonds, by making arbitrage easier, increased liquidity in the bond market and narrowed spreads between benchmark and other issues (Branion (1995), Halpern and Rumsey (1997, 2000)). As this change lead to a large increase in repo activity, it has also been argued that the removal of the withholding tax on foreign repo traders in May 1993 may have increased market liquidity by removing a disincentive for these traders to operate in the Government of Canada bond
market (Morrow (1994-1995)). A decline in inter-dealer broker fees also stimulated a greater proportion of inter-dealer trading to take place through inter-dealer brokers beginning in the early 1990s which lowered search costs and increased the willingness of dealers to trade (Gravelle (1999)). Changes in tax regulations in 1992, which recognized repos as loans rather than dispositions, increased the attractiveness of repos (Morrow (1994-1995)) and, in turn, made it more beneficial to hold and trade Government of Canada bonds (the asset behind most repos). Finally, the clearing and settlement of Government of Canada bond purchases became gradually electronic in the late 1980s and early 1990s, and this likely reduced transaction costs (Branion (1995)).

During the late 1980s and early 1990s, limited liquidity and transparency in the bond market, as well as high transaction costs, may have discouraged pension funds and other entities not subject to tax from actively trading in the secondary bond market. The institutional changes in the early 1990s described above, by lowering transaction costs and making the bond market more transparent and liquid, may have encouraged non-taxpaying entities to become more active traders (even if their proportion of bond holdings did not rise), so that their asset demands began to drive market prices. In this way, relatively modest changes to institutions and regulations may have had a significant impact on the pattern of tax capitalization. Nevertheless, further research is necessary before a more definite conclusion can be reached on the cause of the fall in the degree of tax capitalization in the early 1990s.39

38 However, there were no large changes in trading volumes or turnover ratios in the early 1990s. These both generally increased from 1990 through 1997 (Gravelle (1999)).
39 Policies introduced in 1998 to buy back less liquid bonds and to lower the possibility of a market squeeze (Harvey (1999)) appear to not have had much of an effect on the degree of tax capitalization (see Figures 2 and 3).
## Table 1: Tax Rates (percent)

<table>
<thead>
<tr>
<th>Year</th>
<th>$\tau_c$</th>
<th>Capital Gains ($\tau_g$)</th>
<th>Interest Income ($\tau_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>53.3</td>
<td>27.71</td>
<td>55.42</td>
</tr>
<tr>
<td>1987</td>
<td>52.07</td>
<td>26.265</td>
<td>52.53</td>
</tr>
<tr>
<td>1988</td>
<td>47.95</td>
<td>30.7593</td>
<td>46.139</td>
</tr>
<tr>
<td>1989</td>
<td>44.34</td>
<td>31.4553</td>
<td>47.183</td>
</tr>
<tr>
<td>1990</td>
<td>44.34</td>
<td>36.1703</td>
<td>48.227</td>
</tr>
<tr>
<td>1991</td>
<td>44.34</td>
<td>36.8358</td>
<td>49.1144</td>
</tr>
<tr>
<td>1992</td>
<td>44.34</td>
<td>37.3295</td>
<td>49.7727</td>
</tr>
<tr>
<td>1993</td>
<td>44.34</td>
<td>39.2588</td>
<td>52.345</td>
</tr>
<tr>
<td>1994</td>
<td>44.34</td>
<td>39.8895</td>
<td>53.186</td>
</tr>
<tr>
<td>1995</td>
<td>44.62</td>
<td>39.8895</td>
<td>53.186</td>
</tr>
<tr>
<td>1996</td>
<td>44.62</td>
<td>39.6894</td>
<td>52.9192</td>
</tr>
<tr>
<td>1997</td>
<td>44.62</td>
<td>38.7324</td>
<td>51.6432</td>
</tr>
<tr>
<td>1998</td>
<td>44.62</td>
<td>37.7161</td>
<td>50.28818</td>
</tr>
<tr>
<td>1999</td>
<td>44.62</td>
<td>36.5661</td>
<td>48.7548</td>
</tr>
<tr>
<td>2000</td>
<td>44.62</td>
<td>31.9064 (Feb-Sep)</td>
<td>47.8596</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35.8947 (Jan)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.9298 (Oct-Dec)</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>42.12</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
<tr>
<td>2002</td>
<td>38.62</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
<tr>
<td>2003</td>
<td>36.62</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
<tr>
<td>2004</td>
<td>36.12</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
<tr>
<td>2005</td>
<td>36.12</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
<tr>
<td>2006</td>
<td>36.12</td>
<td>23.2048</td>
<td>46.4096</td>
</tr>
</tbody>
</table>

### Correlation Matrix

\[
\begin{pmatrix}
\tau_c & \tau_g & \tau_i \\
\tau_c & 1 & .43192 \\
\tau_g & .43192 & 1 \\
\tau_i & .682455 & .598691 & 1
\end{pmatrix}
\]
Table 2: Estimates of the Tax Capitalization Parameters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part A: Individuals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual tax capitalization parameter (β_i)</td>
<td>.1809</td>
<td>.3190</td>
<td>-.0384</td>
</tr>
<tr>
<td>Hypothesis Tests†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test that $β_i = 1$</td>
<td>15.90</td>
<td>24.76</td>
<td>110.47</td>
</tr>
<tr>
<td>Test that $β_i = 0$</td>
<td>3.51</td>
<td>11.62</td>
<td>4.09</td>
</tr>
<tr>
<td><strong>Part B: Corporations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate tax capitalization parameter (β_c)</td>
<td>.5350</td>
<td>.9193</td>
<td>-.0858</td>
</tr>
<tr>
<td>Hypothesis Tests‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test that $β_c = 1$</td>
<td>2.71</td>
<td>.69*</td>
<td>47.00</td>
</tr>
<tr>
<td>Test that $β_c = 0$</td>
<td>3.11</td>
<td>7.81</td>
<td>3.72</td>
</tr>
<tr>
<td>Number of Observations:</td>
<td>2190</td>
<td>1257</td>
<td>933</td>
</tr>
</tbody>
</table>

Notes:

Standard errors are shown in brackets below each coefficient estimate. The standard errors are calculated using a variance estimator that provides heteroscedasticity consistent two-way cluster-robust inference, where clustering is by time period (month) and bond pair. See Thompson (2006) and Cameron, Gelbach and Miller (2006) for details.

† The test statistics are t-statistics calculated using the two-way cluster-robust standard errors.

* The hypothesis is not rejected using a 95 percent confidence interval.
Table 3: Share of Holdings of Outstanding Government of Canada Marketable Bonds  
(percent of total, period averages)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons and unincorporated business</td>
<td>8.4</td>
<td>7.5</td>
<td>-.9</td>
</tr>
<tr>
<td>Non-financial corporations including government business enterprises</td>
<td>0.9</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Bank of Canada</td>
<td>7.0</td>
<td>6.8</td>
<td>-0.2</td>
</tr>
<tr>
<td>Government and financial government business enterprises</td>
<td>6.6</td>
<td>9.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Trustees pension plans and Social security funds</td>
<td>21.8</td>
<td>20.7</td>
<td>-1.1</td>
</tr>
<tr>
<td>Chartered banks and near-banks</td>
<td>7.6</td>
<td>15.2</td>
<td>7.6</td>
</tr>
<tr>
<td>Life insurance and other financial institutions</td>
<td>13.4</td>
<td>14.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Non-residents</td>
<td>34.0</td>
<td>24.9</td>
<td>-9.1</td>
</tr>
</tbody>
</table>


- Includes mutual funds. Cansim series: V33483+V34179-V33484.
- Cansim series V33236.
- Cansim series V33689.
- Cansim series: V34085+V34589.
- Cansim series: V33736.
- Includes Life insurance business; Segregated funds of life insurance companies; mortgages; and Total other financial institutions. Excludes mutual funds. Cansim series V34023+V34056+V34114-V34179.
- Cansim series: V34623.

Shares are calculated by dividing by Total Holdings (Cansim series: V34786-V33484).
Figure 1: Tax Rates

[Graph showing tax rates for Corporate Tax, Capital Gains, and Interest Income from 1986 to 2006.]

- Corporate Tax
- Capital Gains
- Interest Income
Figure 2: Year-By-Year Corporate Tax Rate Estimates
Figure 3: Year-By-Year Individual Income Tax Rate Estimates
### Appendix A: Descriptive Statistics

<table>
<thead>
<tr>
<th>Description</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bonds:</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Number of bond pairs:</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Number of bond pair observations:</td>
<td>2190</td>
<td></td>
</tr>
<tr>
<td>Sample period:</td>
<td>1986-2006</td>
<td></td>
</tr>
<tr>
<td>Coupon of high coupon bond in pair:</td>
<td>11.824</td>
<td>4.25 – 15.00</td>
</tr>
<tr>
<td>Coupon of low coupon bond in pair:</td>
<td>7.875</td>
<td>3.0 – 13.0</td>
</tr>
<tr>
<td>Amount issued of each bond (millions $CAN):</td>
<td>2752.8</td>
<td>22.5 – 15,000.0</td>
</tr>
<tr>
<td>Yield to maturity of high coupon bond in pair:</td>
<td>7.670</td>
<td>2.279 – 13.549</td>
</tr>
<tr>
<td>Yield to maturity of low coupon bond in pair:</td>
<td>7.514</td>
<td>2.268 – 13.223</td>
</tr>
<tr>
<td>Months to maturity:</td>
<td>51.1</td>
<td>13 – 132</td>
</tr>
<tr>
<td>Personal income tax rate on other income excluding surtaxes (percent):</td>
<td>44.2</td>
<td>40.16 – 51.0</td>
</tr>
<tr>
<td>Personal income tax rate on other income including surtaxes (percent):</td>
<td>49.3</td>
<td>46.1 – 55.4</td>
</tr>
<tr>
<td>Personal income tax rate on capital gains excluding surtaxes (percent):</td>
<td>28.3</td>
<td>20.1 – 34.4</td>
</tr>
<tr>
<td>Personal income tax on capital gains including surtaxes (percent):</td>
<td>31.7</td>
<td>23.2 – 39.9</td>
</tr>
<tr>
<td>Personal income tax on capital gains as a share of tax on other income (percent):</td>
<td>64.2</td>
<td>50 – 75</td>
</tr>
</tbody>
</table>
Appendix B: A Modified Model

The following bond pricing formula allows the price of a bond \((P_A)\) and the present discounted value of the coupon payments and capital gain associated with the bond to differ by a function \(Z(X_A)\):

\[
P_A = C_A (1 - \beta_i \tau_i) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_i) + 100d_i(t_M, \beta_i \tau_i) - (100 - P_A)\beta_i \tau_g d_i(t_M, \beta_i \tau_i) + Z(X_A)
\]  

(A1)

where \(X_A\) is a vector of variables associated with Bond A, such as a measure of bond liquidity, and all other variables are defined as for equation (1) of the text. The reason for including the \(Z(X_A)\) term is to avoid forcing all pricing errors into the tax capitalization parameter estimates. If the \(Z\) function is excluded from the estimating equation, all pricing errors will potentially be reflected in the \(\beta\) parameter estimate even if the pricing errors are not specifically related to taxes. Re-writing this formula, so that the price appears only on the left-hand side, yields:

\[
P_A = \frac{C_A (1 - \beta_i \tau_i) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_i) + 100(1 - \beta_i \tau_g) d_i(t_M, \beta_i \tau_i) + Z(X_A)}{1 - \beta_i \tau_g d_i(t_M, \beta_i \tau_i)}.
\]  

(A2)

Suppose there exists a second bond (Bond B) with the same maturity date, but a different coupon. The price of this bond will be given by:

\[
P_B = \frac{C_B (1 - \beta_i \tau_i) \sum_{m=1}^{M} d_i(t_m, \beta_i \tau_i) + 100(1 - \beta_i \tau_g) d_i(t_M, \beta_i \tau_i) + Z(X_B)}{1 - \beta_i \tau_g d_i(t_M, \beta_i \tau_i)}.
\]  

(A3)

Using equation (A3) to substitute out for \(\sum_{m=1}^{M} d_i(t_m, \beta_i \tau_i)\) in (A2) yields:

\[
C_B P_A - C_A P_B = \frac{(C_B - C_A)100(1 - \beta_i \tau_g) d_i(t_M, \beta_i \tau_i) + C_A Z(X_A) - C_B Z(X_B)}{1 - \beta_i \tau_g d_i(t_M, \beta_i \tau_i)}.
\]  

(A4)

This model can be estimated in the same fashion as equation (4) once \(Z(X)\) has been specified.
References


