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ABSTRACT

Tax Arbitrage with Risk and Effort Aversion -- Swedish Lottery Bonds 1970-1990

Swedish lottery bonds are valuable tax shelters before the tax reform of 1991. By trading around the coupon lottery, high-tax investors with capital gains from the stock market shift their tax liability to low-tax investors. The uncertainty of the coupon lottery and the effort of

verifying the winning lottery bond numbers are a nuisance to tax traders. We investigate how the Treasury (issuer), market makers (banks), and lottery bond investors respond to those frictions.

JEL Classification: G12 and G18
Keywords: ex-dividend day, lottery number checking, rationing, tax arbitrage, turn-of-the-year effect and underpricing

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1 Introduction

Swedish lottery bonds are government obligations which make coupon payments by lottery. The aggregate payment to all lottery bond holders is a fixed contractual amount that does not depend on the state of the economy. Therefore, the uncertain outcome of the coupon lottery is diversifiable risk that, according to standard asset pricing theory, should not matter to lottery bond prices. Contrary to this prediction, Green and Rydqvist (1997) conclude that the marginal lottery bond investor is risk averse. Their conclusion is also curious from a practical point of view because the coupon lottery has been constructed to attract investors with lottery preferences. If the marginal investor is risk averse, then the issuer loses from issuing bonds with coupon payments determined by lottery.

In a subsequent paper, Green and Rydqvist (1999) show that marginal tax rates can be imputed from ex-lottery day returns. The tax arbitrage is a simple coupon-capture strategy. A high-tax investor with a capital gain from the stock market purchases lottery bonds cum-lottery and sells them at a loss ex-lottery. The capital loss is covered by the tax-free proceeds from the coupon lottery. A low-tax investor takes the other side of the trade, sells lottery bonds cum-lottery and buys them back ex-lottery. Through these transactions, the capital gain from the stock market is transferred from the high-tax investor to the low-tax investor through the lottery bond market, thus resulting in an overall tax reduction.

At glance, the two previous studies of the Swedish lottery bond market analyze unrelated economic problems. However, we show in this paper that the two papers are intimately related, namely that a risk averse tax trader is the marginal lottery bond investor. A simple way to diversify the uncertainty of the coupon lottery is to form a lottery bond mutual fund and sell mutual fund shares to lottery bond investors. This strategy works for buy-and-hold investors, and banks do supply lottery bond mutual funds during the high days of the 1980s (Akelius (1987)). However, a buy-and-hold mutual fund does not meet the demand of a tax trader, who must coordinate with other investors with a need to shield tax liability at a particular point of time. Therefore, the tax trader must cope with the uncertainty of the coupon lottery himself. If the tax trader is the marginal investor, we expect to find a risk premium in lottery bond prices.

Tax-motivated trading of lottery bonds begins on a large scale with the publication of Akelius (1974), and it ends with the tax reform of 1991. Green and Rydqvist (1997) study the electronically available time-series from November 1986–1990 that covers a small portion of the high-activity period. We purchase hard copies of transaction records and backdate the time-series to cover the entire period from 1970–1990. With the extended data set, we can statistically relate market-based measures of risk aversion to marginal tax rates to stock market performance. Specifically, a lottery bond has one series number and one order number. The holder of a complete bond series that covers all order numbers from 1–1000 earns a portion of the expected coupon with certainty. Risk aversion can be inferred from the price difference between a complete bond sequence and a portfolio of the equivalent number of bonds out of sequence (Green and Rydqvist (1997)). Marginal tax rates follow from the observation that lottery bond prices drop by more than the expected coupon payment over the coupon lottery (Green and Rydqvist (1999)). The correlation between the sequenced bond premium, the price drop over the coupon lottery, and lagged stock market performance suggests that the tax trader is the marginal lottery bond investor.

With the extended data set, we also generate other new results. One novel feature is the behavior of ex-lottery day returns over the course of the calendar year. In the first quarter, tax traders are willing to incur capital losses in the amount of 1.9 times the lottery mean while, in the fourth quarter, the average capital loss is 3.4 times the lottery mean. The marginal tax rate that can be imputed from those numbers is 46% in the first quarter and 70% in the fourth quarter. Clearly, competition for tax shelters increases towards the end of the year. The calendar-time effect in ex-lottery day returns resembles the turn-of-the-year effect for small cap stocks (e.g., Keim (1983) and Reinganum (1983)), and we offer a real-option explanation.[1] A corresponding calendar-time effect in ex-dividend day returns has not been found in the stock market. One explanation is that abnormal ex-dividend day returns reflect the transaction costs of market makers (Kalay (1982) and Boyd and Jagannathan (1994)). Since there is no reason for transaction costs to vary over the calendar year, ex-dividend day returns do not vary either. In the Swedish lottery bond market,

[1]There are other examples of increased tax planning towards the end of the fiscal year. For example, contributions to individual retirement accounts (IRA) are higher after the end of the income year before the tax return is due on April 15 (see Feenberg and Skinner (1989)).

market makers cannot eliminate the negative expected returns over the coupon lottery because short sales are infeasible (Green and Rydqvist (1999)). In conclusion, the apparent calendar-time effect in the lottery bond market, therefore, supports the transaction-cost interpretation of abnormal ex-dividend day returns.

A second novel feature stems from market-based evidence of effort aversion. Lottery bonds are bearer securities and investors must manually verify the winning lottery bond numbers. The holder of an unbroken bond sequence can verify in one shot whether any of the bonds in the sequence is winning. Consequently, the more broken up the lottery bond portfolio, the more effort the bondholder must put into lottery number checking. Lottery bonds are issued in blocks of unbroken 500-bond sequences and 100-bond sequences. Packages that consist of two 500-bond sequences are referred to as D-sequences (Roman numeral for 500) and packages of ten 100-bond sequences as C-sequences (Roman numeral for 100). In matched intra-day comparisons, D-sequence prices are mostly above or equal to C-sequence prices. The D-premium emerges in the early 1970s and, for a short period from 1973–1975, it averages 2% of par value. We interpret this price difference as a premium for effort aversion because verifying the winning lottery bond numbers of two 500-bond sequences requires less effort than dealing with ten 100-bond sequences. The premium for D-sequences over C-sequences may appear esoteric to non-lottery-bond scholars, but it provides an example of the price effects of information and how financial institutions arise to solve information problems. In *Wealth of Nations*, Adam Smith tells the story of the Bank of Amsterdam, which was established in 1609 to verify the intrinsic metal content of some 300 silver coins and 500 gold coins that circulated in the Netherlands at the time. In the lottery bond market, the D-premium disappears from 1978–1986 when trading volume shoots up. Like the Bank of Amsterdam, Swedish banks service investors with lottery number checking when trading volume is large enough to justify the personnel costs. For a professional lottery number checker, a C-sequence appears to be a perfect substitute for a D-sequence.[2]

Third, our paper is a case study of the performance of a regulated financial market. Before 1981, supply is rationed and new lottery bonds are underpriced. We estimate that lottery bonds are sold

[2]The D-premium also resembles the higher commission charged by odd-lot stock brokers.

in the primary market approximately 6% below the secondary market price. This complements evidence from numerous studies of initial public offerings of stocks (see, e.g., Ritter (2003) for a survey), and the reason may be the same. According to Treasury officials, the purpose of rationing is to disperse bond ownership, which is believed to stabilize demand for future lottery bond issues (Akelius (1980)).[3] In other words, the issuer is willing to incur the cost of rationing in return for long-term liquidity provision.[4] To further disperse bond ownership, the issuer also breaks up bond sequences into mixed bonds. A price spread between sequenced and mixed bonds in the amount of 4% of par value emerges from the beginning of the secondary market. This cost is borne by the issuer. From 1981–1990, when the primary market is allowed to clear, there is no underpricing, and the sequenced-bond premium does not emerge until several months later. In the deregulated environment, lottery bond investors pay the full sequenced bond price when they purchase mixed bonds in the secondary market. The sequenced-bond premium arises when mixed bonds are resold in the secondary market so, from 1981–1990, the cost of breaking up sequenced bonds into mixed bonds is borne by the buyers of mixed bonds in the secondary market (Green and Rydqvist (1997)).

Fourth and finally, lottery bonds that used to be widespread in the 1800s have largely disappeared from modern financial markets. The literature on lottery bonds is, therefore, limited to a few studies of Denmark, pre-revolution Russia, and Sweden.[5] Why were lottery bonds issued in the past? There is a longstanding tension between central governments' desire to control gambling, and citizens' demand for gambling. In the 1800s, lottery bonds were issued by states and municipalities or under state sanction granted to companies such as the Panama Canal Company and the Suez Canal Company (Levy-Ullman (1896)). Hence, central government's exploited their monopoly power over gambling to borrow at favorable terms. As state lotteries have become abundant during the 1900s, the primary reason to bundle a loan (principal) with lottery tickets (coupons) no longer exists and, as illustrated by the evidence in our paper, those interested in purchasing the principal are not particularly interested in purchasing the lottery tickets. Accordingly, lottery bonds may be

[3]The official name is the Swedish National debt Office, which we refer to the Treasury for convenience.

[4]For similar reasons, bidding in US Treasury auctions is restricted to a small set of primary dealers who, in return for this favor, must promise to purchase securities in future auctions.

[5]See, respectively, Florentsen and Rydqvist (2002), Ukhov (2005), and elsewhere cited Green and Rydqvist (1997) and Green and Rydqvist (1999).

condemned to financial history.[6]

The rest of the paper is organized as follows: Section 2 describes the institutional background and the data. The tax arbitrage is analyzed in Section 3, and the sequenced bond premium in Section 4. Section 5 concludes the paper.

2 Institutional Background & Data

2.1 Swedish Lottery Bonds 1970–1990

The Swedish lottery bond market becomes active during a short period from 1970–1990, when annual turnover of lottery bonds increases from a few percent per year to above 50% in 1986 before turnover reverts back to its low historical level after 1990. The interest for trading in lottery bonds begins with the publication of Akelius (1974), who explains in a simple manner how investors can take advantage of tax features of lottery bonds to reduce personal income tax. When tax trading of lottery bonds begins, Swedish financial markets are inactive. The stock market is in deep sleep before 1980 when capital controls are loosened and foreign investors are allowed to enter, and the bond market has been shut down since Wold War II. The lottery bond market is the only secondary market for fixed-income securities before credit controls are removed in the early 1980s and the regular treasury market is restarted.[7]

Lottery bonds are non-callable, Swedish government obligations that make coupon payments by lottery.[8] Each bond makes two or three coupon payments per year. Time to maturity from issuance varies between five and ten years, so over its life time, a lottery bond conducts between 10 and 30 coupon lotteries. The principal is paid back to investors at maturity. Lottery bonds are bearer securities. They are designed for the retail market and issued in small denominations of 50, 100, and

[6]While lottery bonds have largely ceased to exist, governments in some countries supply savings accounts with interest determined by lottery, e.g., Argentina, Denmark, France, and United Kingdom (Lobe and Hölzl (2008)). Bonds with redemption lottery, e.g., corporate bonds with sinking fund provision, continue to be issued. Studies of redemption lottery bonds include Schilbred (1973) and Bühler and Herzog (2008).

[7]During the regulation period, the discount rate of the Central bank is the only interest-rate time-series against which to compare lottery bond coupon rates and yields. The discount rate does not respond to short-term changes in market conditions.

[8]All lottery bonds issued from 1942–1955 with 20 years to maturity or no pre-set time to maturity are callable after ten years.

200 kronor.[9] Recent lottery bonds have par values 1,000 and 10,000 kronor. Between one and three loans are issued each year. We refer to each bond by issue year and loan number. For example, bond 1974:2 denotes the second loan of the bond issued in 1974. From 1970–1990, the outstanding loan stock averages 9% of Swedish Government debt and 3.5% of Gross Domestic Product. Institutional information about the lottery bond market is taken from the Annual Yearbook of the Swedish National Debt Office 1920–1984, issue prospectuses for the various loans, and the two editions of Akelius (1974) and Akelius (1980).

2.2 Coupon Lottery

Each bond within a lottery bond issue has a series number and an order number. The structure of the coupon lottery of 1974:2 is shown in Table 1. There are 4,000 series with 1,000 order numbers within each series, so the number of bonds outstanding is four million. The coupon lottery pays 3,090 prizes between 400 kronor and 320,000 kronor. These prizes are randomized across all bonds without replacement. Each such prize is awarded by drawing one series number and one order number. The lottery also pays 80,000 small prizes in the amount of 50 kronor each. The small prizes are randomized across the 1000 order numbers in each series. Since there are 4,000 series and 80,000 small prizes, a total of 20 small prizes are distributed among the 1000 order numbers of each series. The holder of a complete bond sequence with all order numbers 1–1000 is certain to win the 20 small prizes of 50 kronor. We refer to this feature as the partial guarantee. For this bond, the annualized certain return from the small payments is 2% of par, and the annualized expected return from the coupon lottery is 5.15%. The guaranteed portion to the holder of a complete 1000-bond sequence is 38.83% (the ratio of 2% and 5.15%). The par value of a 1000-bond sequence is 100,000 kronor.

The dual structure of the coupon lottery with series numbers and order numbers has its roots in the technology to generate and distribute the winning lottery bond numbers. The payments of the 3,090 large prizes between 400 kronor and 320,000 kronor require that the issuer generates 3,090

[9] Purchasing power has decreased by approximately eight times since 1975 and the exchange rate between the krona and the dollar has varied around eight kronor to the dollar, so we can think of the purchasing power of 100 kronor in 1975 as 100 dollars in 2010.

Table 1: Coupon Lottery of Bond 1974:2

Prize (kronor)	Number	Probability	Expectation (kronor)	Variance (kronor)
320,000	2	0.0000005	0.160	51,199
80,000	8	0.0000020	0.160	12,799
40,000	12	0.0000030	0.120	4,799
20,000	28	0.0000070	0.140	2,799
8,000	150	0.0000375	0.300	2,398
4,000	350	0.0000875	0.350	1,398
800	900	0.0002250	0.180	143
400	1,640	0.0004100	0.164	65
50	80,000	0.0200000	1.000	45
0	3,916,910	0.9792275	0.000	6
Sum:	4,000,000	1.0000000	2.575	75,653

The table shows the structure of the semi-annual coupon lottery for bond 1974:2. Prizes are quoted net of 20% lottery tax.

series numbers and 3,090 order numbers, while the payments of the 80,000 small prizes require only 20 order numbers that are equal across all series. Before 1963, the winning numbers are generated manually by drawing numbered balls from two cylinders, one for series numbers and one for order numbers. Generating the numbers could last more than one day (Akelius (1980)). From 1963, the winning lottery bond numbers are computer generated and the marginal cost of generating additional numbers is zero. However, distributing a large set of winning numbers is costly. The winning numbers are printed in a pamphlet and mailed to bondholders. From 1982, banks also receive the list of winning numbers on floppy disk. The list of the winning numbers of the 3,090 large prizes are put into a table that covers four pages (approximately letter size). The list of the 20 order numbers that identify the winners of the small prizes are put in a separate table at the end of the pamphlet. Distributing 80,000 small prizes with only 20 order numbers reduces the costs of generating, printing, and mailing. With expanding issue volume and increasing number of prizes, the two smallest prizes of lottery bonds 1975–1978 and the three smallest prizes of lottery bonds 1979–1980 are distributed by drawing order numbers only.

From 1981–1990, a bond sequence with the partial guarantee is reduced to 100. To illustrate the new procedure, suppose there are 20 small prizes as in Table 1 above. Two order numbers $a, b \in [1, 100]$ are generated. The small prizes are paid to owners of lottery bonds with order numbers:

$$a, b, 100 + a, 100 + b, 200 + a, 200 + b, \cdot\cdot\cdot\cdot\cdot, 900 + a, 900 + b.$$

Accordingly, the owner of a 100-bond sequences earns two of the 20 small prizes with certainty. Finally, to reduce handling costs, a portion of lottery bonds 1984–1987 is pre-packaged into 100-bond sequences, i.e., one ownership certificate represents a complete 100-bond sequence.

2.3 Primary Market

Lottery bonds are sold through a fixed-price offer. Before the general sales begin, holders of maturing bonds can convert old bonds into new bonds at par.[10] The average take-up ratio is 82%. Old bondholders also have an option to purchase one new bond for each old bond at par.[11] This option is exercised by 68% of old bondholders. From 1970–1980, on average, 23% of the lottery bond issue is placed with old bondholders, 9% is sold to registered lottery bond consortia, and 68% is sold to the general public.[12]

A time line around the redemption of an old bond and the flotation of a new bond is shown in Figure 1. After the final coupon lottery, old bondholders can convert maturing bonds into new bonds during a two-week conversion period. Secondary market trading stops after the conversion period, but the old bond remains listed until non-converted bonds have been redeemed. An offer prospectus with the terms of the new bond is presented to the market shortly before the conversion

[10] The conversion option means that lottery bonds are floating rate securities with the interest rate being reset every five or ten years. From 1986, maturing bonds are redeemed for cash. Green and Rydqvist (1999) study the behavior of lottery bond yields after the change of redemption policy.

[11] When 50-kronor bonds are converted into 100-kronor bonds, the bondholder can choose to pay for one new bond with two 50-kronor bonds or one 50-kronor bond plus 50 kronor cash. The same principle applies to the conversion of 100-kronor bonds into 200-kronor bonds. When 50-kronor bonds are converted into 200-kronor bonds, the bondholder chooses between paying with four 50-kronor bonds and one 50-kronor bond plus 150 kronor cash.

[12] A lottery bond consortium must have a minimum number of members, it must register with the Treasury and express in writing that it intends to become a long-term bondholder. In return for these restrictions, lottery bond consortia can finance the lottery bond purchase with a loan from the Central Bank, they can order by mail, and they can purchase sequenced bonds (more below). From 1968:2–1980, on average, 500 lottery bond consortia purchase lottery bonds in each new offering.

period. The offer prospectus specifies the par value, coupon rate, lottery structure, redemption year, and the approximate number of lotteries over the new bond's life time. Shortly before the general sales, the offer price is determined. Most bonds issued in 1970–1980 are sold at a premium above par. The average offer premium is 1.9% and the range of the offer premium is 0–4%. The Treasury sells 6% of the new bonds directly. Banks sell the remaining bonds on commission (best-effort contract).[13] Secondary market trading begins approximately two months after the offer prospectus has been issued.

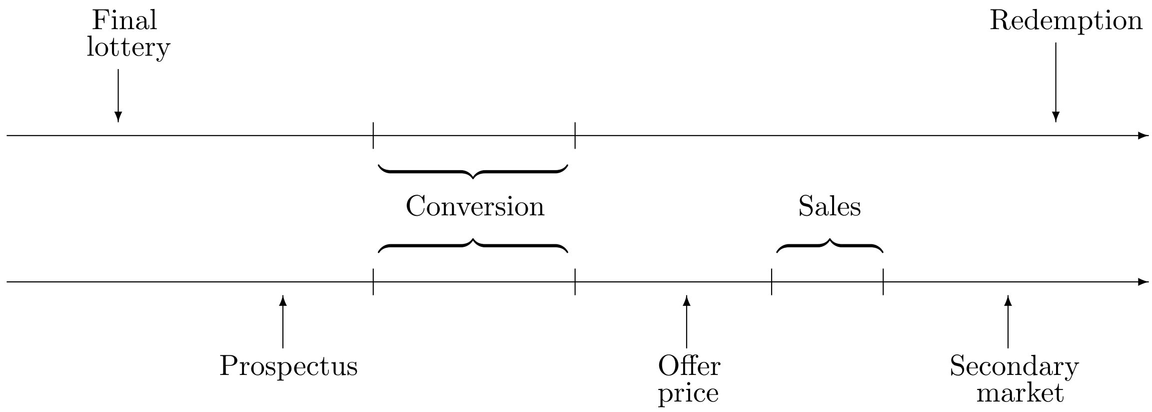
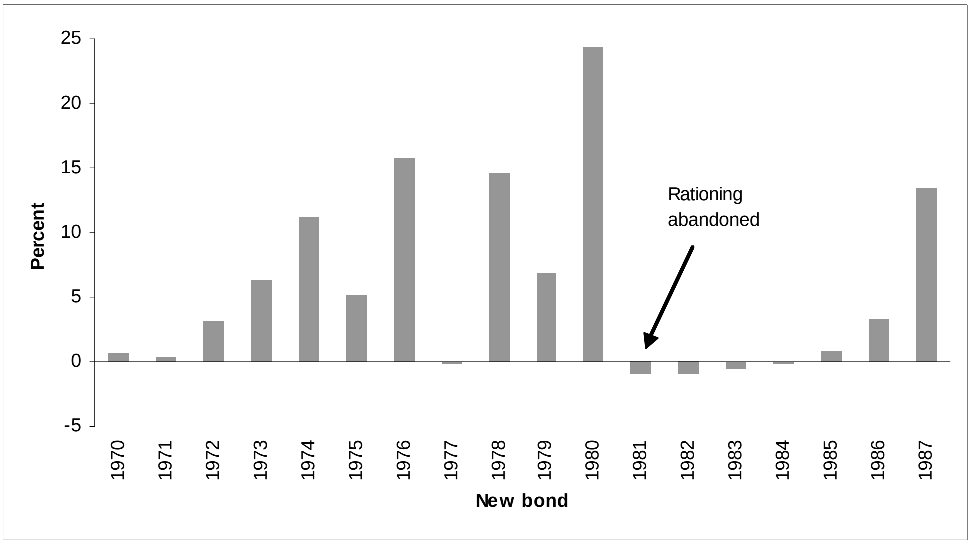


Figure 1: Time Line around Redemption and Flotation: The upper vector represents the time line for a maturing bond, and the lower vector the time line for a new bond. On average, four months elapse from the final lottery to redemption, and two months from the issuance of the offer prospectus to the opening of the secondary market.

From 1963–1980, the Treasury rations supply. The objective of rationing is to disperse ownership, which the Treasury believes stabilizes long-term demand. Akelius (1980) reports from conversations with Treasury officials that the Treasury aims at holding back supply by 10-15% below anticipated demand. In direct sales by the Treasury to the general public, the Treasury offers a small number of bonds per buyer. The initial quota is 25 or 50 bonds per buyer, but the quota is often reduced during the first day of sales. Akelius (1980) describes how investors line up in person over night for the opportunity to buy new bonds the next day. It is not known how the banks allocate the new bonds among its customers, but we conjecture that banks favor their best customers as they tend to do in initial public offerings of stocks. Rationing ends in 1981.

[13]In the 1950s, new lottery bond issues were partly underwritten.

Figure 2: Conversion Premium



The figure shows the time-series of the conversion premium in percent of par. The conversion premium is estimated as the average market price of mixed and sequenced bonds over par.

Effective rationing requires that lottery bonds are underpriced. Underpricing can be estimated as the market price of old bonds over par during the conversion period. The time-series of the conversion premium is shown in Figure 2. From 1970–1980, the conversion option is in the money most of the time. The average conversion premium is 8% and the range is -0.1% to 24.3%. Since the average conversion premium exceeds the average offer premium in the general sales, we conclude that the new bonds are underpriced. After rationing is abandoned, the conversion premium is near zero. Rationing is temporarily reinstated for the two lottery bond issues in 1987, which are reserved for the holders of maturing bonds 1977:1–3 and 1982:1–3. The average conversion premium for those two bonds is 12%.

From 1963–1980, the Treasury also pursues a mixed-bond policy. Fresh out of prints, lottery bonds come in ordered sequences. However, the Treasury breaks up all lottery bond series into sequences of 100 bonds and disperses 100-bond sequences among the banks. The best a bank can do to replicate a complete 1000-bond sequence is to combine 100-bond sequences from ten different series into a broken 1000-bond sequence that covers all order numbers from 1–1000. This package is named a C-sequence. It is an example of a financial innovation in response to regulation.

From 1967–1976:1, the Treasury makes an exception for holders of complete 1000-bond sequences of maturing bonds. These are labeled S-sequences.[14] Old bondholders can convert each old S-sequence into two 500-bond sequences that cover all order numbers from 1–500 and 501–1000. This package is referred to as a D-sequence.[15] From 1968:2–1976:1, lottery bond consortia can also purchase unbroken 500-bond sequences and D-sequences under certain conditions.[16] From 1976:2–1980, the mixed-bond policy is tightened. Unbroken 500-bond sequences and D-sequences are not issued because many lottery bond consortia that have agreed to become long-term bondholders sell their bonds shortly after the secondary market opens (bond flipping). Henceforth, lottery bond consortia must purchase C-sequences, and maturing D-sequences are converted into C-sequences. The mixed-bond policy also ends in 1981.

Table 2: Standard Bond Sequences of 1974:2

Sequence	Series numbers	Order numbers
50	1	1–50, 51–100, 101–150, $\cdots$, 951–1000
100	1	1–100, 101–200, 201–300, $\cdots$, 901–1000
500	1	1–500, 501–1000
1000 C	10	1–1000
1000 D	2	1–1000
1000 S	1	1–1000

A standard bond sequence has one series number and the range of order numbers indicated in the table. A C-sequence is composed of 10 sequences of 100 bonds from different series, a D-sequence of two sequences of 500 bonds from different series, and a S-sequence of one sequence of 1000 bonds. All other combinations are referred to as mixed bonds.

As a result of Treasury policy, lottery bonds trade in many forms. Table 2 lists standard bond sequences of 1974:2. A standard bond sequence must have the same series number and a specific range of order numbers. A complete 1000-bond sequence that covers all order numbers from 1-1000

[14] New S-sequences are not issued from 1963 after a conspicuous price spread has emerged between S-sequences and mixed bonds for bond 1961. S-sequences rarely trade except for this bond where 25% of the loan amount are S-sequences. According to a Treasury official, S-sequences are abolished because the Treasury finds it inequitable that only wealthy households can purchase the higher valued package.

[15] The par amount of old S-sequences converted into new D-sequences averages to 5% of the new par amount. The range of this statistic across lottery bond issues is 1–17%.

[16] A lottery bond consortium with ten members can purchase unbroken 100-bond sequences. If the number of members is 15, the consortium can purchase 500-bond sequences, and a consortium of 20 members with no single member owning more than 10% can purchase D-sequences.

can consist of ten 100-bond sequences with different series numbers (C-sequence), two 500-bond sequences with different series numbers (D-sequence), or one 1000-bond sequence with the same series number (S-sequence).[17] Bondholders can also construct non-standard combinations such as twenty 50-bond sequences that cover all order numbers from 1–1000, but this combination is treated as a portfolio of 50-bond sequences in transactions with other investors.

2.4 Taxation

Lottery bonds generate tax liability from coupon income and capital gains. Coupon income is tax exempt, while capital gains are taxed as personal income. Short-term capital gains are fully taxed, while long-term capital gains are partly or entirely exempt.[18] The taxpayer can offset capital losses on lottery bonds against capital gains on stocks, real estate, and various other assets, but excess capital losses must not offset other income. The loss deduction must be used the same income year. From 1977, capital losses can be carried forward six years. Brokerage costs and interest expense associated with holding lottery bonds are fully deductible against personal income.[19] Deductions are valuable because marginal tax rates are high. In 1974, the marginal tax rate is 52% at an annual income of 30,000 kronor. The top marginal tax rate of 78% kicks in at 150,000 kronor. These numbers can be compared to the cost of purchasing a 1000-bond sequence in the amount of 100,000–200,000 kronor.

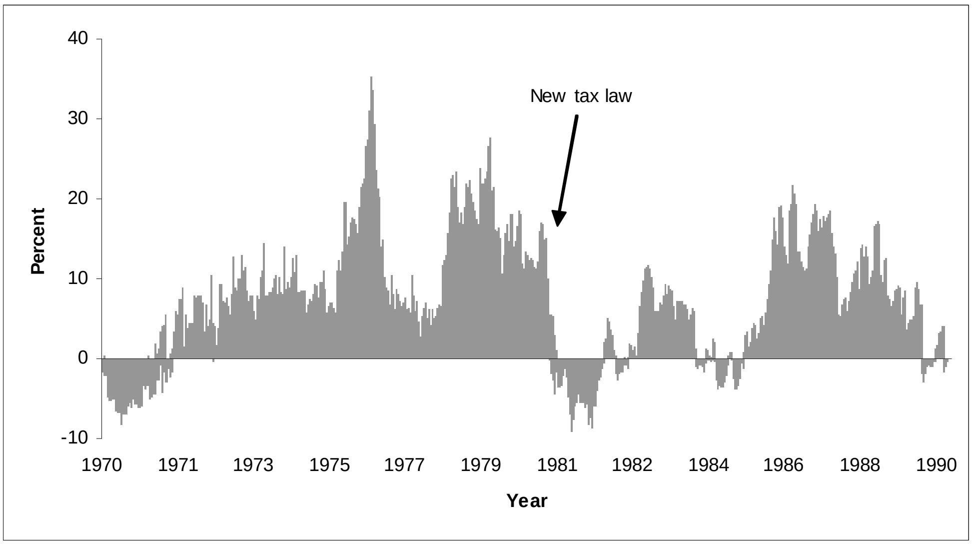
The offset rules change in 1981. The new rules stipulate that capital losses on lottery bonds can only offset capital gains on lottery bonds. Outstanding lottery bonds are grandfathered one year, and capital losses on old bonds continue to offset capital gains on publicly-traded stocks, but capital losses can no longer be deducted from capital gains on closely-held stocks, real estate, and other assets. The tax law passes the Parliament in October 1980. One year later, after a political agreement that sets out the principles for the tax reform of 1991, the grandfather clause

[17] S-sequences of 1974:2 are not issued in the primary market and must, therefore, be constructed in the secondary market by pairing two 500-bond sequences from the same series.

[18] From 1970–1990, 100% of the capital gain is taxable income if the holding period is 0–2 years, 75% if 2–3 years, 50% if 3–4 years, 25% if 4–5 years, and 0% if the holding period exceeds five years.

[19] A simple tax arbitrage that we do not study further in this paper is to lever up a buy-and-hold portfolio of lottery bonds. At a high enough marginal tax rate, the after-tax interest expense equals the guaranteed interest income from ownership of a complete bond sequence. In addition, the lottery bond investor participates in the coupon lottery for the non-guaranteed prizes.

Figure 3: Lottery Bond Price Index 1970–1990



The figure plots the average daily market price over par for C-sequences of old bonds (issued before 1981). The new tax law stipulates that capital losses on lottery bonds can only offset capital gains on lottery bonds.

is made permanent.[20] This means that losses on old bonds continue to offset capital gains on publicly-traded stocks until 1990 when the last old bond matures.

The tax law change has a dramatic impact on the lottery bond market. Figure 3 plots the average lottery bond price for C-sequences in percent of par value. The tax law change is marked. Lottery bond prices fall by 25%, trading volume is cut in half, and demand for new lottery bonds collapses. The Treasury responds with a number of changes to re-stimulate demand. *(i)* Supply is cut back from 4,300 million kronor in 1980 to only 600 million kronor in 1981. *(ii)* The coupon rate is raised from 6.48% to 7.40%. Since borrowing costs are higher, time to maturity is reduced from ten to five years. *(iii)* Rationing and the mixed-bond policy are abandoned. Henceforth, investors can purchase any number of bonds in sequence they want, lottery bonds are not underpriced (Figure 2), and new lottery bond consortia are not formed. *(iv)* The par value of a guarantee sequence is reduced from 200,000 kronor to 20,000 kronor to make the partial guarantee affordable to a broader investor population (see Section 2.2 above).

[20] In 1991, the marginal tax rate on capital losses on lottery bonds is reduced to 21%. This change largely removes the incentive to generate capital losses in the lottery bond market (see Green and Rydqvist (1999)).

2.5 Secondary Market & Data

Lottery bonds are traded on the Stockholm Stock Exchange. From 1970–1980, mixed bonds are traded in a call auction in the morning. The Stockholm Stock Exchange publishes four prices from the call auction: the highest uncleared buy limit order, the lowest uncleared sell limit order, the highest transaction price, and the lowest transaction price. Trading continues on the floor throughout the day. Both mixed and sequenced bonds are traded in the aftermarket. For mixed bonds, the Stockholm Stock Exchange records the daily high, low, and last transaction prices from the after-market. For sequenced bonds, the daily high and low transaction prices are stored. The aggregate transaction volume throughout the day is also published. The publications are archived by the National Library of Sweden. The price and volume information is typed on large paper format (A3) with plenty of space between rows and columns. We purchase hard copies and scan the data. In the analysis below, average daily transaction prices are used.

From 1981–1990, data reporting increases multifold.[21] Data are printed electronically on small paper format (A4) with little space between rows and columns. It is not suitable for scanning, and the magnetic tape that was used to print the hard copies has disappeared. For mixed and sequenced bonds, we collect manually the best buy limit order at the end of the day and the number of bonds traded during the day. From November 1986, a subset of the data are stored electronically by Findata. These data are used by Green and Rydqvist (1997). We merge the manually collected time-series with the corresponding numbers from Findata.

Table 3 lists standard bond sequences of bonds traded in 1970–1990. Henceforth, we highlight the difference between old and new bonds by putting them into separate panels. Boldface marks a bond sequence with the partial guarantee. For bonds issued before 1960, the partial guarantee requires ownership of bonds with order numbers 1–2000.[22] For bonds issued from 1960–1980, the small prizes are distributed across order numbers 1–1000 (C-, D-, or S-sequence). For new bonds,

[21] For mixed bonds and each bond sequence, the publications contain the best buy and sell limit orders from open and from close (four prices). In addition, for mixed bonds and each bond sequence, low and high transaction prices from the call auction are reported along with high, low, and last transaction prices from the aftermarket (five prices). Finally, for mixed bonds and each bond sequence, the number of bonds traded is recorded.

[22] A 2000-bond sequence consists of 2000 bonds with the same series number (S-sequence) or two sequences of 1000 bonds with different series numbers (M-sequence).

Table 3: Traded Bond Sequences 1970–1990

	Standard bond sequence						
A. Old bonds							
1951–1954	Mix	50	100	500	1,000	**2,000 M**	**2,000 S**
1960–1976:1	Mix	50	100	500	**1,000 C**	**1,000 D**	**1,000 S**
1976:2–1980	Mix	50	100		**1,000 C**		
B. New bonds							
1981–1987	Mix	50	**100**	**500**	**1,000 C**		**1,000 M**
1986:1	Mix						
1988–1989:1	Mix	50	100				
1989:2–1990	Mix	50	**100**				

The table lists traded bond sequences. Boldface means that the sequence is entitled to the partial guarantee. For 50-kronor bonds, a M-sequence consists of two 1000-bond sequences and a S-sequence of one 2000-bond sequence. For old 100-kronor and 200-kronor bonds, a C-sequence is composed of 10 sequences of 100 bonds, a D-sequence of two 500-bond sequences, and a S-sequence of one 1000-bond sequence. For new 200-kronor bonds, a M-sequence consists of one 1000-bond sequence.

ownership of a 100-bond sequence is entitled to the partial guarantee.[23] A complete 1000-bond sequence is labeled M-sequence (the Roman numeral for one thousand).

Most lottery bond issues within the same year are very similar as they have the same coupon rate, coupon payment dates, and maturity date. To eliminate this almost perfect dependency across bonds and to fill in gaps in the time-series, we compute the equally weighted average price across the two or three bond issues within the same year and use the average price for the statistical analysis.[24]

[23] Bond 1986:1 does not have a guarantee and the three bonds 1988–1989:1 require ownership of a complete 1000-bond sequence. The latter 1000-bond sequences are not traded because they are too expensive for most investors (one million kronor).

[24] Some years, the second and third lottery bond issue has an initial lottery that is not synchronized with the lotteries of the first bond issue of the year. Then, we delete the price series before the initial lottery. Averaging is not used for the two lottery bond issues in 1964 and the two or three lottery bond issues in 1983:3–1986:2 for which the coupon payment dates are not synchronized.

2.6 Trading Volume

Table 4 reports the percent of business days with transaction volume (first row) and annualized turnover in percent of the number of bonds outstanding (second row).[25] Due to data limitations, turnover is measured from 1981–1990. Starting with the trading of old bonds (Panel A), we see that mixed bonds and short bond sequences are traded more frequently than long bond sequences (first row), but that turnover is concentrated to C-sequences (second row). Trading of 500-bond sequences, D-sequences, and S-sequences is sparse as a result of the Treasury's mixed-bond policy.[26] Trading of new bonds (Panel B)is similar except that M-sequences trade regularly (first row). Turnover of new bonds is evenly spread out and not concentrated to any particular bond sequence (second row). We see furthermore in Figure 4, that trading of C-sequences of old bonds increases

Table 4: Trading Volume

	Period	Mix	50	100	500	1,000 C	1,000 D	1,000 S/M
A. Old bonds								
Days with trade	1970–90	78.2	68.2	81.2	5.8	56.3	21.4	0.6
Turnover	1981–90	2.8	1.9	5.0	0.2	31.6	1.6	0.0
B. New bonds								
Days with trade	1970–90	73.0	79.4	95.9	27.5	41.8	n/a	55.4
Turnover	1981–90	0.7	0.8	3.9	0.5	5.9	n/a	7.8

The first row of each panel shows the percent of business days with transaction volume measured over 1970–1990. The second row reports annualized turnover in percent of bonds outstanding in 1981–1990. A C-sequence is composed of 10 sequences of 100 bonds, a D-sequence of two sequences of 500 bonds, and a S/M-sequence of one sequence of 1000 bonds.

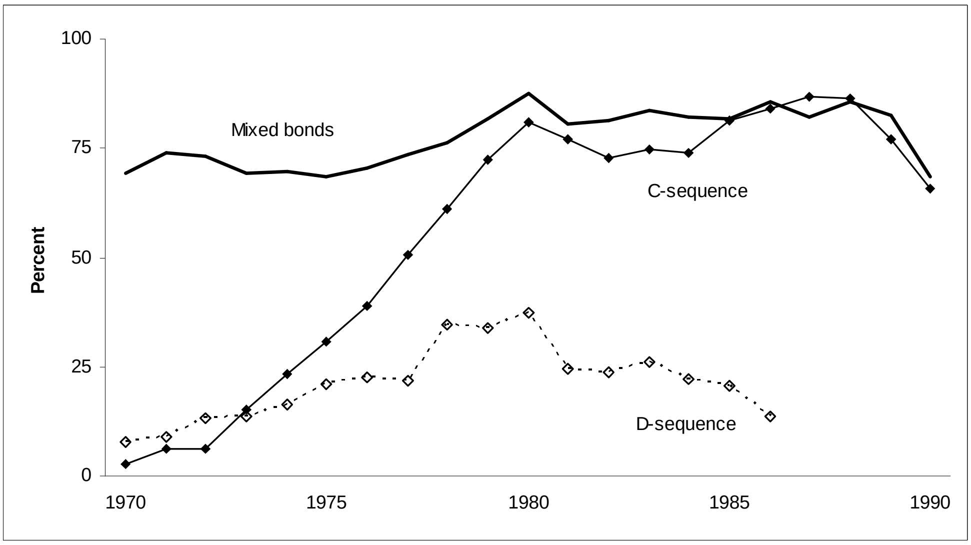
over time. Hence, lottery bond turnover increases as banks put together additional C-sequences of old bonds.

The aggregate trading volume data do not reveal average trade size (except when there is no

[25] Statistics on trading volume are based on individual lottery bond series. Due to space limitations, we omit the few transactions of 1000- and 2000-bond sequences of 1951–1955. There are 12 transactions of 1000-bond sequences, zero transactions of M-sequences, and 66 transactions of S-sequences.

[26] New 500-bond sequences cannot be constructed in the secondary market. Some D-sequences arise from combining 500-bond sequences in the secondary market and, occasionally, S-sequences are formed when lottery bond consortia exchange matching 500-bond sequences with each other. The entire data set contains 231 transactions of S-sequences. In 53 instances, the S-sequences originate from the secondary market.

Figure 4: Trading of Old Bonds



The figure plots the percent of business days in a year with transaction volume for old bonds. A C-sequence is composed of 10 sequences of 100 bonds, and a D-sequence of two sequences of 500 bonds.

transaction or only one transaction during the day), but there are good reasons to believe that mixed bonds trade in packages. About 75% of the days with transaction volume, aggregate trading volume of mixed bonds is a multiple of 50 bonds. This clustering of trade sizes suggests that bond dealers package and sell mixed bonds as "round trading lots". Many mixed-bond packages are large. The aggregate daily volume of mixed bonds exceeds 1000 bonds about 20% of the time.

3 Tax Arbitrage

Lottery bond prices are quoted with accrued interest. This means that lottery bond prices, on average, decrease over the coupon lottery. A simple tax arbitrage means that a high-tax investor with a capital gain from the stock market purchases lottery bonds cum-lottery and sells them at a loss ex-lottery. The high-tax investor covers his loss with the tax-free proceeds from the coupon lottery. A low-tax investor takes the other side of the trade, sells lottery bonds cum-lottery and buys them back ex-lottery. In this way, the capital gain from the stock market is shifted from the high-tax investor to the low-tax investor in the lottery bond market. The implications from these transactions for ex-day returns, lottery bond yields, and trading volume are studied by Green and Rydqvist (1999). Here, we extend the time-series. The calendar-time effect is a new result.

Table 5: Drop-Off Ratios and Marginal Tax Rates

	Mix	50	100	500	1,000 C	1,000 D	1,000 M
A. Old bonds							
Drop-off ratio	1.88 (0.07)	2.34 (0.07)	2.63 (0.09)	3.08 (0.15)	2.92 (0.10)	3.10 (0.13)	n/a
Marginal tax rate (%)	46.7 (1.9)	57.4 (1.3)	62.0 (1.2)	67.5 (1.6)	65.8 (1.1)	67.8 (1.4)	n/a
B. New bonds							
Drop-off ratio	1.09 (0.08)	1.22 (0.08)	1.33 (0.08)	1.16 (0.11)	1.38 (0.09)	n/a	1.35 (0.12)
Marginal tax rate (%)	8.6 (6.8)	18.3 (5.5)	24.6 (4.5)	13.7 (8.5)	27.6 (4.5)	n/a	25.7 (6.6)

The table reports average drop-off ratios and marginal tax rates using Equation (2). Robust standard errors are reported in parentheses below. The standard errors of the marginal tax rates are computed with the delta method. The estimation is based on 365 lottery days in Panel A and 159 lottery days in Panel B.

Denote the last price cum-lottery with P^c and the first price ex-lottery with P^e. The marginal tax rate is τ and the lottery mean $E(C)$. We ignore transaction costs and discounting. A risk-neutral investor breaks even when his capital loss after tax equals the expected proceeds from the coupon lottery:

$$(P^e - P^c)(1-\tau) + E(C) = 0. \tag{1}$$

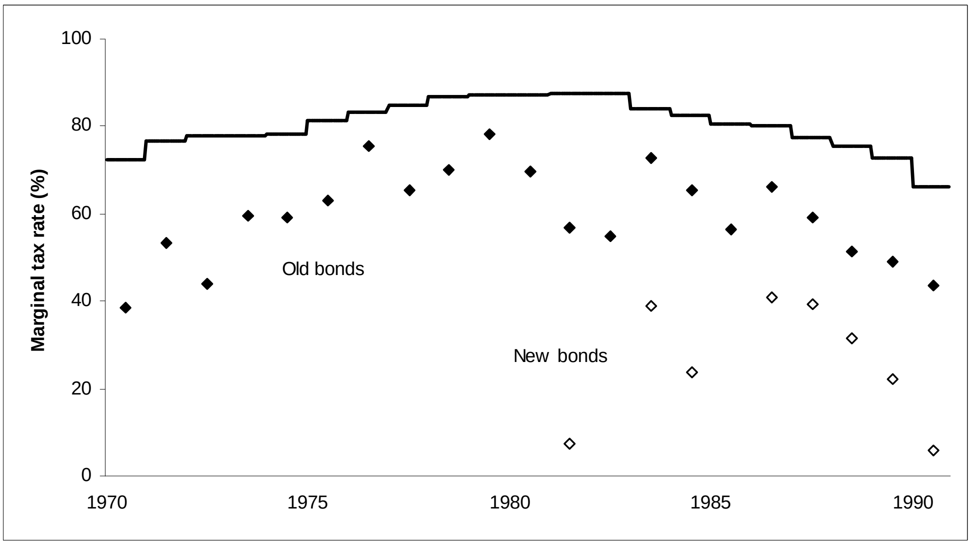
We solve for the marginal tax rate:

$$\tau = 1 - \left(\frac{P^c - P^e}{E(C)}\right)^{-1}. \tag{2}$$

The term within brackets on the right hand side is the price drop scaled by the lottery mean. This variable, often referred to as the drop-off ratio, is the dependent variable in the literature on the ex-dividend day (see Elton and Gruber (1970)).

Table 5 reports average drop-off ratios and imputed marginal tax rates for mixed and sequenced bonds. On average, the drop-off ratio exceeds one, which means that pre-tax capital losses exceed

Figure 5: Evolution of Marginal Tax Rates



The figure plots top statutory tax rates along with imputed marginal tax rates from prices of C-sequences using Equation (2).

the lottery mean. Drop-off ratios for old bonds exceed those of new bonds, but drop-off ratios exceed one also for new bonds. Drop-off ratios for longer bond sequences exceed those of shorter bond sequences and mixed bonds. In Panel A, (old bonds), the average drop-off ratio for mixed bonds is about two times the lottery mean compared to that for 1000-bond sequences (C- and D-sequences), which is approximately three times the lottery mean. Marginal tax rates for old bonds are quite high and range from 46.7% for mixed bonds to 67.8% for D-sequences. Marginal tax rates for new bonds are less and range from 8.6% for mixed bonds to 27.6% for C-sequences.

Figure 5 displays the time-series of top statutory tax rates (solid line) along with marginal tax rates of old bonds (filled diamonds) and new bonds (open diamonds) imputed from C-sequences. Marginal tax rates of old bonds fall below top statutory rates, they increase with statutory rates in the 1970s, and the decrease in the 1980s. We also see that marginal tax rates of new bonds fall below those of old bonds.

While there are many reasons why marginal tax rates can fall below top statutory rates, we first consider a real-option explanation derived from the apparent calendar-time effect reported in Table 6. The table reports drop-off ratios and marginal tax rates of C-sequences by quarter. In the

Table 6: Calendar-Time Effect

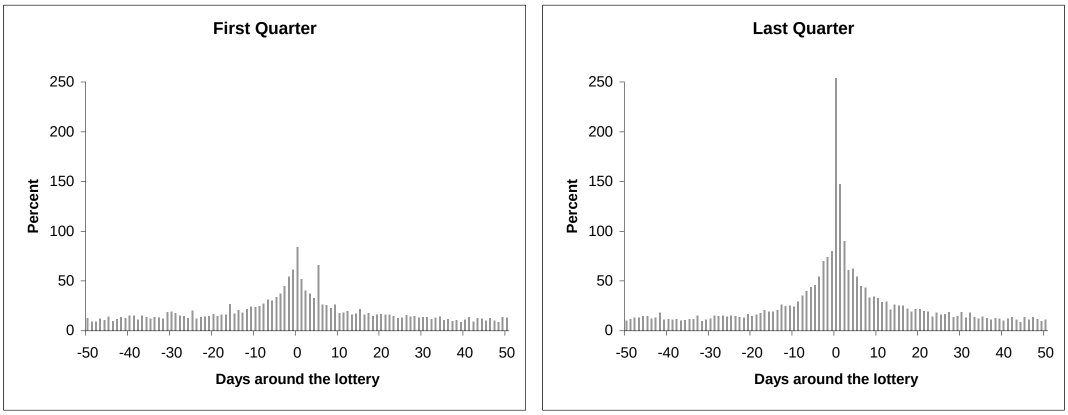
	Quarter				
	First	Second	Third	Fourth	F-test
A. Old bonds					
Drop-off ratio	1.86 (0.11)	2.81 (0.15)	3.51 (0.21)	3.35 (0.21)	16.22 (0.000)
Marginal tax rate (%)	46.4 (3.3)	64.4 (1.9)	71.5 (1.7)	70.2 (1.8)	
B. New bonds					
Drop-off ratio	1.09 (0.10)	1.25 (0.14)	1.40 (0.22)	1.80 (0.17)	3.34 (0.021)
Marginal tax rate (%)	8.4 (8.7)	20.1 (9.1)	28.7 (11.3)	44.4 (5.2)	

The table reports average drop-off ratios and imputed marginal tax rates for C-sequences by quarter. Robust standard errors are reported below in parentheses. The standard errors of the marginal tax rates are computed with the delta method. The F-statistic tests the null hypothesis that the means are equal across quarters. P-values are reported below. The estimation is based on 365 lottery days in Panel A and 159 lottery days in Panel B.

first quarter, investors pay less than two times the lottery mean compared to the last quarter when investors pay more than three times the lottery mean (Panel A). Accordingly, imputed marginal tax rates increase from less than 50% in the first quarter to 70% in the last quarter. This evidence suggests that competition for tax shelters increases over the calendar year. There is a calendar-time effect also for new bonds (Panel B). Marginal tax rates increase from 11.2% in the first quarter to 42.1% in the last quarter. Generating a capital loss in the lottery bond market is a real option, which expires at the time of the last coupon lottery in December. In the beginning of the year when real option value is high, investors are reluctant to generate capital losses in the lottery bond market. The situation is different in December, when real option value is low. Uncertainty about stock market performance has been resolved, and generating a capital loss in the lottery bond market may be one of the few remaining options to escape capital gains tax. On average, during the course of the year, the real option is valuable and, as a consequence, imputed marginal tax rates fall below top statutory tax rates.

Among other reasons why imputed marginal tax rates fall below top statutory rates, we notice the following: First, the marginal investor may not be in the top income bracket. The fact that

Figure 6: Turnover Around the Lottery



The figure shows annualized daily turnover of old bonds around the lottery in percent of the number of bonds outstanding. Day 0 is the first day ex-lottery.

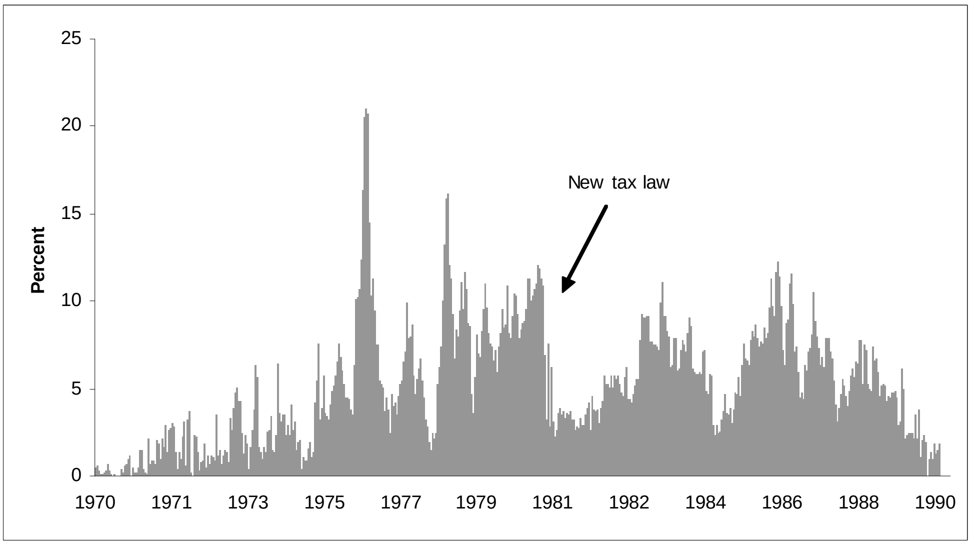
marginal tax rates from new bonds fall below those of old bonds certainly means that the marginal investor for new bonds is not in the top income bracket. Presumably, low-tax investors who supply old bonds cum-lottery shield tax liability on capital gains from old bonds with capital losses from new bonds. Second, the model ignores transaction costs and, third, it assumes risk neutrality. Given the multitude of possible explanations, we do not attempt to calibrate a real-option model, a transaction-costs model, or a risk-averse utility function to the observed difference between top statutory and imputed marginal tax rates.

The calendar-time effect is also visible in the trading volume data. Figure 6 displays annualized average daily turnover around the coupon lottery in percent of the number of bonds outstanding. Turnover of old bonds increases around the lottery, in particular in the fourth quarter. The spike on the first day ex-lottery is indicative of pre-arranged, forward trading.

4 Sequenced Bond Premium

Sequenced bonds trade at a premium above mixed bonds. The price comparison between D- and C-sequences is new.

Figure 7: Sequenced Bond Premium



The figure plots the time-series of the daily average price difference between C-sequences and mixed bonds for old bonds in percent of par.

4.1 Univariate Analysis

Sequenced bonds are generally worth more than mixed bonds. Figure 7 plots the average daily price difference between C-sequences and mixed bonds of old bonds. The sequenced bond premium is small in the beginning of the time-series. The premium subsequently increases and peaks above 25% of par value in 1976. The premium decreases by approximately 10 percentage points or by two thirds in response to the tax law change. Afterwards, the premium oscillates between five and ten percent of par value until the last old bond matures in 1990. The time-series variation reflects the supply of C-sequenced bonds that can be inferred from Figure 4 above. In 1970, C-sequences barely exist and do not trade much. As the sequenced bond premium increases, banks increase supply of C-sequences by putting together 100-bond sequences. The peak in the sequenced bond premium in 1976 occurs after Akelius (1974) has become well known, but before banks have been able to meet demand.

The sequenced bond premium for C-sequences transmits to corresponding premia for all bond sequences. Table 7 reports average price differences between sequenced bonds and mixed bonds of old bonds (top row) and new bonds (bottom row). We notice the following general patterns:

Table 7: Market Value of Sequenced over Mixed Bonds

	50	100	500	1,000 C	1,000 D	1,000 M
Old bonds	2.21	4.02	4.40	5.48	5.45	n/a
New bonds	1.27	1.80	1.90	2.01	n/a	2.47

The table reports the average price difference between sequenced and mixed bonds in percent of par. A C-sequence is composed of 10 sequences of 100 bonds, a D-sequence of two sequences of 500 bonds, and a M-sequence of one sequence of 1000 bonds.

(i) Sequenced bonds generally command a premium above mixed bonds. *(ii)* Sequenced bond premia of old bonds are larger than sequenced bond premia of new bonds.[27] *(iii)* Longer sequences of old bonds are worth more than shorter bond sequences, while longer sequences of new bonds are worth approximately the same as shorter bond sequences.[28] *(iv)* Controlling for the partial guarantee (old bonds: C and D; new bonds: 100, 500, C, and M), the sequenced bond premium is approximately equal.

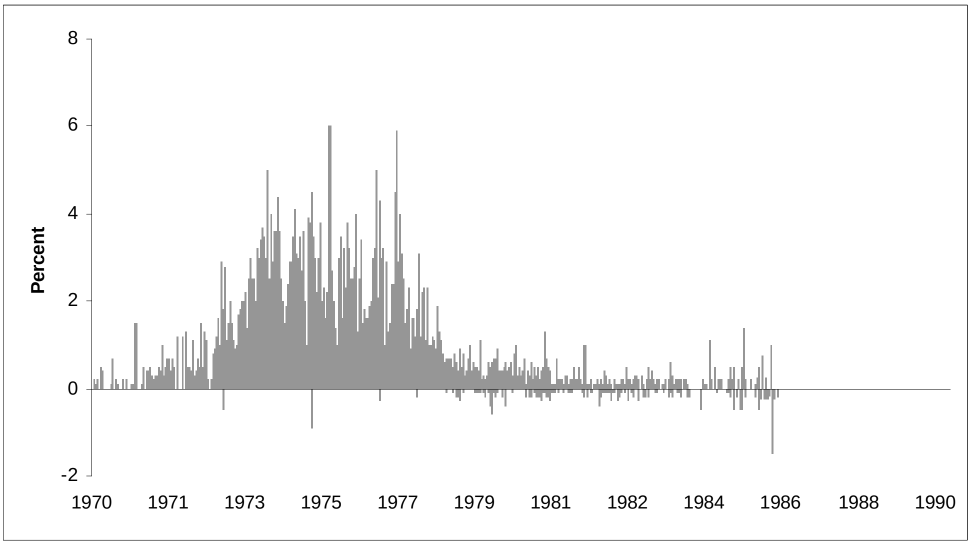
The average premia of old D- and C-sequences over mixed bonds mask important time-series variation. Figure 8 plots the average daily price difference between D- and C-sequences. The D-premium begins near zero, it averages above two percent from 1973–1975, and it reverts back to near zero from 1978–1986. Prices converge when lottery bond turnover increases from previously less than 10% per year to between 25% and 50% per year. In fact, prices of all long bond sequences (100, 500, C, and D) converge from 1978–1990.

The handling cost advantage of a D-sequence is a natural explanation for the price difference between D- and C-sequences. Manual verification of the winning lottery bond numbers of a large lottery bond portfolio can be a non-trivial task. The bondholder must check the numbers of the lottery bonds in his portfolio against the list of winning lottery bond numbers in the pamphlet. The winning lottery bond numbers are sorted by series number and order number. A letter code adjacent to each number pair indicates the prize. Lottery number checking of a complete S-sequence

[27]We omit standard errors from the table, but we are confident that the averages are statistically different from zero. More than 90% of the observations for old bonds and 60% for new bonds are positive.

[28]The few observations of S-sequenced bonds have been omitted from the table. They are concentrated to 1970 when the sequenced bond premium is small. In paired transactions, S-sequences always command a premium above shorter bond sequences and mixed bonds.

Figure 8: Market Value of D-Sequences over C-Sequences



The figure plots the time-series of the daily average price difference between D-sequences and C-sequences of old bonds.

is relatively easy because the bondholder is done after checking only one series number. The holder of a D-sequence must check two series numbers, while the holder of a C-sequence must work through the table ten times. If one series number matches, the lottery bond investor must also check the order numbers. The effort required to checking a portfolio of 1000 mixed bonds depends on the composition of the mixed-bond portfolio. Banks begin using computers for lottery number checking in 1982. Computers raise accuracy and reduce the risk that a prize is not claimed, but banks must continue to register lottery bond numbers manually. To allow banks to register lottery bond numbers, trade is suspended about two weeks around the coupon lottery. Electronic lottery number checking reduces handling costs for buy-and-hold investors, but it may not do much good for a tax trader who purchases the bond right before the coupon lottery and sells it back afterwards. The disappearance of the D-premium from 1978–1986, when trading volume shoots up, suggests that there are economies of scale in lottery number checking. The continued price spread between sequenced and mixed bonds from 1978–1990 may reflect a remaining handling cost advantage of sequenced over mixed bonds, however.

4.2 Multivariate Analysis

We use multivariate regression analysis to establish a statistical link between the sequenced bond premium and ex-lottery day returns. The dependent variable is the premium for C-sequences over mixed bonds in percent of par value. Three variables, GAIN, TIME, and CUM, proxy for the price effects of tax arbitrage around the coupon lottery. A central variable in Green and Rydqvist (1997), the guaranteed portion of the expected coupon, is omitted because it is approximately equal to 40% across old bonds.

GAIN is a proxy variable for capital gains tax liability from the stock market. It is measured as lagged stock price growth computed from end-of-month stock market index values over the previous twelve months. We expect that the sequenced bond premium increases with lagged stock price growth because better stock market performance should raise demand for tax shelters. Lagged stock price growth averages about 1% per year in the 1970s and 10% per year in the 1980s.

TIME measures calendar time from the last lottery of the previous calendar year to the last lottery of the current year. We use separate time counts for old and new bonds. After scaling by 365 days in a year, TIME increases linearly from from zero to one. The calendar-time effect in drop-off ratios in Table 6 suggests that the sequenced bond premium peaks in December.

CUM captures time between lotteries. It is measured as:

$$\text{CUM} = \begin{cases} 1 - t_{cum}/120, & \text{if } N \geq 1 \text{ remaining lotteries,} \\ 0, & \text{if } N = 0 \text{ remaining lotteries,} \end{cases} \tag{3}$$

where t_{cum} measures the number of business days remaining to the next lottery. CUM is uniformly distributed from zero right after the previous lottery to one right before the next lottery. We expect that sequenced bonds are most valuable right before the coupon lottery when uncertainty is resolved. The anticipated regression coefficient can be inferred from Table 5 above where drop-off ratios of sequenced bonds exceed those of mixed bonds.

POST74 is a dummy variable which equals one from 1975–1990 and zero otherwise. It captures the impact of Akelius (1974). Its effect on the sequenced bond premium is apparent from Figure 7.

TAX81 is a dummy variable which equals one from mid October 1980 to mid October 1981. This is the approximate time between the initial tax law change and the final tax law change. The expected, negative effect of this variable on the sequenced bond premium is also apparent from Figure 7.

PACK is the proportion of a lottery bond issue that is pre-packaged into 100-bond sequences (see Section 2.2 above). The variable is zero except for new bonds issued in 1984–1987, for which it ranges from 0.25 to 0.78. The variable captures a negative liquidity effect on the sequenced bond premium. Pre-packaged bonds cannot be broken up and sold as mixed bonds. Excess supply of bond sequences can sometimes depress sequenced bond prices below those of mixed bonds (Green and Rydqvist (1997)).

BEG0–BEG2 and END2–END0 are dummy variables. BEG0–BEG2 equal one when zero, one, or two lotteries has elapsed. Similarly, END2–END0 are dummy variables which equal one

Table 8: Seasoning and Maturity

	#Elapsed lotteries			#Remaining lotteries		
	0	+1	+2	–2	–1	0
Old bonds	4.38	3.78	3.37	4.67	2.36	0.07
New bonds	0.68	1.83	1.44	2.01	1.19	–0.04

The table reports the average premium for C-sequences over mixed bonds in percent of par shortly after seasoning and near maturity.

when there is two, one, or zero remaining lotteries. The seasoning and maturity effects can be seen in Table 8. First, we see in the left section that old C-sequences trade at a premium from the beginning of the secondary market, while the price difference between new C-sequences and mixed bonds is small. The different seasoning effect of old versus new bonds is a new result. Next, we see in the right section that the premium for both old and new C-sequences decreases towards maturity and vanishes after the final lottery. This pattern suggests that the sequenced bond premium is related to the coupon lottery and not to a liquidity difference between sequenced and mixed bonds. Once the uncertainty of the coupon lottery has been resolved, sequenced and mixed bonds are perfect substitutes (Green and Rydqvist (1997)).

Table 9: Determinants of the Sequenced Bond Premium for Old Bonds

Intercept	GAIN	TIME	CUM	END2	END1	END0	POST74	TAX81	R^2
A. 1970–1990									
2.17	1.89	0.27	3.12	–1.32	–2.06	–1.47	1.54	–0.60	0.169
(6.5)	(3.5)	(3.9)	(59.5)	(–7.0)	(–8.2)	(–4.7)	(4.8)	(-4.0)	
B. 1982–1990									
4.20	4.14	0.09	2.67	–2.05	–3.45	–3.17	n/a	n/a	0.189
(25.7)	(7.3)	(0.9)	(34.0)	(–11.8)	(–17.1)	(–12.3)			

The table reports the results of regressing the sequenced-bond premium on explanatory variables. The dependent variable is the price difference between C-sequences and mixed bonds in percent of par. GAIN is one-year lagged stock price growth. TIME$\in [0,1]$ measures time from the last lottery of the previous year. CUM$\in [0,1]$ measures time to next lottery. END2, END1, and END0 are dummy variables that capture the number of remaining lotteries. POST74 is a dummy variable which is one from 1975–1990 and zero otherwise. TAX81 is a dummy variable which is one from mid-October 1980 to mid-October 1981. The standard errors are adjusted for first-order autocorrelation and heteroscedasticity using the POOL command from Shazam. t-statistics are reported in parentheses below the coefficients. There are 14 cross-sections with a total of 21,662 observations in Panel A, and nine cross-sections with 9,534 observations in Panel B.

We estimate a panel regression with 14 cross-sections of old bonds and 12 new bonds. The error term is adjusted for first-order autocorrelation and heteroscedasticity using the POOL command in Shazam. The regression results for old bonds are reported in Table 9. Using the entire data set (Panel A), the coefficients of the three central variables GAIN, TIME, and CUM are positive and statistically different from zero. The coefficients mean that a 100% run-up in stock prices raises the sequenced bond premium by two percentage points, that the sequenced bond premium increases over the calendar year by 0.3 percentage points, and that the sequenced bond premium increases between lotteries by about three percentage points. These regression results link the sequenced bond premium to stock market performance (GAIN), to the calendar-time effect of ex-day returns (TIME), and to the coupon lottery (CUM). The correlation between the sequenced bond premium and stock market performance (GAIN) is stronger in the recent data (Panel B). This is also the case for the calendar-time effect (TIME), which is not statistically different from zero in the recent data (Panel B). The coefficients of END2–END0 capture the maturity effect, and the coefficients of POST74 and TAX81 the time-series effects of Akelius (1974) and the tax law change in 1981, respectively.

Table 10: Determinants of the Sequenced Bond Premium for New Bonds

Intercept	GAIN	TIME	CUM	END2	END1	END0	BEG0	BEG1	BEG2	PACK	R^2
1.86 (9.9)	5.74 (9.9)	0.08 (0.8)	1.33 (14.8)	–0.50 (–2.6)	–0.33 (–1.3)	–0.33 (–0.9)	0.17 (0.5)	0.42 (1.8)	–0.25 (–1.3)	–0.47 (–12.1)	0.045

The table reports the results of regressing the sequenced-bond premium on explanatory variables. The dependent variable is the price difference between C-sequences and mixed bonds in percent of par. GAIN is one-year lagged stock price growth. TIME$\in [0,1]$ measures time from the last lottery of the previous year. CUM$\in [0,1]$ measures time to next lottery. END2, END1, and END0 are dummy variables that capture the number of remaining lotteries, and BEG0, BEG1, and BEG2 are dummy variables for the initial lotteries. PACK$\in [0,1]$ is the proportion of the lottery bond issues 1984–1987 that is pre-packaged into 100-bond sequences. The standard errors are adjusted for first-order autocorrelation and heteroscedasticity using the POOL command from Shazam. t-statistics are reported in parentheses below the coefficients. There are 12 cross-sections with a total of 12,370 observations.

The regression results for the new bonds in Table 10 are qualitatively similar. The correlation between the sequenced bond premium and stock market performance (GAIN) is similar for new and old bonds (Table 9, Panel B). The calendar-time effect as captured by TIME is not statistically different from zero for either new nor old bonds (Table 9, Panel B). The seasoning effect is apparent in the negative coefficients of BEG0–BEG2. The liquidity effect of pre-packaged 100-bond sequences (PACK) is apparent.

5 Conclusions

Undoubtedly, demand for Swedish lottery bonds 1970–1990 is tax driven. The tax law change in 1981 and the market response to the tax law change are prima facie evidence. The time-series behavior of imputed marginal tax rates, the calendar-time effect in drop-off ratios, and trading volume around the coupon lottery also lead to this conclusion.

Sequenced bonds are worth more than mixed bonds. Several observations suggest that the sequenced bond premium is determined by the tax-motivated trading around the coupon lottery.

The regression model summarizes the supporting evidence: the sequenced bond premium increases with lagged stock price growth, it increases between lotteries, it increases over the calendar year, it increases after Akelius (1974), and it drops after the tax law change in 1981. In addition, the sequenced bond premium of new bonds with limited tax deductibility is much smaller. Sequenced bonds offer two advantages over mixed bonds: a portion of the expected coupon payment is guaranteed and lottery number checking requires less effort. For these reasons, the short-term tax trader prefers sequenced over mixed bonds.

When the tax benefits of old lottery bonds disappear with the redemption of the last old bond in 1990, one would expect the price difference between sequenced and mixed bonds to disappear. However, the sequences of some lottery bonds with a large portion of the expected coupon guaranteed (about 80%) continue to trade at prices well above mixed bonds, while the sequences of other lottery bonds with a smaller portion of the expected coupon guaranteed (around 40%) trade at small premia above mixed bonds. Since these price effects are unrelated to tax planning, we leave this asset pricing problem for future research.

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