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The economics of savings bonds

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Abstract

Series EE Savings Bonds have provided floating rate returns since 1982. They also contain valuable embedded options, including an early redemption option, a guaranteed minimum rate option, and a tax-timing option. Our analysis indicates that the simulated risk-return performance of Savings Bonds has been relatively attractive compared to other default-free assets. Thus, Savings Bonds appear to be worthy of consideration by individual investors. Our regression analysis indicates that, over the 1990 through 2001 period, investors considered both interest rates and economic conditions in their EE Savings Bond purchase and redemption decisions. © 2004 Academy of Financial Services. All rights reserved.

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1. Introduction

Savings Bonds, sold by the U.S. Treasury since 1935, received a dramatic "makeover" in 1982: the coupon rate on Series EE bonds began to float with the market rate on ordinary Treasury notes and bills. Before this change, it was widely assumed that EE bonds offered unattractive returns and that investors should generally avoid them. However, even in their present configuration, which along with floating rates includes several embedded options that add value, there has been no examination of their returns and risk relative to other securities, or to the factors that motivate individual investors to purchase them.

In this paper, we have two main objectives. The first, which is of particular interest to

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individual investors, is to examine how Series EE U.S. Savings Bonds' return and risk compare with other default-risk free securities. The second is to determine whether the demand for Series EE Bonds, which unlike most other securities, can be held only by individuals, responds to interest rates and other economic variables.

In Section 2, we review the history of the U.S. Savings Bond program. In Section 3, we describe the characteristics of current Savings Bonds, and describe the options embedded within them. In Section 4, we compare the performance of alternative instruments to a simulated security possessing the same features as current Series EE Bonds. In Section 5, we present empirical findings on the relationship between the demand for Series EE Bonds and interest rates and other economic variables. Our conclusions are in Section 6.

2. History[1]

U.S. Savings Bond sales began in March of 1935, ". . . at a time when people's incentives to save–as well as their confidence in financial institutions—had been shaken by the pain of the Great Depression. . . " (Linehan, 1991). One objective of the program was to broaden the base of public debt by attracting small investors. Designed to be attractive to individual investors, the bonds were sold in small denominations, at a fixed interest rate. A key feature was that they were redeemable after a short period of time, at the purchase price plus accrued interest, eliminating price fluctuations. Another desirable feature was that federal income taxes could be deferred until redemption. Additionally, bonds were issued only in registered form, replaceable in case of loss.

Series A through D bonds sold in relatively small amounts through April of 1941, when a new "Defense" Savings Bond, the Series E, was introduced.[2] After the attack on Pearl Harbor on December 7, 1941, Savings Bonds sales soared, along with other forms of public debt. Sales rose from $2.5 billion in 1941 to $16.0 billion in 1944, and the proportion of the privately held portion of the public debt comprised by Savings Bonds rose from 6.8% in 1940 to 25.4% in 1951.

Savings Bond sales fluctuated moderately over a $4 to $5 billion range over the period from the 1950s through the 1960s, reaching a postwar peak of almost $8 billion in 1978. However, EE yields failed to follow interest rates during the inflationary period of the late 1970s and early 1980s and sales dropped to just $3.3 billion by 1982, while redemptions surged to $15.5 billion.

In November of 1982, the Treasury introduced a market-based formula for Series EE bonds. Bonds held for less than five years earned a variable rate of 85% of the average yield of six-month Treasury securities; bonds held longer than five years earned 85% of the average yield of five year Treasuries. The Treasury retained a guaranteed minimum average yield for bonds held to maturity. These features remained in place until 1997, when the Treasury implemented the current interest rate formula: EE bonds earn a variable interest rate equal to 90% of the five-year constant-maturity Treasury yield, averaged over the previous six-months.[3] Bonds redeemed within five years of purchase lose the last three months of interest.

In 1998, the Treasury introduced a new concept Savings Bond—Series I, with a yield that consists of a fixed base rate plus an inflation adjustment every six months. Over the 1998 through 2000 period, total annual purchases of Savings Bonds, of all types, have ranged between $4 to $6 billion.

3. Features of current series EE savings bonds

Series EE U.S. Savings Bonds are "accrual securities," whose value increases as interest is earned. (Interest accrues monthly and is compounded semiannually.) Individuals can redeem them at their issue price plus accrued interest.

Investors in Series EE Savings Bonds can choose whether to pay federal taxes on accrued interest each year or when the bond is redeemed.[4] This deferral of taxation increases the effective after-tax return.[5] As with other U.S. Treasury securities, there are no state or local taxes.

The Treasury issues Series EE Bonds at one-half of their face value and guarantees that they will reach their face value within a specified term. For bonds issued from March 1993 to April 2003, that doubling interval is 17 years; thereafter the doubling interval was increased to 20 years, resulting in a guaranteed minimum yield of 3.53% compounded semiannually. They can be held beyond the specified doubling interval, for up to a total of 30 years, earning interest according to the preset formula (currently, 0.90 of the five year Treasury yield) but with no guarantee on the minimum average yield.

An EE Bond's semiannual return depends solely on its "coupon," which is set based on the *yield* (not the return) of five-year Treasury notes.[6] The *ex ante* yield becomes the guaranteed six-month *ex post* return. Because Savings Bonds have no price risk and a positive coupon, their semiannual returns are always positive, making them a risk-free store of nominal value. Their real value, however, depends on inflation, as the principal value has no inflation adjustment.

Despite these features, Savings Bonds have some characteristics that prevent them from being true money market substitutes. Most importantly, individuals can redeem Savings Bonds only after a minimum holding period. Over most of the period we analyze, the minimum holding period was six months (extended to one year in March, 2003). In addition, the redemption value of a bond redeemed on any day within a month is the same; interest for each month is credited only on the first day of the subsequent month.[7] There are also limitations on annual purchases. For most of the time interval we analyze, individuals were limited to $30,000 face value ($15,000 market value). However, in May 2003, the ceilings were raised substantially: individuals may now purchase up to $30,000 issue value of paper Series EE bonds each year, plus another $30,000 issue value online through the Treasury Direct Website.

3.1. Embedded options

EE Bonds provide some implicit options to investors, including an "early redemption option," a "minimum return option," and a "tax-timing option." An EE Bond can be regarded as a simple floating rate instrument with these three options added.

3.1.1. The early redemption option

After the minimum holding period, individuals can redeem Savings Bonds at a fixed price, equal to the purchase price plus accrued interest, minus an early redemption penalty (since 1997, one quarter's interest on bonds redeemed before five years).[8] This penalty, which is comparable to that for early redemption of a CD, is low compared to the possible losses on a fixed coupon bond.

The early redemption option can also be used to switch into a more attractive asset. For example, if the yield curve inverts and shorter-term Treasuries achieve higher yields than the five-year note, investors can put the bonds back to the Treasury at par plus accrued interest, and use the proceeds to buy short term Treasuries. If the yield curve steepens, the holder could switch into higher yielding, but riskier, longer-term assets.

3.1.2. The guaranteed minimum return option

Regardless of the actual floating coupons based on market rates, the Treasury guarantees that Series EE Bonds will reach their face value within a specified time period. This feature, which implies a guaranteed minimum return, is also an option. The holder of an EE bond receives the floating coupons, plus an additional amount that depends on the difference of the guaranteed minimum and the average floating rate if the average floating rate falls short of the guaranteed minimum.

We note that the guaranteed return option and the early redemption option would gain value under different circumstances; the former if rates decline, the latter if short-term rates rise. If the early redemption option is exercised, the guaranteed minimum would be foregone.

3.1.3. The tax-timing option

Taxes on Series EE bonds can be deferred until redemption, with a maximum holding period of 30 years. This means that investors can time their taxes by planning redemptions for years when their federal tax rate is low. The value of this tax timing option depends on both the structure of marginal tax rates and the variability of income (Heuson and Lasser, 1990).

4. Relative performance

There is no evidence to date on the risk-return characteristics of EE Bonds versus other financial instruments. In this section, we compare the hypothetical historical returns for Series EE bonds under the current interest rate formula to three default-free instruments: certificates of deposit (CDs), which have similar liquidity; Treasury Bills, which are short-term and extremely liquid; and intermediate-term Government bonds, which are very liquid but that are subject to price risk. These instruments are chosen because returns data are readily available, and they appear to be reasonable alternatives.

We estimate semiannual EE bond returns by (1) using the five-year constant maturity T-Note yields from the Federal Reserve Bank of St. Louis Website, (2) averaging the monthly yields over each six-month period, and (3) multiplying by 0.9. The two semiannual

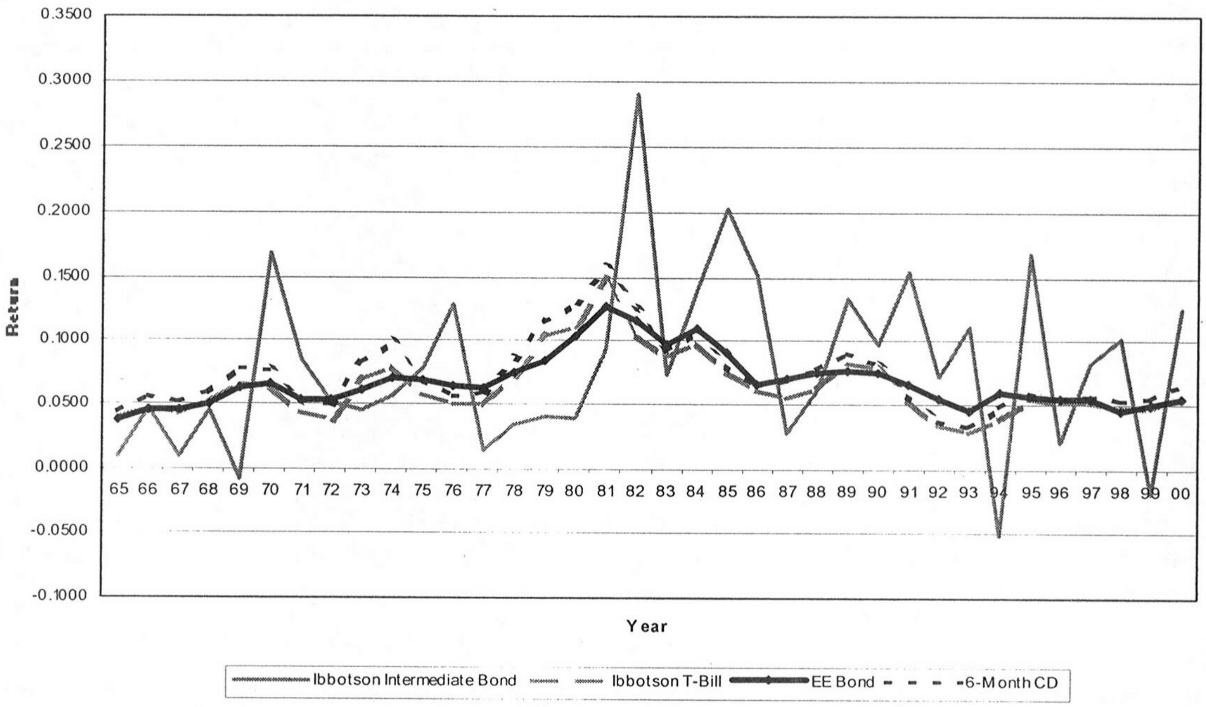

Fig. 1. Simulated Series EE Bond returns and actual six-month Certificate of Deposit, T-Bill and Intermediate Bond returns over the 1965 through 2001 Period. T-Bill and Intermediate Bond returns taken from Ibbotson (2001). Six-month CD returns taken from the Federal Reserve Bank of St. Louis.

yields each calendar year are compounded to compute the effective annual yield, which in the absence of price risk, is the annual return.

We also obtain monthly data on CDs from the Federal Reserve Bank of St. Louis. We estimate the effective annual yield for six-month CDs, the longest maturity in the database, by compounding semiannual yields. The first full year of data is 1965.

The T-Bill and Intermediate-Term Government Bond returns are taken from Ibbotson (2001). Ibbotson uses the Treasury Bill with at least one month to maturity and calculates the gain (loss) until the next month, combining the monthly returns to get an annual figure. Ibbotson uses the Treasury Note that is closest to but greater than five years to maturity and follows that through the subsequent year. Our hypothetical comparison covers the 1954 to 2000 period for T-Bills and Intermediate Bonds, and 1965 to 2000 for CDs.

Fig. 1 depicts Series EE simulated annual returns compared to these other instruments. Series EE bond returns behave similarly to both T-Bills and CDs but are less volatile, perhaps because their returns depend on intermediate bond yields, which are less volatile than short-term interest rates. The return on intermediate bonds, which sustain capital gains and losses, are clearly much more volatile than the others.

Table 1 presents mean annual returns, standard deviations, and coefficients of variation (c.v.) over the 1954 through 2000 and 1965 through 2000 periods. Panel A shows that over 1954 through 2000, intermediate bonds had the highest mean return (0.0663) and the highest SD (0.0664), yielding a c.v. of 1.002. By comparison, Series EE Bonds had a slightly lower mean return of 0.0604, but also much lower SD, 0.0247, resulting in a c.v. of 0.409.

Table 1
Comparison of simulated U.S. series EE savings bond performance to actual returns of short and intermediate term instruments over the 1954 and 1965–2000 periods

	Series EE Bond (simulated)	Six-Month CDs (actual)	T-Bill (actual)	Intermediate U.S. Bond (actual)
A: 1954–2000 period				
Annual return	0.0604	—	0.0551	0.0663
SD	0.0247	—	0.0281	0.0664
C.V.	0.409	—	0.510	1.0020
B. 1965–2000 period				
Annual return	0.0686	0.0735	0.0645	0.0805
SD	0.0212	0.0274	0.0251	0.0685
C.V.	0.309	0.373	0.389	.851

The Series EE bond is simulated by multiplying the U.S. Treasury note constant maturity five-year yield (from the Federal Reserve Bank of St. Louis) by 0.90. CD yields are also taken from the St. Louis Fed. The returns of T-Bills and Intermediate term U.S. Bonds are taken from Ibbotson (2001). Annual Savings Bond returns are compounded semiannually; T-Bill and Intermediate Bond returns are compounded monthly (as reported by Ibbotson, 2001).

Compared to T-bills, the EE Bonds had higher returns and a lower c.v. over the sample time period.

Over the 1965 through 2000 period, as shown in Panel B, the risk-return relationships among EE Bonds, T-Bills, and intermediate bonds are similar to those in Panel A. Returns and standard deviations for six-month CDs (return = 0.0745, SD = 0.027) are somewhat higher than for EE Bonds (return = 0.069, SD = 0.0212). However, the c.v. for EE Bonds (c.v. = 0.309) is lower than that for CDs (c.v. = 0.373), indicating some superiority of EE bonds over that time interval.

Based on our simulations, returns on EE Bonds are comparable to those on other default-risk-free alternatives, and their risk-return characteristics compare favorably to those alternatives. Also, the value of tax deferral on EE bonds implies their returns are actually higher than shown in our table and chart. (The early redemption penalty, however, could subtract some value.[9]) These results demonstrate that EE Bonds are a reasonable alternative for individual investors.

5. The demand for EE bonds

In recent years, a number of studies have examined household holdings of risky versus safe assets. King and Leape (1998), for example, explain the cross-sectional holdings of financial instruments by household characteristics. They combine U.S. Savings bonds with certificates of deposit and money market instruments into a category "less liquid savings instruments." Age (positive) and net worth (negative) appear to be important in explaining that category. Fratantoni (1998) shows that outstanding mortgage obligations influence households to hold less risky assets, while Guiso, Jappelli, and Tertizzese (1996) show that uncertain labor income leads to a reduction in the holding of risky assets among Italian households. Hochguertel, Alessie, and Soest (1997) show that wealth is important in explaining holdings of risk-free assets in the Netherlands.

No study, to date, however, has focused explicitly on Savings Bonds, which not only are safe but also have embedded options that affect their value. Here we use some of the insights of previous theoretical and empirical work to model and test the demand for U.S. Savings Bonds.

If potential buyers are making an *economic* choice about whether to buy EE Bonds rather than other financial assets, the desired stock of savings bonds should depend on relative returns and other economic and financial factors such as the value of the embedded options, the amount of perceived risk in the environment, and other factors that determine financial asset allocation.

The expected return on EE Bonds should be one relevant factor. That depends linearly on the yield on five-year Treasury securities. Other assets that may compete with Savings Bonds are short-term money market instruments such as T-Bills, which are the closest substitutes in terms of safety. Treasury notes and bonds are less close substitutes, as are corporate bonds and equities.

Because EE bonds do not have default or price risk, those facing economic uncertainty may find them particularly attractive. The unemployment rate and or declines in income might influence the demand for this safe asset.

The value of early redemption, which permits a switch into other assets depends on the shape of the yield curve. When the yield curve is flat or inverted, short-term assets would be relatively more attractive.

The value of the guaranteed minimum return depends on the closeness of the current EE Bond yields to that minimum. Also, the expected volatility of interest rates influences both the minimum return option and the early redemption option.

The income variability that affects the tax-timing option could be captured by economic variables such as the unemployment rate. The other influence on the tax-timing options—the structure of the tax code—is difficult to quantify, because we would need information on the income distribution of potential Savings Bond purchasers as well as the tax code itself. We do not attempt that task here.

Our basic model is:

$$S^* = f\,(\text{five-year yield, yield on alternative instruments, economic variables, minimum return guarantee, early redemption option}), \quad (1)$$

$$\text{Purchases} = g(S^*, S(-1)), \quad (2)$$

$$\text{Redemptions} = h(S^*, S(-1)), \quad (3)$$

where S^* is the desired stock of Savings Bonds and $S(-1)$ is the outstanding stock at the end of the previous month. We expect $S(-1)$ to have a negative effect on purchases and a positive effect on redemptions.[10] We expect S^* to have a positive effect on purchases and a negative effect on redemptions.

5.1. Data

We obtained monthly data on EE Bond purchases and redemptions from January 1990 to December 2001 from the U.S. Treasury Department Bulletin (and its Website), which maintains publicly available data on the dollar volume of monthly purchases and redemptions of U.S. Savings Bonds, as well as the outstanding stock of each type of bond.

We obtained personal income (PERSINC) from the Bureau of Economic Analysis, the unemployment rate (UNEMPL) from the Bureau of Labor Statistics, and yield data from the Federal Reserve.

We use the yield on the five-year T-Note (T5YR) as a proxy for the expected yield and return on EE Savings Bonds.[11] For alternative assets, we use the three-month T-Bill yield (T3MO) as a measure of an alternative risk-free investment, and the change in the S&P 500 Index (CHGSP) as a measure of the recent returns on an alternative risky asset class. We measure the volatility of interest rates as the standard deviation of the three-month T-bill rate (SD3MO) over the past 12 months.[12]

We use the level of the VIX, the implied volatility in options on the OEX, an index of 100 large-capitalization stocks, as a measure of perceived stock market risk, a possible influence on EE bond demand.

The guaranteed minimum rate was reduced from 5.95% per year to 4.12% per year for purchases after March 1, 1993. Months before the actual reduction in the minimum in March 1993, market observers began to predict that the Treasury would lower the minimum. (They observed that the yield on the five year Treasury dipped below 6% in July 1992 and remained below 6% in succeeding months.) To capture the rush induced by the expectation that the guaranteed minimum would be lowered, we add a dummy variable (GUARCHG) that is one for from August 1992 to February 1993, and zero for all other months.

Using these variables, our model of Eqs. (1–3) above is:

$$\begin{aligned}&\text{Purchases (or redemptions)}\\&= f\,(\text{OUTSTANDING (-1), UNEMPL, PERSINC, CHGSP, T5YR, T3MO, SD3MO,}\\&\quad\text{MINR, VIX, GUARCHG}),\end{aligned} \tag{4}$$

where (-1) indicates a one month lag and all other variables are contemporaneous. We show our expectations for the signs of each variable in Table 3 for purchases and Table 4 for redemptions.

In addition to the above specification, we examine yield curve effects by creating the variable T5MINUST3, the difference between the five-year T-Note yield and the three-month T bill yield. We examine the impact of the minimum return guarantee by creating the variable T5MINUSMINR, which is the difference between the five year T-Note yield and the guaranteed minimum return. These transformations of the basic variables are designed to identify the effects of the early redemption option and guaranteed minimum return, respectively.

Table 2
Multiplicative seasonal adjustment factors for regression models of monthly savings bond purchases and redemptions as functions of macroeconomic and financial market variables

Month	Purchases	Redemptions
January	0.749	0.810
February	0.955	1.095
March	0.951	1.009
April	1.012	0.941
May	1.091	1.023
June	1.143	0.991
July	1.120	0.810
August	1.110	0.924
September	1.126	1.096
October	0.990	1.067
November	0.998	1.171
December	0.841	0.966

We multiply each monthly observation of purchases and redemptions by the corresponding monthly factor to remove the effect of seasonality.

5.2. Procedure

In many cases, supply and demand functions must be estimated by simultaneous equations methods because price and quantity are jointly determined. Although each individual is subject to a limit on their annual purchases of EE bonds, the aggregate limit on purchases at pre-specified conditions on yields, redemption features, and so forth, is essentially unlimited in comparison to actual demand. In addition, the Treasury stands ready to redeem an unlimited quantity of bonds at their purchase price plus accrued interest. In effect, there is (approximately) an "infinitely elastic" supply curve at the yield implied by the EE coupon formula.[13] The demand function, alone, therefore determines the quantity of Savings Bonds purchased or redeemed.

Both purchases and redemptions display seasonality. We deseasonalize using a standard multiplicative technique (see Newbold, 1995, p. 699), to allow for secular changes in the levels of purchases and redemptions. See Table 2.

Our initial regressions show positive first-order serial correlation, with Durbin-Watson (DW) statistics well below two for both purchases and redemptions. Therefore, we re-estimate assuming the residuals are AR(1).

5.3. Empirical results

5.3.1. Purchases

Table 3 shows the empirical results for the purchase model over the 1990 through 2001 interval. With the exception of Regression 1, which we show for reference, the coefficient estimates are for AR(1) models [the AR(1) label shows the estimated serial correlation coefficient]. The DW statistics for subsequent models, which have the AR(1) correction, are close to 2.00, suggesting the lack of higher order serial correlation.

Table 3
Regressions of monthly EE Bond purchases ($ millions) as a function of macroeconomic and financial market variables, 1990–2001

	Expected sign	Regression				
		1	2	3	4	5
Intercept	—	1406.71 (2.39)†	1502.2 (1.94)*	1089.68 (5.12)‡	1082.91 (4.29)‡	1057.78 (4.08)‡
OUTSTANDING(−1)	−	−0.00014 (−0.09)	0.0015 (0.76)	—	—	—
UNEMPL	+	−26.21 (−0.60)	−61.70 (−1.11)	—	—	—
PERSINC	−	−0.114 (−2.61)†	−0.163 (−2.79)‡	−0.101 (−4.08)‡	−0.100 (−3.70)‡	−0.095 (−3.43)‡
CHGPERSINC	−	—	—	—	—	−25.49 (−2.24)††
CHGSP	−	−0.945 (−0.72)	−1.288 (−0.82)	—	—	—
T5YR	+	3.370 (0.15)	−4.229 (−0.14)	—	46.62 (1.79)*	51.17 (1.91)*
T3MO	−	−99.15 (−3.92)‡	−114.14 (−3.50)‡	−93.91 (−7.77)‡	—	—
SD3MO	+	24.05 (0.43)	47.95 (0.62)			
MINR	+	132.50 (3.24)‡	179.33 (3.74)‡	140.25 (5.72)‡	—	—
T5MINUST3	−	—	—	—	94.59 (5.13)‡	94.21 (4.99)‡
T5MINUSMINR	?	—	—	—	−139.89 (−5.49)‡	−145.29 (−5.55)‡
VIX	+	−6.484 (−2.43)†	−4.985 (−1.73)*	−4.296 (−1.73)*	−4.281 (−1.70)*	−4.851 (−1.92)*
GUARCHG	+	910.86 (14.80)‡	828.00 (10.55)‡	857.27 (12.10)‡	857.85 (11.96)‡	837.47 (11.33)‡
AR(1)	—	—	0.325 (3.64)‡	0.299 (3.43)‡	0.298 (3.40)‡	0.334 (3.79)‡
R^2		0.909	0.916	0.915	0.915	0.918
R^2-Adjusted		0.902	0.909	0.911	0.910	0.913
DW		1.48	2.05	2.03	2.03	2.05

t values in parentheses below coefficients.

* Significant at the 0.10 level using a two-tailed test.

† Significant at the 0.05 level using a two-tailed test.

‡ Significant at the 0.01 level using a two-tailed test.

All data is U.S. data. OUTSTANDING(−1) is the stock of outstanding Series EE bonds, in millions of dollars, lagged one period. UNEMPL is the unemployment rate. PERSINC is the absolute aggregate level of personal income, in billions of dollars. CHGPERSINC is the monthly change in PERSINC. CHGSP is the percentage change in the S&P 500 Index over the previous six months, lagged one month. T5YR is the yield on the constant maturity five-year Treasury Note, in percent. T3MO is the yield on the three-month Treasury Bill, in percent. SD3MO is the SD of the three-month T-Bill yield, in percent, over the past 12 months. MINR is the minimum yield guarantee for Series EE Bonds, held to maturity, in percent. T5MINUST3 is the difference between the five-year T-Note yield and the three-month T-Bill yield. T5MINUSMINR is the difference between the five-year T-Note yield and the minimum guaranteed EE Bond yield. VIX is the implied volatility of 30 day close-to-the-money options on the S&P 100 Index, in percent. GUARCHG is a dummy variable taking on a value of 1 for the period from August 1992 to February 1993, and 0 otherwise. This was the period surrounding the announcement that MINR would be reduced substantially. AR(1) signifies the coefficient for an autoregressive model with one lag.

Table 4
Regressions of monthly EE Bond redemptions ($ millions) as a function of macroeconomic and financial market variables, 1990–2001

	Expected sign	1	2	3	4	5
Intercept	—	−1245.06 (−2.54)‡	−1094.00 (−1.64)	−1092.62 (−7.95)‡	−1089.48 (−7.88)‡	−1219.52 (−2.84)‡
OUTSTANDING(−1)	+	0.0080 (6.03)‡	0.0067 (3.90)‡	0.0063 (6.168)‡	0.0063 (6.14)‡	0.0071 (4.40)‡
UNEMPL	−	−27.36 (−0.75)	−15.05 (−0.32)	—	—	—
PERSINC	+	0.0976 (2.69)‡	0.1157 (2.31)†	0.1240 (6.02)‡	0.1233 (5.95)‡	0.1153 (4.80)‡
CHGPERSINC	+	—	—	—	7.764 (0.90)	—
CHGSP	+	1.950 (1.78)*	2.089 (1.60)	2.144 (1.71)*	2.144 (1.71)*	1.966 (1.56)
T5YR	−	−2.929 (−0.15)	−6.288 (−0.24)	—	—	77.05 (2.01)†
T3MO	+	41.33 (1.96)*	47.60 (1.70)*	59.74 (5.21)‡	59.15 (5.13)‡	—
SD3MO	−	−63.08 (−1.34)	−77.01 (−1.12)	—	—	—
MINR	−	63.86 (1.87)*	38.31 (0.96)	—	—	—
T5MINUST3	+	—	—	—	—	−72.17 (−4.16)‡
T5MINUSMINR	?	—	—	—	—	−26.26 (−0.74)
VIX	−	2.012 (0.90)	1.054 (0.46)	—	—	—
GUARCHG	−	−68.03 (−1.33)	−42.42 (−0.67)	—	—	—
AR(1)	—	—	0.418 (5.15)‡	0.465 (6.06)‡	0.468 (6.08)‡	0.451 (5.77)‡
R^2		0.856	0.879	0.875	0.875	0.876
R^2-adjusted		0.845	0.868	0.870	0.870	0.869
DW		1.20	2.04	2.07	2.07	2.06

t values in parentheses below coefficients.

* Significant at the 0.10 level using a two-tailed test.

† Significant at the 0.05 level using a two-tailed test.

‡ Significant at the 0.01 level using a two-tailed test.

All data is U.S. data. OUTSTANDING(−1) is the stock of outstanding bonds, in millions of dollars, lagged one period. UNEMPL is the unemployment rate. PERSINC is the absolute aggregate level of personal income, in billions of dollars. CHGPERSINC is the monthly change in PERSINC. CHGSP is the percentage change in the S&P 500 Index over the previous six months, lagged one month. T5YR is the yield on the constant maturity five-year Treasury Note, in percent. T3MO is the yield on the three-month Treasury Bill, in percent. SD3MO is the standard deviation of the three-month T-Bill yield, in percent, over the past 12 months. MINR is the minimum yield guarantee for Series EE Bonds, held to maturity, in percent. T5MINUST3 is the difference between the five-year T-Note yield and the three-month T-Bill yield. T5MINUSMINR is the difference between the five-year T-Note yield and the minimum guaranteed EE Bond yield. VIX is the implied volatility of 30 day close-to-the-money options on the S&P 100 Index, in percent. GUARCHG is a dummy variable taking on a value of 1 for the period from August 1992 to February 1993, and 0 otherwise. This was the period surrounding the announcement that MINR would be reduced substantially. AR(1) signifies the coefficient for an autoregressive model with one lag.

In Regression 2, which contains most of the variables in our model and corrects for first-order auto-correlation, the stock of outstanding EE bonds is not significant (t = 0.76). This indicates that the adjustment to the desired stock occurs within one month or that the gradual stock adjustment model is inappropriate. The coefficient of PERSINC is significantly negative (coefficient = −0.163, t = −2.79), as expected. MINR has a positive, highly significant coefficient (coefficient = 179.33, t = 3.74), implying that a one percentage point increase (decrease) in the minimum rate, holding all else constant, would increase (decrease) monthly sales by $179 million. In addition, the coefficient of GUARCHG is significantly positive (coefficient = 828.00, t = 10.55). These results suggest that investors in EE bonds are aware of the value of the minimum return guarantee and are more likely to buy Savings Bonds when the guarantee is high and when they suspect the minimum will be lowered shortly. The three-month T-Bill yield has a significantly negative effect on Savings Bond purchases (coefficient of T3MO = −114.14, t = −3.50), as expected.

Several variables in the original model, however, are not significant. Rather surprisingly, the yield on the five-year T-Note, taken by itself, is not significant (coefficient = −4.229, t = −0.14). Perhaps the positive direct effect of the five-year yield on the EE bond return is offset by its negative effect on the value of the guaranteed minimum. The unemployment rate (UNEMPL) is not significant. The coefficient of SD3MO, the measure of interest rate volatility, had a very low t value. (We had expected a significant positive coefficient reflecting the value of the options embedded in the EE Bond.) Other measures of interest rate volatility, such as the standard deviation of the five-year T-Note yield, were also not significant, either alone or with SD3MO. The change in the S&P 500, CHGSP, was not significant, suggesting that recent stock market performance does not influence Savings Bond purchases. The VIX, which we expected to have a positive effect on Savings Bond purchases, has a negative coefficient (coefficient = −4.985, t = −1.73) of borderline significance.

In Regression 3, we omit variables with low t values. The magnitudes of the remaining coefficients do not change greatly. In general, multi-collinearity does not appear to be a problem: only one correlation, that between MINR and OUTSTANDING is high (−0.91), and removing individual variables from the regressions has little impact on coefficient estimates or t statistics.

In Regression 4, we recombine variables to explicitly consider the spread between the five-year yield and the guaranteed minimum and the spread between the five-year yield and the three-month T-bill rate. T5MINUSMINR, the spread between the current coupon and the guaranteed minimum has a large, highly significant, negative coefficient (coefficient = −139.89, t = −5.49). As the five-year yield drops (rises) relative to the guaranteed minimum rate, purchases increase (decrease).

The spread between the five-year and three-month yields captures two distinct factors: the relative attractiveness of the yields on EE Bonds compared to T-Bills and the distance to the yield where early redemption is attractive. Empirically, we find that it has a large and significantly positive coefficient, suggesting that the former effect dominates: EE Bonds appear to be selected when their yield advantage over T-Bills is large.

The five-year yield by itself has a marginally significant positive coefficient (coefficient = 46.62, t = 1.79). Thus, the five-year yield seems to have a positive influence, over and above its influence on the money market versus Savings Bond choice, and its role in determining the value of the minimum return guarantee.

Because PERSINC is a strongly time-trended variable, in Regression 5, we further explore the importance of personal income by adding the percentage change in personal income (CHGPERSINC) to the variables in Regression 4. The coefficient of PERSINC remains significantly negative (coefficient = −0.095, $t = -3.43$), and the coefficient of CHGPERSINC is also significantly negative (coefficient = −25.49, $t = -2.24$). Recessions with declining growth in personal income add to the demand for Savings Bonds.

To determine if the availability of I Bonds impacted the demand for EE Bonds, we introduce a dummy variable that takes on a value of 1 on and after September 1998, when I Bonds became available, and zero before. That variable was not significant, suggesting that I Bonds and EE Bonds are not regarded as close substitutes (this regression is not shown in the table).

5.3.2. Redemptions

We use the same strategy for the redemption regressions as for purchases. In Table 4, we show Regression 1, which does not have the AR(1) correction, for reference only. In Regression 2, the coefficient on OUTSTANDING(-1) is significantly positive (coefficient = 0.0067, $t = 3.90$), indicating the redemptions are a positive function of the stock of outstanding bonds (including accrued interest). The coefficient of PERSINC is significantly positive (coefficient = 0.1157, $t = 2.31$), suggesting that redemptions tend to occur when personal income is high, reducing the need for safety. The rate on the three-month T-Bill has a marginally significant positive effect on redemptions (coefficient = 47.60, $t = 1.70$), suggesting that Savings Bond holders shift into money market instruments when those rates are high.

There are many variables, however, that are not significant. UNEMPL and the CHGSP are not significant, consistent with the results of the purchases regression. In addition, T5YR, MINR, GUARCHG, and VIX do not appear to influence redemptions.

In Regression 3, we remove variables that have little explanatory power. The results are similar to those of Regression 2, with the exception that the coefficient on T3MO is somewhat larger and significant at greater than the 0.01 level (coefficient = 59.74, $t = 5.21$), further evidence that Savings Bond redemptions are sensitive to changes in short-term interest rates. In Regression 4, we add CHGPERSINC, which has an insignificant coefficient (coefficient = 7.764, $t = 0.90$) and has very little effect on the remaining variables.

In Regression 5, we examine the spread variables T5MINUST3 and T5MINUSMINR that are important in determining purchases. TSMINUSMINR is not significant. However, T5MINUST3 receives a large, significantly negative coefficient (coefficient = −72.17, t = 4.16); there is obviously something important in this variable. However, note that the positive coefficient on T5YR (coefficient = 77.05, $t = 2.01$) more than offsets the negative coefficient on T5MINUST3. This leaves us with the mainly the three-month T-Bill yield as the interest rate determinant of redemptions.

The empirical results for redemptions are broadly consistent with the findings in the purchase regressions, although several variables that are significant in the purchase model are not significant in determining EE bond redemptions. The five-year yield relative to the minimum does not seem to factor into decisions on redemptions. In addition, the three-month yield by itself, rather than the spread between the five-year and three-month, seems to induce redemptions.

Taken together, the purchase and redemption regressions suggest that Series EE Savings Bonds are relatively more attractive when the economy is weak and when short-term interest rates are low. However, there are some notable differences between the variables that determine purchases and those that determine redemptions. Purchases seem to be more closely related to the embedded options and attractiveness of alternatives, whereas redemptions appear to be swayed mainly by money market rates, the outstanding stock of bonds, and the level of personal income.

6. Conclusions

U.S. Series EE Savings Bonds provide relatively attractive floating rate returns and embedded options that are valuable to investors. EE Bonds have embedded within them an early redemption option, which can be used to switch to alternative investments before maturity, a guaranteed minimum return, and a tax-timing option.

Our comparison of simulated EE Bond returns to alternative instruments, over the 1954 through 2000 period, shows that Saving Bonds have favorable risk-return characteristics, as measured by coefficients of variation. This fact should be important to individual investors.

Our examination of EE Bond purchases and redemptions over the 1990 through 2000 period indicates that investors appear to have considered alternative investments and economic factors, as suggested by theory, in their demand for these bonds. Savings Bond demand is higher in periods of economic uncertainty and when short-term rates are low. It also appears that purchasers of new bonds strongly value the minimum return guarantee.

Notes

1. Much of this section is taken from Linehan (1991).
2. At roughly the same time, Series F and G bonds and U.S. Defense Savings Stamps were introduced, differing from Series E in a number of features.
3. The appendix contains the exact language from 31§ CFR 351.2(k) that specifies yields.
4. At one time, the tax deferral could be extended beyond the bond's 30 year interest-paying period for an additional 20 years by converting the bonds into Series H Bonds. As of August 2004, H bonds are no longer available.
5. For example, for annual bonds with a 5% pre-tax yield, 10-year holding period, and 30% Federal tax bracket, the compounded after-tax annual return is 3.5% per year for an income bond and 3.72% per year for an accrual bond that is not taxed until redemption.
6. The *returns* on EE bonds differ from those on five-year Treasuries because the latter are subject to capital gains and losses due to interest rate fluctuations.

7. The issue date of Savings Bonds is always the first day of the month. Bonds purchased any day within a month earn interest from the first day of the month.
8. Before 1997, the penalty for Series EE Bonds was that yields were shifted to short-term Treasury rates rather than the five-year rate.
9. Assuming a holding period of four years and a 6% coupon, the 1.5% interest penalty would subtract roughly 38 basis points from the average annual return.
10. The stock of EE Bonds includes accrued interest. Thus, the stock of outstanding bonds in not equal to purchases minus redemptions.
11. The formula for EE Bonds, until 1997, depended on the holding period of the bond as well as the five-year yield and the six-month yield (for bonds held less than five years). We are being somewhat imprecise in using the five-year Treasury yield, unadjusted, throughout the period.
12. Most of the variability in the shape of the yield curve between three months and five years is because of the variability of the yield of three-month T-Bills.
13. The supply curve has generally allowed up to $30,000 face of EE bonds per person per year.

Appendix

Determination of interest rates taken from 31 § cfr 351.2(k)(2):

1. Treasury uses market bid yields for bills, notes, and bonds to create a yield curve based on the most actively traded Treasury securities. This curve relates the yield on a security to its time to maturity. Yields at particular points on the curve are referred to as "constant maturity yields" and are determined by the Treasury from this daily yield curve. The five-year Treasury securities yields described below are derived from these yield curves.
2. No less frequently than on each May 1 and November 1, Treasury announces a variable market-based savings bonds rate. To determine this rate, Treasury compiles five-year Treasury securities yields as of the close of business as of the close of business for each day of the previous six months and calculates the monthly average to the nearest one-hundredth of 1%. The savings bonds rate is then determined by taking 90% of the six-month average and rounding the result to the nearest one-hundredth of 1%.

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