Tax News

Identifying the Household Consumption Response to Tax Expectations using Bond Prices

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Abstract

Although theoretical models often emphasize fiscal foresight, most empirical studies neglect the role of news, thereby underestimating the total effect of tax changes. Measuring the path of expected future tax rates from the yield spread between taxable and tax-exempt bonds, this paper finds that consumption of high-income households increases by close to 1% in response to news of a 1% increase in expected after-tax lifetime income, consistent with the basic rational-expectations life-cycle theory. Using novel high-frequency bond data, I develop a model of the term structure of municipal yield spreads as a function of future top income tax rates and a risk premium. Testing the model using the presidential elections of 1992 and 2000 as two natural experiments, this paper shows that financial markets forecast future tax rates remarkably well in both the short and long run. Combining these market-based tax expectations with consumption data from the Consumer Expenditure Survey shows that households who have lower income, less education, or are more credit constrained respond less to news. However, the same households also respond one-for-one with large news shocks, consistent with rational inattention. Overall, the results in this paper suggest that ignoring anticipation effects biases estimates of the effect of fiscal policy downward.

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1 Introduction

The effectiveness of fiscal policy as a tool to stabilize business cycles is widely debated among both academics and policy-makers, and this debate can become heated at times. The foundation for this disagreement is the difficulty in credibly identifying both the timing and the magnitude of expected future tax shocks, and in estimating the transmission of those shocks in the economy through anticipation effects. This paper tackles these problems in the following way: first, it measures the expected timing and magnitude of future personal income tax shocks using a novel high-frequency data set of municipal bond yields; second, it combines these market-based expectations with micro-level data from the Consumer Expenditure Survey (CEX) to estimate the effect of tax news shocks on household consumption.

To identify news about future taxes, I exploit the differential tax treatment of two types of bonds. Interest on municipal bonds is tax-exempt, while interest on Treasury bonds is subject to federal income taxes; thus, relative price changes between municipal and Treasury bonds reflect changes in expected future tax rates, among other things. I go beyond identification of the timing of news to directly measure the entire path of expected tax rates. My tax news shocks measure not only *when* households receive information, but also *what* information they receive. Identifying the path of expected tax rates is important for testing the rational-expectations life-cycle hypothesis of consumption, as the theory predicts that consumption responds to changes in expected after-tax *lifetime* income.

I infer the entire path of expected tax rates over a forecasting horizon of up to 30 years at any given point in time by comparing municipal yield spreads of maturities of 1 to 30 years. The fact that different bonds have different maturities quantifies the degree of tax foresight, since yield spreads of bonds with different maturities reflect information about future taxes over different horizons. To take into account factors other than tax news, I derive a model that relates the term structure of municipal yield spreads to the path of expected tax rates and a risk premium.

I validate my tax news shocks using the presidential elections of 1992 and 2000 as two natural experiments and daily data from a political prediction market as source of additional variation. Changes in election probabilities reflect changes in expected future tax rates because each candidate had a very different tax reform proposal during both elections. With this additional data, I show that financial markets have strong fiscal foresight with respect to both the timing and the magnitude of the shocks.

This paper provides a new test of the basic rational-expectations life-cycle hypothesis by combining the market-based tax news shocks with data from the CEX to calculate changes in expected after-tax lifetime income for each household. The basic rational-expectations life-cycle theory implies that consumption should move one-for-one with changes in the expected after-tax lifetime income. Starting with the sample of high-income households, for which the identified news shock is most directly related to changes in expected after-tax lifetime income, this paper finds that nondurable consumption increases by 1.1% in response to news about a 1% increase in after-tax lifetime income. The prediction of the rational-expectations life-cycle theory that current consumption moves one-for-one with lifetime income cannot be rejected; however, the hypothesis that there is no response to tax news is strongly rejected.

Using household-level data allows me to explore the heterogeneity of responses across households and the importance of non-linearities. Extending the sample to include all households that pay taxes at some point in their lifetime – and therefore are potentially affected by future tax reforms – I find that the consumption response in the full sample is only 0.5%. This estimate is sufficiently precise to reject responses of 0% and 1%. Moreover, I find that the response varies significantly, both with the absolute size of the shock and with household characteristics. If all households affected by income tax reforms are included in the sample, then consumption responds by 1.1% using the largest 50% of news shocks in absolute value, which is consistent with rational inattention. Furthermore, consumption of more educated, less cash-constrained, or richer households responds one-for-one to both large and small news shocks.

To the best of my knowledge, this paper provides the first direct estimates of the effect of news about future after-tax income on consumption at the household-level.[1] The lack of direct estimates of news effects at the household-level is due primarily to the difficulty in identifying expectations about future income changes that vary across households. Previous research either uses survey expectations – which are based on responses to hypothetical questions (for example how much would you spend now if your income went up by $1,000 next year?) and thus could be different from actual choices made by households – or estimates news shocks directly from observed behavior.[2] Inferring expectations from observed behavior requires strong assumptions and might lead to circularity when the news shocks are used to test the same theory that was employed to infer expectations; see for example Blanchard, L'Huillier and Lorenzoni (2009).[3] In contrast, the news

[1] There is a large literature on consumption-based asset pricing; however, these theories impose restrictions on the joint distribution of asset returns and (aggregate) consumption, and do not separately test consumption behavior. Consumption theory is usually the starting point from which one derives implications for asset prices.

[2] Fuhrer (1988), Batchelor and Dua (1992), and Pistaferri (2001) rely on subjective survey expectations.

[3] Schmitt-Grohe and Uribe (2010) and Barsky and Sims (forthcoming) also infer news shocks from

shocks analyzed in this paper come from auxiliary data on bond prices, thus avoiding any circularity between the identification of the news and the estimated response to news.

This paper contributes to several strands of literature. The first strand focuses on the effects of expectation formation and news shocks on the economy.[4] While most of this literature is theoretical, this paper instead provides an empirical foundation for these theoretical findings. The responses in the sub-samples are consistent with this literature, which emphasizes heterogeneous expectation formation and the importance of non-linearities in the presence of small adjustment frictions. This heterogeneity of consumer responses observed in the cross-section is obscured in studies that use aggregate data or a representative agent framework.

The second strand of literature is research on household consumption behavior.[5] The basic rational-expectations life-cycle theory of household consumption has two central implications: first, consumption should not respond to predictable income changes; second, consumption should respond one-for-one to news about changes in after-tax lifetime income. There is a large and growing literature that tests the first implication of the rational-expectations life-cycle theory either by instrumenting for current income with variables known in advance or by using exogenous changes in predictable income provided by natural experiments.[6] This literature generally rejects the basic rational-expectations model by finding significant consumption responses to predictable income changes – that is, it finds that consumption is in fact excessively sensitive to predictable income changes.

However, the results in this paper are not directly comparable with the excess sensitivity coefficients. The estimated response to predetermined cash-on-hand that is reported in these studies typically measures the response of consumption to one-time cash receipts either in real dollars or as a fraction of *current income*. In contrast, the estimates reported in this paper show the percentage change of consumption in response to a 1% change in expected *lifetime income*. This distinction is important if one interprets the results of this paper in the context of a model with optimization frictions such as lim-

observed behavior, both of which use aggregate data.

[4] Recent research on expectation formation includes Mankiw and Reis (2002), Sims (2003), Barsky and Sims (forthcoming), and Coibion and Gorodnichenko (2011). Research on news shocks includes Cochrane (1994), Beaudry and Portier (2006), and Jaimovich and Rebelo (2009). See Lorenzoni (2011) for a survey of this literature.

[5] This literature is among the oldest and largest in economics – see for example Deaton (1992), Hayashi (1997), Attanasio (1999), and Jappelli and Pistaferri (2010) for a survey.

[6] Employing aggregate data, Campbell and Mankiw (1989) use an instrumental variables approach, while Poterba (1988) uses tax reforms as natural experiments. Another large segment of the literature uses cross-sectional variation in predictable income changes to test the first implication of the basic rational-expectations life-cycle theory; see for example, Shapiro and Slemrod (1995), Souleles (1999, 2002), Parker (1999), Shapiro and Slemrod (2003), Johnson, Parker and Souleles (2006), and Agarwal, Liu and Souleles (2007).

ited attention or costly information. Nonetheless, the results in this paper are related to the excess sensitivity literature, since they test the same model. If all households were cash-on-hand consumers, consumption should not respond to news but only to changes in current disposable income.

Finally, this paper addresses an important, but still unsettled, question posed by Campbell and Deaton (1989): if aggregate income is non-stationary, why is aggregate consumption so smooth? If consumption should move one-for-one with permanent shocks to income, and there is evidence that aggregate income has a unit root, then consumption should be more volatile than observed in the data. That aggregate consumption does not satisfy the restriction of the basic rational-expectations life-cycle model on the joint distribution of consumption and income is called the excess smoothness puzzle (or Deaton's paradox). The persistence of the income process is important not only for testing consumption theory, but also for asset pricing. The main difficulty in resolving this puzzle is statistical power: with a finite time series of aggregate data it is impossible to statistically differentiate between a unit root and a highly persistent but stationary process. Using household-level data instead of aggregate time series allows me to provide new evidence on this important question.[7] The estimate of the response of household consumption to a persistent income shock of 1% is only 0.5% when I use the full sample, so on average household consumption exhibits excess smoothness. However, the responses estimated in sub-samples that are conditional on family characteristics or the size of the news shock are one-for-one, and do not show excess smoothness.

The paper is structured as follows. Section 2 derives rational-expectations of future income tax rates from a model of the relative spread between taxable and tax-exempt bond yields. This model is then tested using two natural experiments. Section 3 derives and tests the second implication of the basic rational-expectations life-cycle theory, that household consumption should respond to news about changes in the expected after-tax lifetime income. Section 4 analyzes non-linearities in the response function, as well as response heterogeneity across households. Section 5 concludes.

2 Tax Expectations from Municipal Yield Spreads

In order to measure fiscal foresight in the economy the econometrician needs to identify information sets that are at least as large as the ones used by the agents. This challenge goes back at least to Hansen, Roberds and Sargent (1991) and has recently been em-

[7] See Attanasio and Pavoni (2011) for an alternative recent explanation for excess smoothness of consumption.

phasized by Leeper, Walker and Yang (2011). I identify rational information sets using expectations that are based on asset prices. Under informational efficiency asset prices aggregate information and reflect the largest public information set available at any given point in time. The yield spread between Treasury and municipal bonds reflects expected future tax rates because interest income from Treasury bonds is taxable while interest from municipal bonds is tax-exempt. At the same time, the yield spread also contains a premium to compensate for other factors such as liquidity risk and tax uncertainty.

In this section I derive the path of expected tax rates from relative spreads between Treasury and municipal bond yields. I then use two independent pieces of data, the Flow of Funds and the Survey of Consumer Finances (SCF), to provide evidence that the marginal investor is a household near the top of the income distribution. Furthermore, the marginal investor's position in the income distribution is stable over the sample period from 1977 to 2001, which is an important finding since it shows that changes in the yield spread reflect changes in expected future tax rates rather than movements across tax brackets by the marginal investor. I use two natural experiments that provide additional variation at daily frequency to validate the tax news shocks and to assess the degree of foresight over a horizon of 1 to 30 years. Using these natural experiments I formally test the hypothesis that the marginal tax rate implied in the municipal yield spread is the top personal income tax rate. Finally, I extract the entire path of expected future tax rates at each point in time over the entire sample period from 1977 to 2001. This period spans all income tax reforms since the 1980s, from the first Reagan tax cuts (ERTA 1981) to the G.W. Bush tax cuts (JGTRRA 2001). In the next section I then use changes in these expected tax paths to estimate the response of household consumption to tax news shocks.

This section also contributes to a large literature in empirical finance. Using data mostly from the 1960s and 1970s, Fama (1977) identifies the corporate tax rate as the fundamental determinant of the municipal yield spread. Later studies, such as Green (1993), Poterba (1986), Park (1995) and many others find the individual income or capital gains tax rate to be an important explanation of the spread. I contribute to this literature in two ways. First, I identify the marginal investor for an important class of assets and show that the disagreement about the fundamental determinants of the municipal yield spread are most likely due to changes in the marginal investor over time. While high-income households clearly are the marginal investors since the late 1970s, bank corporations were probably the marginal investors in the 1960s and early 1970s. Second, I show that economic fundamentals explain most of the variation in the municipal yield spread over long horizons, while liquidity or discount rate shocks are important in the short run. Previous studies that found tax rates to be important determinants of the municipal yield spread include Mankiw and Poterba (1996), Slemrod and Greimel (1999), and Ayers, Cloyd and Robinson (2005).

2.1 Factors other than Expected Tax Rates I use a novel data set of municipal bond yields at daily frequency from 1983 on and at weekly frequency since 1977, described in more detail in Appendix A.1. The municipal bond yields are based on an index of state bonds that have a AAA rating and are general obligations. I use state bonds because of the higher liquidity compared to other types of municipal bonds; see for example Harris and Piwowar (2004). General-obligation bonds are backed by the full faith and credit of the issuing state, similar to the backing of Treasury bonds, and prime-grade general-obligation municipal bonds are therefore essentially free from default risk.[8] Moreover, municipal bonds in general and general-obligation bonds in particular have a high recovery rate. For instance, Fitch Ratings assumes that general-obligation municipal bonds recover 100% of par within one year of default.[9] Since the Civil War no state has permanently defaulted on its general-obligation debt.[10] Hempel (1971) looks at the Great Depression, which is the most recent period with significant defaults on municipal debt. He shows that between 1929 and 1937 all outstanding municipal bonds – consisting mostly of debt of lower quality than general-obligation bonds – defaulted at an annual rate of 1.8%. However, 97% of the defaulted debt was eventually repaid.

[Table 1 about here.]

Table 1 provides historical default rates for municipal bonds by credit rating. Corporate bond default rates are shown for the sake of comparison. Two facts stand out: first, AAA rated municipal debt is indeed essentially default-risk free; and second, the credit ratings for municipal and corporate bonds are not comparable. For instance, municipal bonds that are rated only BBB have a lower default rate than AAA rated corporate bonds.

[Figure 1 about here.]

[8] The other main class of municipal bonds is revenue bonds. The credit worthiness of revenue bonds is tied to the underlying project that they finance. For instance, a state might issue a revenue bond to finance a new bridge, and the bridge might in turn generate revenue by collecting a toll. If the income from the toll falls short of the interest costs, the state might default on the revenue bond without defaulting on any other bond. This selective default is not possible with general-obligation bonds.

[9] Fitch Ratings, "Default Risk and Recovery Rates on U.S. Municipal Bonds," *Public Finance Special Report*, 2007.

[10] While there have been 'technical' defaults of general-obligation bonds due to municipalities failing to pay interest on time, the payment obligations were all satisfied later on. In this sense there was no 'permanent' default since the Civil War.

Figure 1 shows the yield difference between AAA general-obligation and pre-refunded municipal bonds. Pre-refunded bonds are issues of municipal debt that are used to pay the principal and interest of another outstanding municipal bond, for example to take advantage of lower interest rates. The proceeds from pre-refunded bonds are deposited in an escrow account and are usually invested in special local government securities (SLGSs) issued by the Treasury Department. Since pre-refunded municipal bonds are escrowed and invested in Treasury securities they bear essentially the same default risk as Treasury bonds. Pre-refunded municipal bonds should therefore offer lower yields than similar AAA general-obligation municipal bonds in the absence of any other risk. However, pre-refunded municipal bonds are less frequently issued and traded and are therefore less liquid. The pre-refunded municipal yield spread supports the conclusions from Table 1, showing that the liquidity premium outweighs the default risk premium over the available sample period.[11] The yield spread is very small and the default risk premium of AAA general-obligation bonds is therefore also small. This finding is consistent with a similar exercise reported in Chalmers (1998).[12]

[Table 2 and Figure 2 about here.]

State personal income taxes are another factor that might confound the relationship between the investor's marginal *federal* tax rate and the municipal yield spreads. Table 2 shows that many states exempt municipal bond interest from state and local income taxes, either for all or at least for in-state investors, and several states do not collect personal income taxes at all. Moreover, investors have strong incentives to avoid paying state taxes on municipal bonds, for instance by investing in municipal bonds of their state of residence. Figure 2 compares the 10-year Treasury yield with 10-year municipal yields of four states, each of which taxes municipal interest differently. The four different tax treatments correspond to all possible combinations listed in Table 2. With the exception

[11] Yields on pre-refunded municipal bonds are available only from 1993 on. Moreover, the data set contains only few maturities for those bonds. For these reasons and because pre-refunded yields are higher than AAA general-obligation bonds I use the latter to construct the spread between Treasury and municipal yields.

[12] Credit Default Swaps (CDS) on municipal debt are a more recent financial innovation that offers an alternative way of measuring expected default risk. However, one is confronted with several issues when inferring default risk from CDS spreads. First, data of CDS spreads on municipal bonds is available only starting in 2005. Second, CDS contracts on state bonds with a AAA rating are traded very infrequently, most likely due to the low hedging demand for such a rare credit event. Third, CDS spreads are often dominated by liquidity and counter-party risk; see for example Giglio (2011). Figure A.2 shows CDS spreads for Treasury bonds, for AAA rated municipal state bonds from Maryland, and (for comparison) the spread on AAA rated corporate bonds issued by Berkshire Hathaway, one of only a few corporations that until recently were rated AAA from the beginning. Figure A.2 highlights both the low liquidity of the municipal CDS and the low premium of such contracts relative to Treasury CDS in times when trading activity is high. The CDS spreads therefore also support the conclusions from Table 1 and Figure 1.

of Illinois, all state bonds shown have a AAA rating and are general obligations. For Illinois there are no AAA general-obligation bonds available in the sample, so instead I use AA rated state bonds that are insured against default risk so that they are comparable to general-obligation bonds.[13] Figure 2 shows that the municipal yields are very similar, in particular compared to the yield on Treasury bonds, despite the different tax treatment of municipal bond interest in the four states. This result strongly suggests that state taxes are not an important determinant of municipal yield spreads. Furthermore, Figure 2 shows that the dispersion of AAA general-obligation municipal yields is small, suggesting that the relative liquidity shocks are common to all municipal bonds and have only a small idiosyncratic component. Taking an index of AAA general-obligation bonds further reduces the idiosyncratic component by averaging out any remaining idiosyncratic liquidity and state-specific shocks.[14]

2.2 A Model of Break-Even Tax Rates (BETR) Interest income from Treasury bonds is exempt from state and local taxes, but is subject to federal income taxes. Bonds issued by states – which are part of the class of municipal bonds – are exempt from federal income taxes. Moreover, as shown in Table 2, most states also exempt municipal bonds from state and local taxes, either for all investors or at least for in-state investors.

In order to interpret the yield data it is important to note that the relative municipal yield spread is different from the expected tax rate. Similarly, the yield spread between nominal and real Treasury bonds – the so-called break-even inflation rate – does not equal the expected rate of inflation. However, in both cases the yield spreads are related to the underlying expectations. To formalize the relationship between municipal yield spreads and the underlying path of expected tax rates, I start with the definition of the par yield of a Treasury bond. It is useful to note that Treasury bonds are taxed based on their imputed par yield. While zero coupon bonds are the starting point of most fixed-income models (which abstract from taxes), the par bond is the natural concept when analyzing the effects of taxes on bond prices.[15]

The real yield $y^T_{t,m}$ on a Treasury bond maturing in m years and selling at par at date

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[13] The main remaining difference in default risk between an insured and a general-obligation bond is counter-party risk, i.e. the risk that the insurer defaults at the same time as the insured municipal bond.

[14] In a previous version of this paper I have calculated average state top income tax rates and checked whether my results are sensitive to the treatment of state income taxes. Since there is little variation in state income tax rates over my sample period, and since state income tax rates are lower that federal income taxes, I could not find any tangible effect of state income taxes on my results.

[15] Appendix C provides a detailed overview of the tax treatment of bonds since 1970.

t is implicitly defined by[16]

$$1 = \sum_{s=1}^{m} \mathbb{E}_t[D_s(1-\tau_s)y^T_{t,m}] + \mathbb{E}_t[D_m] \; . \tag{1}$$

D_s is the stochastic discount factor of after-tax income s years ahead.[17,18] In order to satisfy equation (1), the Treasury par yield y^T needs to increase in response to an increase in expected future tax rates $\mathbb{E}_t\tau_s$, holding fixed the discount factor D.

In practice, factors other than taxes influence the yield spread, and the discussion above suggests that these factors are mainly related to liquidity. To account for such factors I follow Krishnamurthy and Vissing-Jorgensen (2008) and introduce a latent stochastic liquidity shock λ_m for holding municipal bonds. Moreover, I use off-the-run Treasury bonds which are less liquid than on-the-run issues and are therefore more similar to municipal bonds.[19] The par yield $y^{\mathcal{M}}_{t,m}$ of a similar tax-exempt municipal bond is given by

$$1 = \sum_{s=1}^{m} \mathbb{E}_t[D_s(y^{\mathcal{M}}_{t,m} - \lambda_m)] + \mathbb{E}_t[D_m] \; . \tag{2}$$

To satisfy equation (2), the real municipal par yield $y^{\mathcal{M}}$ has to increase to compensate a positive liquidity shock λ, holding fixed the discount factor D.[20]

The marginal investor is indifferent between investing one more dollar in a Treasury or a municipal bond with the same maturity. Let M be the longest maturity available. I solve (1) and (2) as a function of the relative municipal yield spread $y^{\mathcal{M}}/y^T$ to obtain

[16] To simplify notation I abstract here from the fact that coupon payments are semi-annual rather than annual, but I take this into account when analyzing the data.

[17] A word on notation: Whenever possible I use the first subscript – usually t – to denote calendar or "household time" and the second subscript – usually m or s – to denote the forecast horizon in years. For example, $y^T_{t,m}$ is the yield at date t (today) on a Treasury bond that matures in m years. For bond yields, calendar time t is daily or weekly before or after 1983, respectively. "Household time" t in the CEX is quarterly such that $\Delta_t x_t$ is the quarterly change of x_t. However, since the CEX is a *monthly rotating panel*, the overall sampling frequency of the consumption data is monthly.

[18] In a consumption-based capital asset pricing model (C-CAPM) the stochastic discount factor (SDF) is the ratio of the marginal values of wealth in s years and today, i.e. $D_s = V'_s(W_s)/V'_t(W_t)$. If preferences are additively separable then the SDF reduces to $D_s = \delta^{s-t}u'_s(C_s)/u'_t(C_t)$.

[19] Treasury bonds that are issued before the most recently issued bond of a particular maturity are called *off-the-run*, while the most recently issued bond is called *on-the-run*.

[20] I add the liquidity shocks in a linear way to obtain an analytical expression that is linear in both the path of expected tax rates as well as the liquidity premium; see equation (3) below. Adding the liquidity shock in a multiplicative way does not change the conclusions of this paper.

$$\theta_{t,m} \equiv 1 - \frac{y^{\mathcal{M}}_{t,m}}{y^{T}_{t,m}}$$

$$= \sum_{s=1}^{m} \overbrace{\frac{\mathbb{E}_t D_s}{\sum_{i=1}^{m} \mathbb{E}_t D_i}}^{w^{(m)}_{t,s}} \cdot \mathbb{E}_t \tau_s - \underbrace{\overbrace{\frac{\sum_{s=1}^{m} \mathbb{E}_t D_s \lambda_m}{y^{T}_{t,m} \sum_{i=1}^{m} \mathbb{E}_t D_i}}^{\Lambda^{\lambda}_{t,m}}}_{\geq 0} + \underbrace{\overbrace{\frac{\sum_{s=1}^{m} \mathbb{C}\mathrm{ov}_t(D_s, \tau_s)}{\sum_{i=1}^{m} \mathbb{E}_t D_s}}^{\Lambda^{\tau}_{t,m}}}_{\leq 0} \quad (3)$$

$$\equiv w^{(m)\prime}_t \, \mathbb{E}_t \tau - \Lambda^{(m)}_t \, .$$

The sum of the liquidity premium Λ^{λ} and the tax risk premium Λ^{τ} is $\Lambda^{(m)}_t = \Lambda^{\lambda}_{t,m} - \Lambda^{\tau}_{t,m}$. The expected tax path over the horizon M is given by the vector $\mathbb{E}_t\tau = (\mathbb{E}_t\tau_1 \ldots \; \mathbb{E}_t\tau_M)'$.[21] $w^{(m)}_t = (w^{(m)}_{t,1} \ldots \; w^{(m)}_{t,m} \; 0 \ldots 0)'$ is the vector of annuity weights such that $w^{(m)\prime}_t \mathbb{E}_t\tau = \sum_{s=1}^{m} w^{(m)}_{t,s} \mathbb{E}_t\tau_s$ is the annuity value of the path of expected tax rates over the maturity m of the two bonds.[22]

In analogy to the break-even inflation rate I call θ the *break-even tax rate* (BETR). If there were no uncertainty and if taxes were constant over the maturity of the two bonds then the break-even tax rate equals the marginal tax rate of the marginal investor, i.e. $\theta_{t,m} = \tau$. If one allows for uncertainty about future tax rates and liquidity risk then the relationship between expected tax rates and break-even tax rates becomes more complicated. Equation (3) reveals that the BETR is in general a weighted average of expected future tax rates over the maturity of the bonds minus a premium Λ.

Both the Treasury and municipal bond markets are deep. During the period 1980 to 2001, Treasury debt has a share between 16 and 32% of all outstanding U.S. marketable debt while the share of municipal debt is between 9 and 19%. To put these numbers in perspective, the total volume of marketable US debt was \$18.5 trillion in 2001.[23] Since the market for Treasuries is more liquid than the municipal bond market, and because liquidity demand is high in bad times, the liquidity premium is non-negative, i.e. $\Lambda^{\lambda} \geq 0$.

On the other hand, marginal income tax rates are low in bad times because of the progressivity of the income tax and the possibility of countercyclical tax policies. After an extensive analysis of the narratives surrounding all major post-war tax changes,

[21] When I calculate the weights in the empirical section below I take into account that coupon payments are semi-annual and use $\mathbb{E}_t[D_s] = (1 + y^{\mathcal{M}}_{t,s}/2)^{-2s}$.

[22] In the absence of discounting, the first m elements of $w^{(m)}_t$ are equal to $1/m$. With discounting, the weights are generally decreasing in m such that $w^{(m)}_{t,m} < 1/m$. If the tax-exempt yield curve steepens, then future income is discounted more heavily, leading the weights on future tax rates to decrease.

[23] These calculations are based on data from the Securities Industry and Financial Markets Association (SIFMA), http://www.sifma.org/research/statistics.aspx.

Romer and Romer (2010) conclude that all income tax changes from 1980 to 2001 – with one minor exception in 2001 – are not countercyclical policies or spending related but motivated by concerns about the long-run growth rate or the federal debt. Hence, the tax risk premium Λ^τ is likely primarily due to the progressivity of the income tax. The progressivity induces an insurance mechanism by paying larger after-tax interest in bad times and lower after-tax income in good times. The tax premium is therefore non-positive, i.e. $\Lambda^\tau \leq 0$. To quantify Λ^τ I estimate the following population moments: $\min_s\{\mathbb{C}\mathrm{ov}(D_s, \tau)\}$, $\max_s\{\mathbb{C}\mathrm{ov}(D_s, \tau)\}$, and $\sum_s \mathbb{E}_t D_s$. The estimates are -0.0013, 0.00128, and 13.80, the latter with a standard deviation of 2.02. Since Λ^τ is only of order 1/1000, the tax risk premium is non-positive and negligible.

Stacking equation (3) for the entire term structure of length M I obtain a system of equations that provides a mapping between the M break-even tax rates θ_t and the underlying path of expected forward tax rates $\mathbb{E}_t\tau$ over the forecasting horizon of 1 to M years at any point in time t,

$$\theta_t = W_t\ \mathbb{E}_t\tau - \Lambda_t\ . \tag{4}$$

W_t is the M-by-M lower triangular annuity weighting matrix $\left[w_t^{(1)} \dots\ w_t^{(M)}\right]'$ and the vector of risk premia is given by $\Lambda_t = (\Lambda_t^{(1)} \dots\ \Lambda_t^{(M)})'$.

[Figure 3 about here.]

2.3 The Marginal Tax Rate of the Marginal Investor In order to recover the underlying path of expected tax rates $\mathbb{E}_t\tau$ one needs to know the marginal tax rate of the marginal investor and correct for the risk premium Λ_t. Figure 3 contrasts the 2- and the 15-year BETR – both the raw data and the trend component after applying a low-pass filter – with the marginal tax rate of the top 1% of the income distribution, taken from Saez (2004). The 2-year BETR follows the top marginal tax rate closely, with the exception of the early 1990s, suggesting that the marginal investor is a household in the top of the income distribution. This finding is consistent with the fact that incentives to hold tax-exempt debt increase with the effective marginal tax rate. Importantly, movements in the 2-year BETR anticipate movements in the top rate. The 15-year BETR, which averages expected future tax rates over a longer horizon, behaves differently. It sharply decreases during the early 1980s in anticipation of the Reagan tax cuts and stays relatively constant until the late 1990s when it starts to decline again in anticipation of the Bush tax cuts of the early 2000s. The fact that the time series of BETRs with different maturities do not move one-for-one strongly suggests that the bond market not only forecasts the timing of future income tax changes but also the *expected path* of tax rates. Therefore, bond prices determine not only the *expected timing* of future tax changes but also the *expected persistence* of such shocks.

For the analysis of the response of household consumption to tax news in the next section it is important to identify the entire path of expected tax rates $\mathbb{E}_t\tau$ from the term structure of break-even tax rates θ_t. According to the basic rational-expectations life-cycle model, consumption should respond to changes in the expected after-tax lifetime income. In particular, two tax reforms that affect the expected after-tax lifetime income by the same amount should have the same effect on current consumption independent of the timing of the tax changes (abstracting from any liquidity constraints). In order to compute the expected after-tax lifetime income one needs to identify the entire path of expected future tax rates.

Finally, Figure 3 shows that the 2-year and the 15-year break-even tax rates are generally below the top marginal tax rate reflecting the existence of a positive risk premium Λ_t.[24] The risk premium appears to be larger for the 15-year than the 2-year BETR, causing the 15-year BETR to be below the 2-year BETR which in turn is below the realized tax rate. The finding that the relative risk premium increases with the maturity of the yield spread is consistent with a large literature on the so-called "muni puzzle", the observation that the slope of the municipal bond yield curve is almost always steeper than the slope of the Treasury yield curve. There is a large literature in finance that tries to explain this fact; see for example, Fama (1977), Poterba (1986), Green (1993), Park (1995), and Mankiw and Poterba (1996). So far, no single explanation of this puzzle has emerged, although some factors have been rules out, such as default risk; see Chalmers (1998). The main remaining explanations are taxes and liquidity. This paper shows that while taxes can explain much of the variation of the first moment of the municipal yield spread – at least at lower frequencies – tax uncertainty is probably not the main driver of the second moment and hence of the risk premium.

[Figure 4 about here.]

Figure 3 suggests that the simple model of the BETR given by equation (3) fits the data well. To provide further evidence on the identity of the marginal investor I turn to two additional data sources, the Flow of Funds and the Survey of Consumer Finance (SCF), described in more detail in Appendix A.2 and Appendix A.3.

Figure 4 taken from Ang, Bhansali and Xing (2007) shows the evolution of municipal debt ownership since 1950 using the Federal Reserve's Flow of Funds Accounts. Households' ownership, either direct or indirect via mutual funds, increases starting in the 1970s.

[24] Figure 10 shows the average break-even tax rate risk premium $\mathbb{E}[\Lambda_t]$ as a function of the maturity m. I calculate the premium using equation (11) derived below.

This change in ownership can partly be explained by the emergence of mutual funds which facilitate investment in municipal bonds considerably. The decline of bank ownership of municipal debt mirrors the rise in household ownership and is partly explained by legislative actions limiting the tax-exemption of municipal debt for corporations and by changes in regulations of bank charters in many states. The share held by insurance companies and other institutions is low and remains roughly constant. The changing pattern of municipal bond ownership might explain the conflicting evidence found in the earlier literature that tries to identify which marginal tax rate is implied in the municipal yield spread; see for example Fama (1977), Poterba (1986), Green (1993), and Park (1995). The important point for this paper is that the data from the Flow of Funds indicates that starting in the 1970s households are the marginal investors in municipal and Treasury bonds.

[Figure 5 about here.]

Next, one needs to know which households own municipal bonds in order to determine the marginal tax rate identified by the relative bond spread. Since equations (1) and (2) are first-order conditions of the marginal investor's portfolio choice problem, they should apply to all households holding both types of bonds. To analyze this claim I map the SCF to the NBER TAXSIM calculator (Feenberg and Coutts (1993)) and impute effective marginal tax rates for each household. I define the marginal tax rate of the marginal investor as the asset-weighted average of the effective marginal tax rate over all households that own both taxable and tax-exempt bonds. Figure 5 compares the estimates of the marginal investor's marginal tax rate with the marginal tax rates of different percentiles of the income distribution taken from Saez (2004).[25] The imputed tax rates in the SCF are very similar to the (risk-adjusted) short-run break-even tax rates derived from the municipal yield spreads. The marginal tax rate of the marginal investor identified in the SCF is close to the tax rate of the top 1% and above the marginal tax rate of the top 5% to 1% of the income distribution.[26] Since the top two tax brackets move very closely during my sample period it is not important whether the marginal investor is in fact in the top bracket or one bracket below that. The identification of the consumption response to tax news shocks in the next section relies on *changes* in the path of expected tax rates, not the level. Therefore, choosing the wrong level of the marginal investor's tax rate does not affect the results as long as this tax rate moves closely with the true tax rate.[27]

[25] Saez (2004) uses annual tax return data from the Internal Revenue Service (IRS).

[26] Using data from federal income tax returns in 1988, Feenberg and Poterba (1991) find similar marginal tax rates for households that report receiving tax-exempt interest income.

[27] The point estimates of the marginal investor's marginal income tax rate are precise except for 1994. The larger standard errors in 1994 probably reflect the fact that the tax increase introduced in August

In sum, the preceding analysis demonstrates that the position of the marginal investor in the income distribution remains stable during the sample period. Hence changes in break-even tax rates, holding fixed the risk premium, are due to changes in the effective tax rate of the marginal investor and not due to the marginal investor changing her position in the income distribution holding tax rates fixed.

2.4 Two Presidential Elections as Natural Experiments The asset allocation data – the Flow of Funds and the SCF – as well as the relative bond prices – the time series of BETRs – both strongly suggest that the marginal investor is a household in the upper tail of the income distribution. Using two natural experiments I formally test this hypothesis and asses the degree to which bond markets predict the evolution of future tax rates. The presidential elections of 1992 and 2000 are close to ideal natural experiments for this purpose.[28] During both elections the nominees from the Democratic and the Republican Party campaigned on very different proposals concerning the top income tax rates. Furthermore, these tax proposals received extensive coverage by the media and featured prominently in both the primary and presidential debates.[29] In 1992 Bill Clinton proposed to increase the top tax rate by 10% to deal with the high level of government debt. His victory ultimately lead to the Omnibus Budget Reconciliation Act (OBRA 1993), which increased the top rate by 8.6% retroactively back to January 1, 1993. Importantly, OBRA 1993 left the dividend and the long-term capital gains tax rates unchanged.[30] President George H.W. Bush, haunted having broken his tax pledge

1993 was *retroactive* back to January 1, 1993 (OBRA 1993). Heterogeneity in portfolio re-balancing of marginal bond investors might explain these larger standard errors.

[28] Other studies that looked at the impact of elections on the bond markets include Slemrod and Greimel (1999) and Ayers et al. (2005). Slemrod and Greimel (1999) find that changes in the election probability of Steve Forbes in 1996, who proposed to introduce a flat tax, had an impact on the municipal yield spread of maturities 5 and 10 years but not for the 30-year maturity. Ayers et al. (2005) also use election probabilities from 1992 and find a positive response of the break-even tax rates using maturities 5, 10, and 30 years. Interestingly, they also find negative excess returns on dividend-yielding stocks in response to changes in the election probability of Bill Clinton. My results are an extension of their analysis. I use the entire term structure of BETRs and I offer a quantitative interpretation of the regression coefficients. Moreover, I extract the path of expected forward tax rates from the vector of regression coefficients.

[29] For a comparison of the campaign proposals, see Seib and Murray (1992) and Calmes (2000).

[30] OBRA 1993 also increased the top corporate tax rates, but only by 1% from 34% to 35%. George H.W. Bush proposed to cut long-term capital gains tax rates from 31% to 15.4%. Clinton on the other hand planned to leave the rates unchanged but offered to exclude 50% of long-term capital gains from taxation; see Seib and Murray (1992). Therefore, the presidential election of 1992 is useful to test the importance of the corporate tax rate against the income tax rate as a determinant of the municipal yield spread. However, the election of 1992 is not fully suited to discriminate between income taxes and taxes on long-term capital gains. Fortunately, the presidential election of 2000 allows me to discriminate between these two tax rates.

from the 1988 election campaign, promised not to raise any taxes.[31]

Similarly, during the presidential election of 2000 George W. Bush proposed to cut taxes across the board – including the top rate – by about 5%, using the budget surplus that accumulated under President Clinton. Incumbent Vice President Al Gore proposed tax breaks for low and middle income taxpayers while leaving the top rates unchanged. Bush's victory in 2000 ultimately lead to the Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA) and the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA) which lowered the top income tax rate by 4.6% over three years. Importantly, EGTRRA 2001 leaves the top corporate income, capital gains, and dividend tax rates unchanged.[32]

In this exercise I use data from the Iowa Electronic Markets (IEM), a political prediction market described in more detail in the Appendix A.4. The IEM provides the daily price of a winner-takes-all contract during the last few month of the presidential races of 1992 and 2000. Those contracts pay \$1 if the specific candidate wins and \$0 otherwise. Since bets are limited to \$500, market participants cannot use the prediction markets to hedge their income tax risk. Changes in the prices of such contracts can be interpreted as measuring daily changes in the election probability of the presidential candidates.[33] In the following derivation of the regression equations I use the presidential election of 2000, but the same applies for the election of 1992 substituting "Clinton" for "Bush" and "Bush" for "Gore".

[Table 3 about here.]

Let p_t be the price of a contract that pays \$1 if George W. Bush wins the election in 2000 and 0 otherwise. $\mathbb{P}\mathrm{r}_t(\text{Bush})$ denotes the probability of Bush winning the election conditional on all information available at time t. I assume that the price corresponds to the rational conditional probability measure, i.e.

$$p_t = \mathbb{P}\mathrm{r}_t(\text{Bush}) \ . \tag{5}$$

[31] In a speech at the 1988 Republican National Convention as he accepted the nomination, George H.W. Bush used the (in)famous phrase "Read my lips: no new taxes". In 1990 and under pressure from a Democratic congress he signed the Omnibus Budget Tax Reconciliation Act (OBRA 1990) which went into effect on January 1, 1991.

[32] Later in his first term, President George W. Bush lowered the dividend tax rates and the long-term capital gains tax rates to 15%, 5%, and 0% (JGTRRA 2003). However, these cuts were not part of his campaign platform; see Calmes (2000). The presidential election of 2000 can therefore be used to test the impact of the top income tax rate on the municipal yield spreads against all other marginal tax rates.

[33] See Snowberg, Wolfers and Zitzewitz (2011) for a more extensive discussion of the use of prediction markets for economic inference.

Using the law of iterated expectations, I decompose the conditional expectation of the path of future tax rates $\mathbb{E}_t\tau$ as follows,

$$\mathbb{E}_t\tau = p_t \cdot \underbrace{(\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}])}_{\mathbb{E}_t[\tau|\Delta\text{Bush}]} + \mathbb{E}_t[\tau|\text{Gore}] \ . \tag{6}$$

Substituting (6) in (4) I obtain a system of 30 regression equations

$$\begin{aligned}\theta_t &= p_t \cdot W_t\mathbb{E}_t[\tau|\Delta\text{Bush}] + (W_t\mathbb{E}_t[\tau|\text{Gore}] - \Lambda_t) \\ &= p_t \cdot \beta + (\alpha + Z_t\Gamma + \varepsilon_t) \ \ ,\end{aligned} \tag{7}$$

where α are maturity fixed effects and Z_t is a list of variables that capture risk premium shocks Λ_t.[34] Model (4) delivers the interpretation of the population parameters to be estimated,

$$\beta = \mathbb{E}[W_t] \ \mathbb{E}[\tau|\Delta\text{Bush}] \ . \tag{8}$$

$\mathbb{E}[\cdot]$ without a subscript is defined as the average of the conditional expectations over the election sample, i.e. $\mathbb{E}[x] \equiv \frac{1}{T}\sum_{t=1}^{T}\mathbb{E}_t[x]$.[35] Equation (8) shows that the vector of population regressions β contains the annuity values of the difference in the paths of expected tax rates $\mathbb{E}[\tau|\Delta\text{Bush}]$ between a world in which Bush wins the election in 2000 and the counter-factual world in which Gore wins. Table 3 lists the estimated response $\hat{\beta}$ of the BETRs to changes in the election probability in 2000 and 1992 for the eight most commonly traded maturities. Most coefficients are statistically significantly different from zero and have the expected sign.

[Figure 6 and Figure 7 about here.]

To interpret the magnitudes of the estimated coefficients, note that the contracts pay 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election. Multiplying the coefficients by 100 yields the predicted change

[34] I include in this list among other variables the yield spread between off- and on-the-run Treasuries, between corporate and Treasury bonds, between Aa and pre-refunded municipal bonds, the credit spread between Baa and Aa municipal bonds, the 30-day visible municipal bond supply, and the trading volume in the prediction market. Table A.3 and Table A.4 in Appendix E show the full set of regression results for the eight most commonly traded maturities.

[35] I searched the archives of *The New York Times* and *The Wall Street Journal* for articles that would indicate a change in the tax proposal of the candidates during the sample period but did not find any. Hence I assume that the relative difference between the tax proposals $\mathbb{E}_t[\tau|\Delta\text{Bush}]$ remains constant during the final months of the election, i.e. $\mathbb{E}_t[\tau|\Delta\text{Bush}] = \mathbb{E}[\tau|\Delta\text{Bush}] \ \forall \ t$. Otherwise, β identifies the average value of the relative difference between the two proposals during the final months of the presidential election, i.e. $\beta = \mathbb{E}\left[W_t\mathbb{E}_t[\tau|\Delta\text{Bush}]\right]$.

in the BETRs if George W. Bush (Clinton) wins the election in 2000 (1992) relative to the counter-factual that Gore (George H.W. Bush) wins. Figure 6 and Figure 7 plot the vector of all 30 regression coefficients multiplied by a hundred and not just the eight maturities reported in Table 3. Letting $\tau_t^{pf} = (\tau_{t,1} \dots \ \tau_{t,M})'$ denote the perfect-foresight path of realized tax rates at date t over the horizon of 1 to $M = 30$ years, I calculate the hypothetical regression coefficients one should obtain under perfect foresight,

$$\beta^{pf} = \mathbb{E}[W_t](\tau_t^{pf} - \tau_t) \ . \tag{9}$$

Here I assume that the level of the counter-factual tax path – $\mathbb{E}_t[\tau|\text{Gore}]$ in 2000 and $\mathbb{E}_t[\tau|\text{H.Bush}]$ in 1992 which is not identified by the regression – is the status quo tax rate during the election year, i.e. $\tau_t = 39\%$ in 2000 and $\tau_t = 31\%$ in 1992, respectively. I show two scenarios for the tax path of future tax rates beyond 2011, one in which the Bush tax cuts expire in 2011 as scheduled and one in which they become permanent.

Figure 6 and Figure 7 show the path of expected break-even tax rate changes $\hat{\beta}$ together with the change in the break-even tax rates under perfect foresight β^{pf}. Note that the regression does not impose any restrictions on the sign, size, or the shape of the estimated path. While the estimates are somewhat less precise for short maturities, the coefficients for the entire term structure of BETRs show a strong relationship between the estimated path of expected BETR changes and the perfect-foresight change in the BETRs. I conclude that the municipal yield spread is strongly driven by expected future top income tax rates.

2.5 Deriving Expected Tax Rates from Break-Even Tax Rates I am ultimately interested in the inverse mapping of equations (4) and (8), i.e. $\mathbb{E}[\tau|\Delta\text{Bush}]$ as a function of β and $\mathbb{E}_t\tau$ as a function of θ_t. These market-based expected tax rates can be interpreted as *forward tax rates* in analogy to forward interest rates derived from the term structure of Treasury yields. Recall that W_t is a lower triangular annuity matrix with its last column vector given by $(0 \dots 0 \ w_{t,M}^{(M)})'$. In the data, $w_{t,M}^{(M)}$ has a mean of 0.01 with a standard deviation of 0.003 and a minimum of 0.003, so W_t can be close to singular. Inverting this matrix makes the solution sensitive to small perturbations of β or θ_t that are unrelated to tax news. Instead of a direct inverse I use a robust inverse of W_t, know as a first-order ridge regression in the statistics literature.[36] I impose that the expected tax path

[36] The word *regression* can be misleading in this context since I do not perform statistical inference in the traditional sense of projecting a vector from a larger onto a smaller space. Instead, the first-order ridge "regression" calculates M forward tax rates $\mathbb{E}_t\tau$ from M observed break-even tax rates θ_t. The constraint on the first-derivative of the solution is matched by the additional regularization penalty parameter μ. See Appendix B.1 for more details.

is a smooth function across maturities $m = 1, \ldots, 30$, since it is implausible that the expected tax rate e.g. in 20 years is very different from the expected tax rate in 19 or 21 years. The robust inverse penalizes such non-smooth solutions with a factor μ, called the regularization parameter. In Appendix B.1 I show that the parameter μ only significantly affects long-run expectations and I discuss how to optimally choose μ.

[Figure 8 and Figure 9 about here.]

Figure 8 shows the path of expected tax rates during the presidential election of 2000 obtained by inverting the regression coefficients $\hat{\beta}$. The top tax rate is expected to decrease to 35% by the year 2002 and to return quickly back to the initial level of 39.6%. Moreover, the bond markets expect the initial tax cuts to be off-set by later tax increases above the initial level of 39.6%. One interpretation is that the bond markets expect the tax cuts to be unsustainable. Compared to the perfect-foresight tax path, the path of the expected tax rates returns quickly back to rates around 40%. The expected tax rate starts to increase sharply after four years. One interpretation of this behavior is that the bond markets expect President George W. Bush to serve for only one term. Turning to the presidential election of 1992, Figure 9 graphs the path of expected tax rates against the perfect-foresight path. The bond markets correctly anticipate the new level of the top tax rate induced by the Clinton tax increase in 1993. The path of expected tax rates slightly underestimates the duration of the Clinton tax increase. The path also shows that the bond markets in 1992 expect the long-run tax rates to return back to the initial level. However, the tax cuts enacted under President W. Bush "only" lowered the top rate to 35% instead of 31%, the level in 1992.

It is remarkable that the results from both elections suggest that both tax reforms were expected to be temporary. In both cases, the long run tax rates eventually return back to the initial levels of the election year.[37] In the next section I have to make an assumption about the perfect-foresight path of tax rates beyond 2011. Consistent with the regression results from the presidential election of 2000 I assume that from 2011 on the expected tax rate reverts back to the Clinton level.

The two natural experiments show that the model of the BETRs given by equation (4) is an accurate description of the relative municipal yield spread. They also show that the expected tax rates that underlie the BETRs forecast future top tax rates surprisingly well. The experiments highlight the necessity of imposing some restrictions on the solution to

[37] More precisely, in the long run the tax rates return back to the unobserved counter-factual expected tax path $\mathbb{E}[\tau|\text{Gore}]$ respectively $\mathbb{E}[\tau|\text{H.Bush}]$ which might be different than the top tax rate in the election year.

the inverse problem in order to obtain a smooth and hence reasonable path of expected forward tax rates.

[Figure 10 about here.]

Unfortunately, the additional source of variation provided by the election probabilities is not available for the entire sample period. Instead, I impose two identifying assumptions to recover $\mathbb{E}_t\tau$ from θ_t during the sample period from 1977 to 2001. The first assumption requires that the bond spreads reflect rational-expectations,

$$\mathbb{E}[\underbrace{\mathbb{E}_t\tau - \tau_t^{pf}}_{\text{forecast error}}] = 0 \ . \tag{10}$$

The time series of the BETRs (Figure 3), the Flow of Funds (Figure 4), the SCF (Figure 5), and the two natural experiments (Figures 6, 7, 8, and 9) all show that the marginal tax rate of the top 1% of the income distribution is the tax parameter that determines the municipal yield spreads (in the absence of any shocks to the relative risk premium).[38] Rearranging (4) and imposing (10) yields a measure of the average risk premium

$$\mathbb{E}[\Lambda_t] = \mathbb{E}[W_t\tau_t^{pf} - \theta_t] \ . \tag{11}$$

Figure 10 shows the average risk premium as a function of the maturity m, estimated globally over the entire sample from 1977 to 2001. The average risk premium is monotone in the maturity of the BETR.

The second identification assumption deals with temporary shocks to the risk premium. Adding $\mathbb{E}[\Lambda_t]$ to θ_t only adjusts the level of the BETR series but does not deal with shocks to the risk premium.[39] I assume that households and the marginal investors form tax expectations independently of the municipal yield spread.[40] For instance, households read newspapers or follow political campaigns and use all these sources of information to form expectations about future tax rates. The econometrician does not directly observe those news sources, but can infer the aggregate information set by looking at municipal yield spreads and interpret the data through the lens of the BETR model, equation

[38] Note that the tax shocks are still identified even if the tax rate of the marginal investor is not exactly the tax rate of the top 1% but say of the top 3%. There are two reasons for this robustness. First, the top tax rates move more or less one-for-one over the sample period 1980-2001. Second, I will use *changes* in the expected tax rates to estimate the response of household consumption to tax news. Hence, any misspecification of the *level* will be differenced out.

[39] Note that ignoring the average risk premium would lead one to falsely infer a much lower marginal tax rate that the top income tax rate.

[40] I do not assume that all rich households in the CEX are marginal municipal bond investors. Instead, the marginal investors are a subset of all rich households.

(4). For instance, suppose the break-even tax rates decrease at date t but immediately rebound the next day, at $t+1$. The econometrician can use this fact to estimate the tax expectations at date t. He will conclude that this change in break-even tax rates was most likely due to liquidity shocks instead of tax news. If he uses only past and current prices he will underestimate the rational information set. This way of modeling tax news implies that the econometrician wants to use all prices – past, current, and future – to infer the path of expected tax rates $\mathbb{E}_t\tau$ at any point in time.

Filtering the tax news shocks from the "noise" shocks – i.e. the liquidity shocks – is important since the tax news shocks form the regressor in the consumption analysis in Section 3. Liquidity shocks introduce noise and therefore potentially attenuation bias of the consumption response coefficient. This attenuation bias toward zero would lead to the conclusion that households do not respond to news even if they in fact behave according to the rational-expectations life-cycle model. To obtain a more precise measure of the expected tax rates I use a two-sided low-pass filter that passes all frequencies below two years. While the filter may remove some tax news shocks in addition to liquidity shocks, it reduces potential attenuation bias in the analysis of household consumption. The two-year low pass filter is motivated by the fact that two years is the shortest period between two income tax reforms in the sample (OBRA 1990 and OBRA 1993).[41] I denote the low-frequency component of the BETR by $\tilde{\theta}_t$; Figure 3 shows θ_t and $\tilde{\theta}_t$ for 2- and 15-year maturities.[42]

With these two identification assumptions – that there is no systematic forecast error, and that the expected tax rates affect the trend component of the BETR series while high-frequency fluctuations reflect liquidity shocks – I recover the underlying path of

[41] I checked my results using other frequency cut-offs but did not find any tangible effects on the results. The two year cut-off is conservative since it probably filters out some tax news shocks. This loss of information lowers the precision of the consumption response estimates. On the other hand, this cut-off value lowers the level of noise in the tax news shocks. The reduction of the measurement error reduces the potential attenuation bias in the consumption response coefficients. Therefore, the choice of the frequency cut-off reflects a trade-off between bias and efficiency of the estimates. Note that measurement error biases the consumption response towards zero and hence against finding an effect of tax news shock on household consumption.

[42] A different approach of modeling tax news assumes that households try to infer the path of expected tax rates $\mathbb{E}_t\tau$ from municipal yield spreads θ_t. This approach implies that the households and the econometrician solve the same signal extraction problem at each point in time. Therefore, the econometrician can only use current and past bond prices to infer the households' information sets. The difference between the two ways of modeling information can be seen from the way the econometrician solves the signal extraction problem of equation (4). The first view implies that the optimal solution is a two-sided filter while the second view requires the use of a one-sided filter. In Appendix B.3 I estimate the consumption response to tax news shocks under this alternative way of modeling news using a one-sided filter and show that the results are robust to this alternative view. The results in Table A.2 show that the attenuation bias increases with the degree of noise, causing the response using the one-sided filter to be lower that the response using the two-sided filter, and in turn biasing the response using no filter all the way to zero.

expected future tax rates $\mathbb{E}_t\tau$ using a first-order ridge regression. For more details see Appendix B.1.[43]

[Figure 11 about here.]

Figure 11 shows the path of expected tax rates $\mathbb{E}_t\tau$ at the beginning of each year against the perfect-foresight tax path τ_t^{pf} for each month of January from 1977 to 1982. While Figure 3 already suggests that the Reagan tax cuts were well anticipated, this is only a conjecture since the time series shown in Figure 3 are break-even tax rates θ_t and not forward tax rates $\mathbb{E}_t\tau$. The path of expected forward tax rates in Figure 11 obtained by inverting the break-even tax rates of all available maturities confirms this conjecture.[44] The sequence shows that taxes are expected to remain high during Jimmy Carter's presidency and to even increase over the foreseeable future.[45] The long-run expectations decreased sharply during the presidential election of 1980 as it became increasingly clear that Ronald Reagan would become the next president. Between 1980 and 1982 as Reagan passed his first tax cut – the Economic Recovery Tax Act (ERTA 1981) – the bond market also started to anticipate the second tax reform, the Tax Reform Act of 1986 (TRA 1986). This figure reveals an astonishing degree of fiscal foresight contained in the municipal yield spreads. In the next section I use changes in the paths of expected tax rates to estimate the household consumption response to tax news.

The time series of market-based expectations derived in this section shows that fiscal foresight can be considerable. Moreover, the path of expected tax rates $\mathbb{E}_t\tau$ derived from municipal yield spreads does a good job of recovering the underlying rational tax expectations. While the wealthy households that invest in municipal bonds have a high degree of fiscal foresight, their expectations may not be representative of consumers as a whole. In the next section I quantify the degree of fiscal foresight of households by

[43] Finally, before I combine the tax shock with the household consumption data I normalize the level of the expected tax rate such that the one-year expected tax $\mathbb{E}_t\tau_1$ rate is zero. By using this normalization I assume that permanent tax shocks which move all BETRs in the same direction by the same amount have to be anticipated at least one year in advance. Fundamental tax reforms such as TRA 1986 for example are usually discussed years in advance before they pass Congress. Hence, if an unanticipated permanent shock to all BETRs occurs, then I assume that it is related to changes in the liquidity premium. The purpose of this normalization is to further reduce measurement error and potential attenuation bias towards zero in the consumption response coefficients. All the identifying variation then comes from changes in the BETRs *relative* to each other, that is from the cross-section (i.e. the term structure) of municipal yield spreads.

[44] The web appendix of this paper (https://sites.google.com/site/lorenzkueng/) contains a video of the evolution of $\mathbb{E}_t[\tau]$ from January 1977 to August 1982 that shows monthly changes in the path of expected tax rates over a 15-year forecasting horizon.

[45] The forecast horizon for this period is 15 years because Treasury yields are not available at longer maturities before 1983.

estimating the response of household consumption to tax news in order to learn more about consumer behavior and the transmission of tax news shocks in the real economy.

3 Household Consumption Response to Tax News

I use the basic framework of the rational-expectations life-cycle model to estimate the response of household consumption C_{it} to tax news and to quantify the degree of fiscal foresight of households. The empirical analysis uses household-level micro data from the Consumer Expenditure Survey (CEX), described in more detail in Appendix A.5. The model is basic in the sense that the economy is frictionless and household income before taxes Y_{it} is treated as exogenous.[46] Households can freely borrow and lend at the risk-free interest rate and there are no frictions to adjust consumption from one to the next quarter. Using a first-order approximation to the household's first-order condition, the Euler equation is given by[47]

$$\mathbb{E}_t \Delta_t \log(C_{i,t+1}) \approx \frac{1}{\gamma} \log(\delta R_{t+1}) \ . \tag{12}$$

R_{t+1} is the gross risk-free real after-tax interest rate between period t and $t+1$, γ is the coefficient of relative risk aversion, and δ is the household's discount factor in the steady state.[48] Households have identical preferences and hence identical stochastic discount factors holding fixed the life-cycle income profile. However, the empirical specification will

[46] In future work I plan to quantify other margins of adjustment to tax news such as labor supply, taxable income and income shifting in general.

[47] A second-order approximation of the first-order condition (or an exact solution if consumption is log-normal) adds the second moment of log-consumption to equation (12), $\frac{\gamma}{2}\mathbb{V}_t(\Delta_t \log(C_{i,t+1}))$. I abstract from this term in order to obtain a closed form solution of consumption as a function of expected after-tax lifetime income. In future research I plan to estimate the response of household consumption to changes in *tax uncertainty* in the presence of precautionary savings motives due to higher order terms. Since the bond yield data is available at higher frequency than the consumption data I can estimate second moments of changes in the expected tax path at quarterly intervals. These uncertainty shocks can then be used to assess the effect of tax uncertainty on household consumption behavior.

[48] I abstract from the effect of marginal tax rates on consumption via intertemporal substitution through their effect on the effective after-tax interest rate. There are two main justifications for neglecting this effect. First, the consumption model derived in this section applies to the consumption of nondurable goods, services and the service flow of durable goods, but not directly to durables expenditures. Moreover, theory suggests that durables should be the component of total expenditures that is most affected by the interest rate. Second, empirical evidence suggests that the effect of the interest rate (and hence the marginal tax rate) on the saving rate is small. Blinder and Deaton (1985) note that "standard consumption functions often omit the rate of interest as an argument – not on theoretical grounds, but on empirical grounds." (p.468) They find that while the nominal interest rate does affect consumption, the real interest rate does not. Interestingly, the nominal interest rate affects mostly service consumption but not durable expenditures. Nevertheless, an interesting avenue of future research is to use changes in expected marginal tax rates to estimate the elasticity of intertemporal substitution at the household-level.

allow for household-specific shocks to the family composition which can be interpreted as preference shocks. Moreover, I allow for predictable consumption changes as a function of the age of the head of the household and other family characteristics. To map the model to the data I assume that $\delta R_{t+1} \approx 1$. Substituting the Euler equation in the intertemporal household budget constraint over the planning horizon H and solving for current consumption using the fact that log-changes approximate growth rates results in a closed form solution for the current level of consumption,

$$C_{it} = \sum_{s=0}^{H} \overbrace{\frac{\mathbb{E}_t D_s}{\sum_{q=0}^{H} \mathbb{E}_t D_q}}^{w_{t,s}^{(H)}} \left(\mathbb{E}_t Y_{is} - \mathbb{E}_t T_{is}\right) \ , \tag{13}$$

where $w_{t,s}^{(H)}$ is the annuity weight on after-tax income $Y_{is} - T_{is}$ and T_{is} is household i's tax liability in s years. The change in household consumption due to new information arriving in period $t+1$ is

$$\Delta_t \mathbb{E}_{t+1} C_{i,t+1} = \sum_{s=0}^{H} \left[w_{t+1,s}^{(H)} \Delta_t \mathbb{E}_{t+1}(Y_{is} - T_{is}) + \Delta_t w_{t+1,s}^{(H)} \mathbb{E}_{t+1}(Y_{is} - T_{is}) \right] \ , \tag{14}$$

where $(\mathbb{E}_{t+1} - \mathbb{E}_t)[x_{i,s}] \equiv \Delta_t \mathbb{E}_{t+1} x_{i,s}$. Using the approximation $\Delta_t w_{t+1,s}^{(H)} \approx 0$, equation (14) reduces to[49]

$$\Delta_t \mathbb{E}_{t+1} C_{i,t+1} = \sum_{s=0}^{H} w_{t+1,s}^{(H)} (\Delta_t \mathbb{E}_{t+1} Y_{is} - \Delta_t \mathbb{E}_{t+1} T_{is}) \ . \tag{15}$$

Household i's tax liability in h years, $T_{i,t+h}$, is a function of future income $Y_{i,t+h}$ and the future tax schedule $\{\tau_{t+h}(b), y_{t+h}(b)\}_{b=1}^{B}$, where $\tau_{t+h}(b)$ is the tax rate in bracket b and $y_{t+h}(b)$ is the size of the income bracket b at future date $t+h$. The marginal tax rate of the top income bracket identified by the municipal yield spreads is $\tau_{t+h}(B) \equiv \tau_{t+h}$. Let $y_{i,t+h}(b)$ denote household i's income in bracket b such that $Y_{i,t+h} = \sum_{b=1}^{B} y_{i,t+h}(b)$. For example, suppose that the income brackets have a constant range of \$10,000, i.e. $y_{t+h}(b) = \$10,000 \ \forall \ b$, and that household i has a total income of $Y_{i,t+h} = \$25,000$. Then $y_{i,t+h}(1) = y_{i,t+h}(2) = \$10,000$, $y_{i,t+h}(3) = \$5,000$ and $y_{i,t+h}(b) = 0$ for $b \geq 4$. Let $\tau_{i,t+h}$

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[49] To see that $\Delta_t w_{t+1,s}^{(H)} \approx 0$, note that in general $\frac{\mathbb{E}_t D_s}{\sum_q \mathbb{E}_t D_q} \leq \frac{\mathbb{E}_t D_1}{\sum_q \mathbb{E}_t D_q}$. The bounding statistic $\frac{1}{T} \sum_t \Delta_t \left(\frac{\mathbb{E}_{t+1} D_1}{\sum_{q=1}^{30} \mathbb{E}_{t+1} D_q} \right)$ has a sample mean of $-9.48 \cdot 10^{-6}$ with a standard deviation of 0.00376. Hence the last term is of order $1/10,000$.

be the marginal tax rate of household i defined as

$$\tau_{i,t+h} \equiv \max_b \{\tau_{t+h}(b) \ : \ y_{i,t+h}(b) > 0\} \ . \quad (16)$$

Taking a first-order approximation of $T_{i,t+h} = T(Y_{i,t+h}, \{\tau_{t+h}(b), y_{t+h}(b)\}_{b=1}^B)$ around current expectations $(\mathbb{E}_t Y_{i,t+h}, \{\mathbb{E}_t \tau_{t+h}(b), \mathbb{E}_t y_{t+h}(b)\}_{b=1}^B)$ yields

$$T_{i,t+h} \approx \mathbb{E}_t[\tau_{i,t+h}] \cdot (Y_{i,t+h} - \mathbb{E}_t Y_{i,t+h}) + \sum_{b=1}^{B} \mathbb{E}_t[y_{i,t+h}(b)] \cdot (\tau_s(b) - \mathbb{E}_t \tau_s(b)) \ . \quad (17)$$

Therefore, the change in household i's expected taxes h years ahead is

$$\Delta_t \mathbb{E}_{t+1} T_{i,t+h} \approx \mathbb{E}_t[\tau_{i,t+h}] \cdot \Delta \mathbb{E}_{t+1} Y_{i,t+h} + \sum_{b=1}^{B} \mathbb{E}_t[y_{i,t+h}(b)] \cdot \Delta_t \mathbb{E}_{t+1} \tau_s(b) \ . \quad (18)$$

In an ideal setting I would observe news shocks for each tax rate $\tau_{t+h}(b)$ in each income bracket b, i.e. $\Delta_t \mathbb{E}_{t+1} \tau_s(b) \ \forall \ b$. However, in practice I only observe news shocks for the top tax rate $\tau_{t+h}(B)$. Therefore, I replace the unobserved expected tax rates in lower income brackets using two assumptions. First, I assume that changes in the tax base – if they do occur – are perfectly foreseen, so $\mathbb{E}_t y_{t+h}(b) = y_{t+h}(b)$. With the exception of TRA 1986, which I discuss in more detail in Appendix B.2, this assumption approximates the income tax reforms in my sample well. Second, I scale the perfect-foresight tax rate in each lower income bracket – $\tau_{t+h}(b)$ with $b < B$ – by the ratio of the market-based expected top tax rate $\mathbb{E}_t \tau_{t+h}(B)$ to the perfect-foresight top tax rate $\tau_{t+h}(B)$, which is taken from Saez (2004), such that

$$\mathbb{E}_t \tau_{t+h}(b) = \tau_{t+h}(b) \ \frac{\mathbb{E}_t \tau_{t+h}(B)}{\tau_{t+h}(B)} \equiv \tau_{t+h}(b) \ \frac{\mathbb{E}_t \tau_{t+h}}{\tau_{t+h}} \ . \quad (19)$$

This implies that the lower bracket rates are expected to change proportionately to the top tax rate,[50]

$$\Delta_t \mathbb{E}_{t+1} \tau_{t+h}(b) = \tau_{t+h}(b) \ \frac{\Delta_t \mathbb{E}_{t+1} \tau_{t+h}(B)}{\tau_{t+h}(B)} \ . \quad (20)$$

It is important to note that this assumption does *not* imply that the expected change in the *average* tax rate is the same for all households. To see this, suppose that the expected future tax schedule in h years from now has only two tax rates, 10% and 50%. Let the

[50] Since the sampling frequency is quarterly at the household-level while expectations are formed at annual frequency I assume without loss of generality that the perfect-foresight variables do not change between quarters, e.g. $\tau_s(b)$ and $y_s(b)$ are the same for all four quarters in which I observe household i.

first tax bracket range from \$0 to \$10,000 so that all income above \$10,000, which is the second income bracket, is expected to be taxed at the 50% rate. Suppose that the expected top tax rate increases by 10%, i.e. $\frac{\Delta_t \mathbb{E}_{t+1}\tau_{t+h}(B)}{\tau_{t+h}(B)} = 0.1$ such that the lower tax rate increases by 1 percentage point from 10% to 11% and the top tax rate by 5 percentage points from 50% to 55%. The expected average tax rate of a household with an income of $Y_{i,t+h} = \$10,000$ increases by 1 percentage point. However, the expected average tax rate of a household with an income of $Y_{i,t+h} = \$15,000$ increase by 2⅓ percentage points. Moreover, as income goes to infinity the expected change of the average tax rate approaches 5 percentage points, which equals the expected change of the top tax rate. The assumption in equation (20) is therefore least restrictive for high-income households for which changes in the top tax rate are closely related to changes in their average tax rate. For this reason I start the consumption analysis by estimating the consumption response of high-income households to tax news.

To make the estimated responses to tax news comparable with results in other studies I estimate the response of consumption to tax news shocks in growth rates rather than in first differences. To avoid a possible division bias of the tax news response coefficient I normalize consumption changes and income and tax changes using two different variables. Avoiding this type of bias is important since division bias increases the probability of finding a response to tax news even if there is no response in the economy. I normalize changes in tax liabilities and income by the estimated household income in period $t + h$, which is based on the predetermined income from the first interview – interview 2 in CEX terminology – and described in more detail below. Using income from the first instead of the last interview avoids any endogeneity bias due to the fact that income from the last interview might contain new information that the household received during the survey year. I normalize consumption changes by consumption instead of income. To reduce measurement error I use average consumption $\bar{C}_i$ over all four interviews.[51]

I calculate perfect-foresight average tax rates $\bar{\tau}_{is}$ that depend on the head of household's age and the household's income percentile. These profiles allow for predictable changes in average tax rates due to the hump shape of the life-cycle income profile. Lagged

[51] The CEX measures expenditures more precisely than income. Since my purpose here is only to normalize consumption changes I can use an average over all survey responses without violating the flow of information received by households. The consumption response is purely driven by the quarterly changes and all those changes are normalized by the same quantity $\bar{C}_i$. This averaging further reduces measurement error. At the earliest, the actual tax shock can occur one quarter *after* the household exits the survey because households are in the survey for at most one year. I checked my results using both lagged consumption and consumption from the first interview to normalize consumption changes and I also estimated the model using log-changes in consumption. The estimates are quantitatively similar but have somewhat larger standard errors.

income and household age are good predictors of future household income.[52] Lagged income summarizes observed household characteristics such as education and experience as well as unobserved heterogeneity such as work effort. Household age has predictive power for future income even conditional on work experience. I estimate future average tax rates non-parametrically; in particular, I discretize the joint distribution of age and income and assume that the household remains in the same age-specific income percentile throughout its life-cycle.[53] Having only two dimensions guarantees that there is a sufficient number of households in each age-income cell in each year, i.e. at least 20. I restrict the sample to households where the head's age is between 25 and 64 years and the head is not a student – a sample selection that is common in most studies that use the CEX; see for example, Souleles (1999), and Johnson et al. (2006).[54] I use households age 65 to 75 to estimate counter-factual retirement income after age 65.[55] I assume that households expect to receive this level of retirement income for the rest of the planning period.[56] Finally, I set the planning horizon H equal to the maximum available bond maturity M, either 15, 20, or 30 years depending on the sample period.

Using these assumptions, the response of quarterly household consumption growth to new information arriving in period $t+1$ is[57]

$$\frac{\Delta_t \mathbb{E}_{t+1} C_{i,t+1}}{\bar{C}_i} = \underbrace{\sum_{s=1}^{M} w_{t,s}^{(M)} \ \frac{\bar{\tau}_{is}}{\tau_s} \ \Delta_t \mathbb{E}_{t+1} \tau_s}_{\text{tax news shock}} + \underbrace{\sum_{s=0}^{M} w_{t,s}^{(M)} \ (1 - \mathbb{E}_t \tau_{is}) \ \frac{\Delta_t \mathbb{E}_{t+1} Y_{is}}{Y_{is}}}_{\text{structural error term } \varepsilon_{i,t+1}^{S}} , \tag{21}$$

[52] I confirm this conjecture in independent work. I extend the income imputation model of the BLS for the CEX, which started in 2004, back to 1980; see Appendix A.5. Lagged income as well as household age are the best predictors of future levels of household income. Other studies also found that household income dynamics are well approximated by a random walk after controlling for the age profile of income, e.g. MaCurdy (1982), Abowd and Card (1989), and Meghir and Pistaferri (2004).

[53] More precisely, I use the following income percentile thresholds: $10, 20, \ldots, 50, 55, \ldots, 95$. I use a finer grid for higher incomes to better account for the increasing income inequality during the sample period. I use age bins with a 10-year range to make sure that the number of observations in each cell is at least 20. The five age bins – age 25-34, 35-44, 45-54, 55-64, 65-75 – approximate the income life-cycle profiles well.

[54] See Appendix A.5 for a more detailed description of the household sample selection.

[55] I use the tax code of 2004 to compute perfect-foresight average tax rates for years 2005 to 2011 after which I assume that the Bush tax cuts expire. This assumption is supported by the bond markets' expectations during the presidential election of 2000. I use the tax code of 2000 – the last year under Clinton – to calculate perfect-foresight average tax rates beyond the year 2011.

[56] I limit the estimation of the retirement period to households age 65 to 75 due to the fact that the quality of the survey answers tends to be poorer for old retirees.

[57] Note that the first element in the first sum drops out since the current tax schedule is known, hence $\mathbb{E}_{t+1}\tau_0(b) = \mathbb{E}_t \tau_0(b) \ \forall \ b$. Therefore, the first sum starts at $s = 1$. The same is not true fore household income because in general $\mathbb{E}_{t+1} Y_{i0} \neq \mathbb{E}_t Y_{i0}$, where Y_{i0} is household i's current income during the interview year.

where household i's future average tax rate in s years is $\bar{\tau}_{is} = \frac{T_{is}}{Y_{is}}$. $\Delta_t \mathbb{E}_{t+1} \tau_s$ measures news about the top marginal income tax rate s years ahead. This shock, which I derived in Section 2, can be interpreted as the signal that the household receives between date t and $t+1$. The term $\frac{\bar{\tau}_{is}}{\tau_s}$ is a measure of the relevance of the signal for the household's consumption decision. One can think of this ratio as an importance weight for the signal: if this ratio is low then the impact of news about the top tax rate in s years has only a small impact on the household's expected after-tax lifetime income, and a rational household should therefore largely ignore the signal $\Delta_t \mathbb{E}_{t+1} \tau_s$. On the other hand if the ratio is large, then the household should pay close attention to the signal.

The *realized* consumption change $\Delta_t C_{i,t+1}$ is the sum of the response to news and the predictable growth component of consumption given information at time t,

$$\Delta_t C_{i,t+1} \equiv \Delta_t \mathbb{E}_{t+1} C_{i,t+1} + \mathbb{E}_t \Delta_t C_{i,t+1} \ . \tag{22}$$

Consistent with previous studies I model the predictable component of consumption using a linear control function,

$$\frac{\mathbb{E}_t \Delta_t C_{i,t+1}}{\bar{C}_i} = \phi_z' \Delta_t z_{i,t+1} + \alpha_{t+1} + \varepsilon_{i,t+1}^{ME} \ . \tag{23}$$

$\Delta_t z_{i,t+1}$ contains changes in the family composition and a second-order polynomial in household age, α_{t+1} are monthly fixed effects, and $\varepsilon_{i,t+1}^{ME}$ captures measurement error.

Combining (21) and (23) yields the following regression,

$$\frac{\Delta_t C_{i,t+1}}{\bar{C}_i} = \beta \underbrace{\left(\sum_{s=1}^{M} w_{t+1,s}^{(M)} \ \frac{\bar{\tau}_{is}}{\tau_s} \ \Delta_t \mathbb{E}_{t+1} \tau_s \right)}_{\text{tax news shock}} + \phi_z' \Delta_t z_{i,t+1} + \alpha_{t+1} + \varepsilon_{i,t+1} \ , \tag{24}$$

with the combined error term $\varepsilon_{i,t+1} = \varepsilon_{i,t+1}^{S} + \varepsilon_{i,t+1}^{ME}$. The tax news response β is identified if news about future tax changes are uncorrelated with news about before-tax household income $\varepsilon_{i,t+1}^{S}$, conditional on household characteristics $\Delta_t z_{t+1}$ and monthly fixed effects α_{t+1}, i.e. if

$$\mathbb{C}\text{ov}\left(\sum_{s=1}^{M} w_{t+1,s}^{(M)} \ \frac{\bar{\tau}_{is}}{\tau_s} \ \Delta_t \mathbb{E}_{t+1} \tau_s \ , \ \varepsilon_{i,t+1} \ \middle| \ \Delta_t z_{i,t+1}, \alpha_{t+1} \right) = 0 \ . \tag{25}$$

Monthly fixed effects control for changes in the average interest rate, and they also control for the extent to which fiscal policy is used to counteract aggregate fluctuations in economic activity. While fiscal policy was extensively used prior to the 1980s, it was largely replaced by monetary policy as the main countercyclical policy tool since then, at least until very recently. For instance, Romer and Romer (2010) find that all income tax changes between 1980 and 2003 – with one minor exception in 2001 – are not countercyclical nor did they coincide with changes in government spending.[58] Romer and Romer therefore classify those income tax reforms as exogenous, driven either by attempts to increase long-run economic growth (ERTA 1981, TRA 1986, EGTRRA 2001 and JGTRRA 2003) or by concerns about the federal budget deficit (OBRA 1990 and OBRA 1993).

While the tax reforms in the sample are orthogonal to the current state of the economy – and hence exogenous according to the terminology of Romer and Romer (2010) –, the corresponding tax news shocks might nevertheless be correlated with news about future income. Thus, while it is not possible to fully rule out that the consumption response is at least partially driven by correlated income news shocks, a consumption response to either type of shock still indicates that households are forward-looking.

One final concern is that liquidity shocks are correlated with the business cycle or with bad income news in general. When financial markets are under stress – such as during the financial crisis of 2008-2010 – the liquidity premium on Treasury bonds tends to increase. Such periods are also associated with lower consumption. An increase in the demand for liquidity provided by Treasury bonds relative to municipal bonds increases the relative price for Treasuries and hence lowers the Treasury yield relative to the yield on municipal bonds. Equation (3) shows that this mechanism causes the BETRs θ_t to decrease and therefore decreases the measured path of expected forward tax rates $\mathbb{E}_t\tau_t$. To the extent that such liquidity shocks are not absorbed by monthly fixed effects or by the filtering of the time series, they induce a spurious *positive* correlation between changes in the measured path of expected tax rates and consumption changes. This possible correlation leads the response coefficients to be biased towards the cash-on-hand model if the rational-expectations model is the correct description of household behavior, and will lead to positive response coefficients even if the cash-on-hand model is in fact the true model. For these reasons – that income tax reforms in the sample are exogenous to the current state of the economy, and that any remaining liquidity shock biases the results against the basic rational-expectations model – equation (25) is a reasonable identification assumption.

The null hypothesis under the basic rational-expectations life-cycle income model

[58] The minor exception is the Economic Growth and Tax Relief Reconciliation Tax Act of 2001 (EGTRRA). The countercyclical part of EGTRRA concerns the accelerated implementation of the tax cuts but it does not concern the overall size of the cuts. For instance, Romer and Romer (2008) note that "this [countercyclical] motivation was almost always discussed in the context of making some of the cuts retroactive to January 1, 2001 rather than having them begin on January 1, 2002." (p.84)

(RELC) is that

$$H_0^{RELC}: \; \beta = -1 \; .$$

Many alternative theories such as myopia, cash-on-hand constraints (COH), and others predict that consumption does not respond to news, i.e.

$$H_0^{COH}: \; \beta = 0 \; .$$

[Figure 12 about here.]

3.1 Two Sources of Identification To summarize, I combine two sources of variation to identify the response of household consumption to news about future income taxes. First, I use changes in the path of expected top tax rate to identify the quantity of new information revealed at each point in time. Second, I use cross-sectional variation in expected *average* tax rates since changes in expected average tax rates determine the response of household consumption in the basic rational-expectations life-cycle model, while marginal tax rates affect the portfolio allocation decision. Figure 12 shows the changes in the average tax rate as a function of taxable income for all major income tax reforms in my sample. To generate the profiles I use a distribution of incomes with equally spaced grid points of $100 increments. I feed this income distribution into the TAXSIM calculator and assume that the households are married, file jointly, and have no children. For example, Figure 12(a) shows the change in average tax rates caused by the first Reagan tax cut (ERTA 1981) as a function of taxable income. The tax cuts were phased-in over three years from 1981 to 1983. The thick black line shows the total change by comparing the average tax rate after the reform in 1984 with the average tax rate before the reform in 1980. Figure 12(a) emphasizes the fact that households were affected differently by the income tax changes depending on the taxable income.

The average tax rates imputed in the CEX have more variation than Figure 12 suggests. This additional variation comes from the fact that different households have different deductions, exemptions, tax credits, as well as different family characteristics, such as the number of children and dependents or the marital status. The CEX provides a rich set of household characteristics that allows me to compute household specific tax rates. The only main input variables used by TAXSIM that are missing from the CEX are short- and long-run capital gains. The fact that changes in the average tax rate are not constant as a function of taxable income provides identifying variation in the cross-section when I control for monthly fixed effects.

3.2 Consumption Response of High-Income Households The news shock that I identify from the municipal yield spread is most relevant for high-income households, since equation (21) shows that changes in the expected marginal tax rate are most closely related to changes in the expected average tax rates for high-income households. Therefore I start my analysis of the consumption response to tax news shocks by restricting the sample to high-income households. I then extend the analysis to the full sample of households that are directly affected by income tax changes. The interpretation of the results for this larger sample of households will depend more strongly on the validity of equation (19) for lower-income households. On the other hand, the full sample allows me to move beyond testing the basic rational-expectations life-cycle model. Using differences in household characteristics and the larger sample size I can assess the importance of heterogeneity and non-linearity in the consumption responses. Using the full sample also makes the estimates comparable to other studies that use consumption data as well as to studies that use aggregate data.

[Table 4 about here.]

Table 4 shows the regression results of estimating equation (24) using high-income households. In the following I report both the response of nondurables and services as well as the response of total expenditures. However, the Euler equation (12) of the consumption model derived in Section 3 applies only to changes in consumption of nondurables, services, and *service flows* from durable goods. The response of durable *expenditures* does not have to occur instantaneously, although expenditures on durables have to satisfy the household's intertemporal budget constraint. Durables expenditures are very volatile and more likely to be affected by changes in the household-specific interest rate and hence by changes in the marginal tax rate. These issues lead to larger standard errors of the estimated response to news shocks. Thus, the response of total expenditures has to be taken with a grain of salt, but it nevertheless helps to interpret some of the nondurable consumption responses.

Nondurables and services (consumption henceforth) increase by 1.1% in response to a 1% increase in the expected after-tax lifetime income. The point estimate is statistically different from zero, thereby rejecting the cash-on-hand model, but I cannot reject that the coefficient is -1; so the consumption response of high-income households to tax news is consistent with the basic rational-expectations life-cycle model.

The estimated coefficients of the control variables are in line with the previous literature. Not surprisingly, changes in the family composition strongly affect household consumption. The household age profile is not statistically significant at quarterly frequency for nondurables and services but significantly affects total expenditures. This difference in the effect of age on total expenditures relative to nondurables and services has previously been documented, for example by Souleles (1999, 2002).

[Table 5 about here.]

4 Full Sample, Non-Linearity and Heterogeneity

4.1 Consumption Response in the Full Sample Table 5 shows the consumption response to tax news shocks using all households that pay income taxes at some point in their life. The estimate is halfway between the cash-on-hand model and the basic rational-expectations life-cycle model, and is sufficiently precise to reject both models. The point estimate in the full sample is similar to the estimated response of aggregate consumption to predictable income changes reported by Campbell and Mankiw (1989). However, the two estimates are not directly comparable. Campbell and Mankiw measure the response of consumption to predictable changes in *current income*. The estimates reported in this paper differ from these excess sensitivity coefficients since they reflect the percentage change of consumption in response to a 1% change in the expected after-tax *lifetime income*.

There are two main potential explanations for the different responses in the full sample and the sample of high-income households.[59] The first explanation is that the tax news shock might be a poor measure of changes in the after-tax lifetime income of lower-income households. The resulting measurement error would bias the coefficient up towards zero. There are several factors that could increase the measurement error for lower-income households. For example, the assumptions in equation (19) might fail or there might be offsetting government transfers that affect lower-income households differently than high-income households. It is also conceivable that household income is correlated with the household's steady state discount factor δ; lower-income households might be less patient than high-income households. Appendix B.2 addresses some of these issues.

A second interpretation of the results is that households form expectations differently and this heterogeneity might be systematically related to household income. More educated households might acquire and process information more easily than households with less education. Households might rationally choose to ignore news that do not affect their after-tax lifetime income much if there are costs to acquiring or processing information. Lower-income households might also face cash constraints that prevent them from

[59] Note that I cannot reject the hypothesis that the two estimates are the same in the two samples. However, in the full sample I can reject a coefficient of 0 or -1 while I can only reject a coefficient of 0 in the high-income sample. It is this difference in the ability to discriminate between the cash-on-hand and the basic rational-expectations life-cycle income model that I analyze next.

responding optimally to news. In this section I use the full sample of households but condition the response using additional restrictions in order to gain more insight into the causes of the difference between the full sample and the high-income sample response.

[Table 6 about here.]

4.2 Non-Linearity of the Consumption Response Models of near (or bounded) rationality and of rational inattention predict that households only respond to shocks that are large relative to some metric. Models of near rationality – for example, Akerlof and Yellen (1985) and Cochrane (1989) – stress the fact that optimization mistakes have only second-order effects on the objective function around the frictionless solution. It might therefore be optimal for a household not to adjust the consumption path in response to new information if there exist small re-optimization costs. Models of rational inattention – for example, Sims (2003) and Reis (2006) – go one step further and explicitly model the cost of acquiring and processing information and of re-optimizing. However, they offer similar predictions as the more ad-hoc models of near rationality: there is a region of inaction depending on the size of the news shock.

In Table 6, column 1, I estimate equation (24) using the largest 50% of news shocks in absolute value. Household consumption responds by a factor of 1.1 to news about large tax shocks. I can reject the cash-on-hand model but I cannot reject the hypothesis that household consumption responds according to the basic rational-expectations life-cycle model. Models of near rationality or rational inattention are consistent with the lower response in the full sample and the higher response conditional on the shock being large in absolute value.

[Table 7 about here.]

4.3 The Role of Liquidity Constraints Next I investigate whether liquidity constraints can explain the different response of the high-income sample and the full sample. If lower-income households are more credit constrained than high-income households then one should see a weaker response in the full sample compared to the response in the high-income sample, which is what we observe.

Following Zeldes (1989) I split households into a sub-sample that reports having low liquid assets and a sub-sample that reports a sufficient amount of liquid assets and hence is least likely to be affected by cash constraints. I define liquid assets as the sum of assets in savings and checking accounts, and I assume that households with liquid assets in excess of 2% of total annual expenditures are not credit constrained. Since the 1^{th} percentile of tax news shocks is larger than -2%, this threshold guarantees that those households can respond one-for-one to large negative shocks. Moreover, defining the thresholds for liquid wealth as a function of total annual expenditures adjusts for the differences in (permanent) income across households.

It is well known that households in the CEX significantly under-report wealth; see for example, Branch (1994) and Lusardi (1996). In particular, there are too many households that report having substantial income but no liquid assets. I therefore group these households separately to avoid contamination of the consumption response of household with low liquid wealth.

Columns 2 and 3 of Table 7 show that the consumption response of households with and without sufficient liquid assets is indeed different. These results suggest that liquidity constraints do seem to significantly affect the response of nondurables and services to news shocks. Columns 3 and 6 confirm the suspicion that many households that report having no liquid wealth are in fact not cash-constrained. The consumption responses are both negative and significant for total expenditures.

However, models of liquidity constraints also predict an asymmetric response depending on the sign of the shock. A cash-constrained household can always lower its consumption in response to bad news but cannot increase consumption in response to good news that have not materialized yet. If the news is sufficiently bad then it is indeed optimal for the household to cut its consumption.[60] In Table 6, columns 2 and 3, I test for an asymmetric consumption responses by estimating the consumption response to large negative and large positive news shocks. The response of nondurables and services to large negative and large positive shocks is not different and both coefficients are statistically significantly different from zero but not from -1. This symmetric response can be explained by the fact that most tax reforms in the sample affected higher-income households more than lower-income households. Therefore, the consumption response to large shocks is driven by households that are not cash-constrained.

[Table 8 about here.]

4.4 Consumption Response and Household Heterogeneity Models of rational inattention predict that households with lower costs of acquiring and processing information should respond more to a news shock holding fixed the size of the shock. Table 8 shows the consumption response as a function of the household's level of education. The response in the full sample is entirely driven by households with a college degree, who

[60] The shock is sufficient bad if it causes the household's optimal consumption path to drop enough such that the liquidity constraint in the current period is not binding anymore.

respond one-for-one to news shocks. The response of households without a college degree is not statistically different from zero. While education and income are of course not independent, the results in Table 8 nevertheless suggest that heterogeneity in education might explain differences in how households form expectations.

5 Conclusion

This paper identifies tax expectations using the yield spread between taxable and tax-exempt bonds with maturities of one to thirty years. Combining these tax expectations with household consumption data shows that the basic rational-expectations life-cycle model describes the behavior of high-income households well. This paper is the first to directly measure the response of household consumption to news shocks, and thus is the first direct test of the theory's restriction on the response of household consumption to new information.

In this paper I also document departures from the basic life-cycle model. The full cross-section of households responds only half as much to news shocks as predicted by the life-cycle theory. While liquidity constraints can account for some of this difference, they cannot fully explain it, since the response of unconstrained households is still too low. However, the different responses in the two samples are fully consistent with both rational inattention or near rationality, as well as with heterogeneous expectation formation across households; households respond according to the life-cycle theory to large news shocks and consumption of more educated households also conforms with the basic theory.

While a full analysis of the macroeconomic implications of these results is beyond the scope of this paper, it is nevertheless useful to consider certain policy issues. The consumption response to news shocks suggests an additional anticipation channel exists through which fiscal policy can affect the economy. This is particularly interesting given that the long implementation lag (or "inside lag") of fiscal policy is often used as an argument against countercyclical fiscal policy and in favor of monetary policy. This policy lag might be less of a concern if households respond directly to the news and do not wait for the actual implementation of the policy.

However, some qualifications to this analysis are necessary. These results show that the aggregate response stems mostly from high-income households, that the policy must affect household *lifetime income* and not just *current income*, and that the policy must be credible in order to change household expectations. As such, tax policies that trigger large anticipation effects may not be good countercyclical policy instruments. Nonetheless, in situations where the recovery is expected to be slow, or if monetary policy is ineffective as in a liquidity trap, such fiscal policies might offer additional options.

The flip side of this argument is that the size of effective countercyclical fiscal policies is bounded. The evidence presented in this paper suggests that the consumption response to news is stronger if tax changes are large. Since countercyclical policies are usually designed to be budget neutral over the business cycle, households will realize that countercyclical fiscal policy has little effect on lifetime income. Thus, unconstrained households may not respond to either the news shock or to the actual policy if the announced policy is large but designed to be countercyclical.

Clearly, more research on the response of households to news shocks needs to be undertaken before such data can offer policy guidance that is empirically well-grounded. Two directions seem particularly promising for future research. First, it would be interesting to extend this analysis to other margins of adjustment, in particular to the labor supply response and to the response of taxable income.[61] Second, identifying more news shocks that directly affect household budget sets is clearly desirable in order to verify the results of this study. A particularly useful task is the identification of news shocks that affect lower-income households directly. Such additional independent news shocks could be used to more thoroughly examine the cause of the different responses between high-income and lower-income households reported in this paper.

[61] The argument that taxable income is a sufficient statistic for all margins of adjustment goes back to Feldstein (1995, 1999). However, recent literature questions this finding, since taxable income is prone to reporting problems; see for example, Gorodnichenko, Martinez-Vazquez and Sabirianova Peter (2009) and Chetty (2009). Therefore, consumption may be a better summary statistic of all behavioral responses to tax shocks.

References

Abowd, John M. and David Card, "On the Covariance Structure of Earnings and Hours Changes," *Econometrica*, 1989, *57* (2), 411–445.

Agarwal, Sumit, Chunlin Liu, and Nichola S. Souleles, "The Reaction of Consumer Spending and Debt to Tax Rebates: Evidence from Consumer Credit Data," *Journal of Political Economy*, 2007, *115* (6), 986–1019.

Akerlof, George A. and Janet L. Yellen, "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia," *Quarterly Journal of Economics*, 1985, *100* (Supplement), 823–838.

Ang, Andrew, Vineer Bhansali, and Yuhang Xing, "Taxes on Tax-Exempt Bonds," *Working Paper*, 2007.

Aster, Richard C., Brian Brochers, and Clifford H. Thurber, *Parameter Estimation and Inverse Problems*, Elsevier Academic Press, 2005.

Attanasio, Orazio, "Consumption," *Handbook of Macroeconomics*, 1999, *1*, 741–812.

Attanasio, Orazio P. and Nicola Pavoni, "Risk Sharing in Private Information Models with Asset Accumulation: Explaining the Excess Smoothness of Consumption," *Econometrica*, 2011, *79* (4), 1027–1068.

Auerbach, Alan J and Joel Slemrod, "The Economic Effects of the Tax Reform Act of 1986," *Journal of Economic Literature*, 1997, *35* (2), 589–632.

Ayers, Benjamin C., Bryan C. Cloyd, and John B. Robinson, ""Read My Lips ...": Does the Tax Rethoric of Presidential Candidates Affect Security Prices?," *Journal of Law and Economics*, 2005, *48* (1), 125–148.

Barsky, Robert B. and Eric R. Sims, "Information, Animal Spirits, and the Meaning of Innovations in Consumer Confidence," *American Economic Review*, forthcoming.

Batchelor, Roy and Pami Dua, "Survey Expectations in the Time Series Consumption Function," *Review of Economics and Statistics*, 1992, *74* (4), 598–606.

Beaudry, Paul and Franck Portier, "News, Stock Prices and Economic Fluctuations," *American Economic Review*, 2006, *96* (4), 1293–1307.

Blanchard, Olivier J, Jean-Peaul L'Huillier, and Guido Lorenzoni, "News, Noise, and Fluctuations: An Empirical Exploration," *NBER Working Paper No. 15015*, 2009.

Blinder, Alan S. and Angus Deaton, "The Time Series Consumption Function Revisited," *Brookings Papers on Economic Activity*, 1985, *1985* (2), 465–521.

Branch, Raphael E., "The Consumer Expenditure Survey: a comparative analysis," *Monthly Labor Review*, 1994, *117*, 47–55.

Calmes, Jackie, "Bush Promotes Big Tax Cuts in a Move To Attract Middle-Class Swing Voters," *The Wall Street Journal*, 2000, *Monday, Septermber 25*, A.16.

Campbell, John Y. and Angus Deaton, "Why is Consumption So Smooth?," *Review of Economic Studies*, 1989, *56* (3), 357.

_ and Gregory N. Mankiw, "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," *NBER Macroeconomics Annual*, 1989.

Chalmers, John M.R., "Default Risk Cannot Explain the Muni–Puzzle: Evidence from Bonds that Are Secured by U.S. Treasury Obligation," *Review of Financial Studies*, 1998, *11* (2), 281–308.

Chetty, Raj, "Is the Taxable Income Elasticity Sufficient to Calculate Deadweight Loss? The Implications of Evasion and Avoidance," *American Economic Journal : Economic Policy*, 2009, *1* (2), 31–52.

Cochrane, John H., "The Sensitivity of Tests of the Intertemporal Allocation of Consumption to Near-Rational Alternatives," *American Economic Review*, 1989, *79* (3), 319–337.

_ , "Shocks," *Carnegie-Rochester Conference Series on Public Policy*, December 1994, *41*, 295–364.

Coibion, Olivier and Yuriy Gorodnichenko, "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts," *NBER Working Paper No. 16537*, 2011.

Constantinides, Geroge M. and Jonathan E. Ingersoll, "Optimal Bond Trading with Personal Taxes," *Journal of Finance*, 1984, *13* (3), 299–335.

Deaton, Angus, *Understanding Consumption*, Oxford University Press, 1992.

Fabozzi, Frank J., *Fixed Income Securities*, 2 ed., John Wiley & Sons, 2002.

_ and David Z. Nirenberg, "Federal Income Tax Treatment of Fixed Income Securities," in Frank J. Fabozzi, Dessa T. Fabozzi, and Irving M. Pollack, eds., *The Handbook of Fixed Income Securities*, 1991.

Fama, Eugene F., "A Pricing Model of the Municipal Bond Market," *Working Paper*, 1977.

Feenberg, Daniel R. and Elizabeth Coutts, "An Introduction to the TAXSIM Model," *Journal of Policy Analysis and Management*, 1993, *12* (1), 189–194.

— and James M. Poterba, "Which Households Own Municipal Bonds? Evidence From Tax Returns," *National Tax Journal*, 1991, *44* (4), 93–103.

Feldstein, Martin, "The Effect of Marginal Tax Rates on Taxable Income: A Panel Study of the 1986 Tax Reform Act," *Journal of Political Economy*, 1995, *103* (3), 551–572.

— , "Tax Avoidance and the Deadweight Loss of the Income Tax," *Review of Economics and Statistics*, 1999, *81* (4), 674–680.

Fuhrer, Jeffrey C., "On the Information Content of Consumer Survey Expectations," *Review of Economics and Statistics*, 1988, *70* (1), 140–144.

Giglio, Stefano, "Credit Default Swap Spreads and Systemic Financial Risk," *Working Paper*, 2011.

Gorodnichenko, Yuriy, Jorge Martinez-Vazquez, and Klara Sabirianova Peter, "Myth and Reality of Flat Tax Reform: Micro Estimates of Tax Evasion Response and Welfare Effects in Russia," *Journal of Political Economy*, 2009, *117* (3), 504–554.

Green, Richard C., "A Simple Model of the Taxable and Tax-Exempt Yield Curves," *Review of Financial Studies*, 1993, *6* (2), 233–264.

Gürkaynak, Refet S., Brian Sack, and Jonathan H. Wright, "The U.S. Treasury yield curve: 1961 to the present," *Journal of Monetary Economics*, 2007, *54* (8), 2291–2304.

Hansen, Lars Peter, William T. Roberds, and Thomas J. Sargent, "Time Series Implications of Present Value Budget Balance and of Martingale Models of Consumption and Taxes," in Lars Peter Hansen and Thomas J. Sargent, eds., *Rational Expectations Econometrics*, Boulder and Oxford: Westview Pres, 1991, pp. 121–61.

Harris, Lawrence E. and Michael S. Piwowar, "Municipal Bond Liquidity," *Working Paper*, 2004.

Hausman, Jerry A. and James M. Poterba, "Household Behavior and the Tax Reform Act of 1986," *Journal of Economic Perspectives*, 1987, *1* (1), 101–119.

Hayashi, Fumio, *Understanding Saving: Evidence from the United States and Japan*, The MIT Press, 1997.

Hempel, George H., *The Postwar Quality of State and Local Debt*, Columbia University Press, 1971.

Jaimovich, Nir and Sergio Rebelo, "Can News about the Future Drive the Business Cycle?," *American Economic Review*, 2009, *99* (4), 1097–1118.

Jappelli, Tullio and Luigi Pistaferri, “The Consumption Response to Income Changes,” *Annual Review of Economics*, 2010, *2*, 479–506.

Johnson, David S., Jonathan A. Parker, and Nicholas S. Souleles, “Household Expenditure and the Income Tax Rebates of 2001,” *American Economic Review*, 2006, *96* (5), 1589–1610.

Kramer, Andrea S., *Financial Products: Taxation, Regulation and Design*, Aspen Publishers, 2003.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen, “The Aggregate Demand for Treasury Debt,” *NBER Working Paper No. 12881*, 2008.

Leeper, Eric M., Todd B. Walker, and Shu-Chun S. Yang, “Foresight and Information Flows,” *NBER Working Paper No. 16951*, 2011.

Lorenzoni, Guido, “News and Aggregate Demand Shocks,” *Annual Review of Economics*, 2011, *3*, 537–557.

Lusardi, Annamaria, “Permanent Income, Current Income, and Consumption: Evidence from Two Panel Data Sets,” *Journal of Business & Economic Statistics*, 1996, *14* (1), 81–90.

MaCurdy, Thomas E., “The Use of Time Series Processes to Model the Error Structure of Earnings in a Longitudinal Data Analysis,” *Journal of Econometrics*, 1982, *18* (1), 83–114.

Mankiw, N. Gregory and James M. Poterba, “Stock Market Yields and the Pricing of Municipal Bonds,” *NBER Working Paper No. 5607*, 1996.

_ and Ricardo Reis, “Sticky Information Versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve,” *Quarterly Journal of Economics*, 2002, *117* (4), 1295–1328.

Meghir, Costas and Luigi Pistaferri, “Income Variance Dynamics and Heterogeneity,” *Econometrica*, 2004, *72* (1), 1–32.

Mehra, Yash P., “The Output Gap, Expected Future Inflation and Inflation Dynamics: Another Look,” *The BE Journal of Macroeconomics*, 2004, *4* (1), 1–17.

Park, Sangkyun, “The Relationship between Government Financial Condition and Expected Tax Rates Reflected in Municipal Bond Yields,” *Federal Reserve Bank of New York Staff Reports*, 1995.

Parker, Jonathan A., “The Reaction of Household Consumption to Predictable Changes in Social Security Taxes,” *American Economic Review*, 1999, *89* (4).

Pistaferri, Luigi, “Superior Information, Income Shocks, and the Permanent Income Hypothesis,” *Review of Economics and Statistics*, 2001, *83* (3), 465–476.

Poterba, James M., *Explaining the Yield Spread between Taxable and Tax-exempt Bonds: The Role of Expected Tax Policy*, The University of Chicago Press, 1986.

— , "Are Consumers Forward Looking? Evidence from Fiscal Experiments," *American Economic Review Papers and Proceedings*, 1988, *78* (2), 413–418.

Ravn, Morten O. and Harald Uhlig, "On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations," *Review of Economics and Statistics*, 2002, *84* (2), 371–376.

Reis, Ricardo, "Inattentive consumers," *Journal of Monetary Economics*, 2006, *53* (8), 1761–1800.

Romer, Christina D. and David H. Romer, "A Narrative Analysis of Postwar Tax Changes," *online appendix to Romer and Romer (American Economic Review 2010), "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks"*, 2008.

— and — , "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *American Economic Review*, 2010, *100* (3), 763–801.

Saez, Emmanuel, "Reported Incomes and Marginal Tax Rates, 1960-2000: Evidence and Policy Implications," *NBER Working Paper No. 10273*, 2004.

Schmitt-Grohe, Stephanie and Martin Uribe, "What's News in Business Cycles," *Working Paper*, 2010.

Seib, Gerald F. and Alan Murray, "Where They Stand: A Voters' Guide to the Candidates and the Issues," *The Wall Street Journal*, 1992, *Monday, Septermber 21*, R6.

Shapiro, Matthew D. and Joel Slemrod, "Consumer Response to the Timing of Income: Evidence from a Change in Tax Withholding," *American Economic Review*, 1995, *85* (1), 274–283.

— and — , "Did the 2001 Tax Rebate Stimulate Spending? Evidence from Taxpayer Surveys," *Tax Policy and the Economy*, 2003, *17*, 83–109.

Sims, Christopher A., "Implications of rational inattention," *Journal of Monetary Economics*, 2003, *50* (3), 665–690.

Slemrod, Joel and Timothy Greimel, "Did Steve Forbes scare the US municipal bond market?," *Journal of Public Economics*, 1999, *74* (1), 81–96.

Snowberg, Erik, Justin Wolfers, and Eric Zitzewitz, "How Prediction Markets Can Save Event Studies," *NBER Working Paper No. 16949*, 2011.

Souleles, Nicholas S., "The Response of Household Consumption to Income Tax Refunds," *American Economic Review*, 1999, *89* (4), 947–958.

—, "Consumer response to the Reagan tax cuts," *Journal of Public Economics*, 2002, *85* (1), 99–120.

Temel, Judy W., *The Fundamentals of Municipal Bonds*, 5 ed., John Wiley & Sons, 2001.

Wolff, Edward N., "Recent Trends in Household Wealth in the United States: Rising Debt and the Middle-Class Squeeze – an Update to 2007," *Working Paper*, 2010.

Zeldes, Stephen P., "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy*, 1989, *97* (2), 305–346.

A Data

A.1 Bond Data Municipal bond yields are taken form two proprietary data sets. The first data set is provided by a large bond data vendor that prefers to remain anonymous. The generic AAA curve is written daily starting in 1983 to represent a fair value offer-side of the highest-grade AAA rated general-obligation state bonds and is determined from trading activity and markets of non-AMT blocks of two million dollars or more. The second municipal bond data set is provided by *Delphis Hanover* and contains yields at weekly frequency between 1976 and 1983.[62] The 30-Day Visible Supply is the total dollar volume of new municipal bonds carrying maturities of 13 months or more that are scheduled to reach the market within 30 days and is taken from the *Bond Buyer: The Daily Newspaper of Public Finance*. The Treasury term-structure is the off-the-run par yield curve taken from Gürkaynak, Sack and Wright (2007). On-the-run Treasury yields and corporate bond yields are taken form the *Board of Governors of the Federal Reserve System, Historical Data Table H.15*. Credit Default Swap (CDS) spreads are based on data from *Credit Market Analysis (CMA)* taken from *Datastream*.

A.2 Flow of Funds The *Flow of Funds* accounts are provided by the *Board of Governors of the Federal Reserve System*. The accounts measure the aggregate stock of assets and liabilities for the financial and non-financial sector as well as the corresponding flows. The statistics can be disaggregated along various dimensions, for instance by ownership.

A.3 Survey of Consumer Finances (SCF) The *Survey of Consumer Finances (SCF)*, which is provided by the *Board of Governors of the Federal Reserve System*, is conducted every three years and is the most comprehensive source of household wealth in the U.S. The survey has a two sample design; the first sample is a standard geographically based random sample of households, while the second supplemental sample is selected to disproportionately include wealthy families. Therefore, the choice of sampling weights is important to infer population parameters. However, the SCF supplies alternative sets of sampling weights in some years. In choosing the sampling weights I follow Wolff (2010) who minimizes the discrepancy between national balance sheet totals derived from the SCF and corresponding values from the Federal Reserve Board Flow of Funds. For the 1983 SCF I use the 'Full Sample 1983 Composite Weights' (b3005) and for the 1989 SCF I use the average of the SRC-Design-S1 series (x40131) and the SRC design-based weights (x40125). From 1995 on I use the design-based weights (x42000 for 1995 and

[62] I loose one year of data by applying the low-pass filter to the time series of break-even tax rates.

x42001 from 1998 on) which is a partially design-based weight constructed on the basis of original selection probabilities and frame information, adjusted for non-response. In the case of the 1992 SCF, these weights produce major anomalies in the size distribution of income for 1991. As a result, I modify the weights to conform to the size distribution of income as reported in the IRS Statistics of Income and as recommended by Wolff (2010). In particular, I adjust the 1992 weights to conform to the 1989 weighting scheme. The adjustment factors for the 1992 weights are given by the inverse of the normalized ratio of weights between 1992 and 1989 and shown in the following table.

Adjusted Gross Income (AGI) in 1989	Adjustment Factors for 1992 Weights
AGI $< 200,000$	0.992
$200,000 \leq$ AGI $< 1,000,000$	1.459
$1,000,000 \leq$ AGI $< 4,000,000$	1.877
$4,000,000 \leq$ AGI $< 7,000,000$	4.844
AGI $\geq 7,000,000$	12.258

Bonds include direct and indirect holdings, and whenever possible I use market values of bonds and face values otherwise. Direct ownership of taxable bonds includes 'face amount of other taxable/corporate bonds and foreign bonds' (b3461,x3912), 'market or face value of Treasury bonds' (b3459, x3908, x7636), 'market or face value of mortgage-backed bonds' (x3906, x7635), 'market value of other taxable bonds' (x7639), 'market value of foreign bonds' (x7638), and 'market value of all bonds not listed otherwise' (x6706). Indirect holdings of taxable debt include 'dollar amount of shares in taxable mutual funds' (b3464), 'market value of Treasury bond mutual funds' (x3826), and 'market value of other taxable bond mutual funds' (x3828). Direct ownership of tax-exempt bonds includes 'market or face value of tax-free bonds' (b3460, x3910, x7637). Indirect holdings of tax-exempt debt includes 'dollar amount of shares in tax-free mutual funds' (b3463) and 'market value of tax-free bond mutual funds' (x3824).

A.4 Election Probabilities Election probabilities are based on the winner-takes-all market of the *Iowa Electronics Markets (IEM)*. The IEM is an on-line futures market operated by *University of Iowa Henry B. Tippie College of Business School*. All interested participants world-wide can trade in the political markets, and bets are limited to $500. The payoff of the contract is determined by which of the nominees receive the biggest share of the popular vote cast. Contracts associated with nominees that do not receive the bigger number of popular votes in the election will pay off \$0; contracts associated with the nominee that receives the bigger number of popular votes will pay off \$1. I use last price quotes of the winner-takes-all contracts which reflect the price of the last trade before midnight. 'Last prices' ensure a close relationship between the information in the prices of the betting contracts and the bond prices, which also reported at the end of the trading day.

A.5 Consumer Expenditure Survey (CEX) The *Consumer Expenditure Survey (CEX)*, which is provided by the *Bureau of Labor Statistics (BLS)*, is the most comprehensive data source on household consumption in the U.S. This paper uses the raw data of the interview survey, which can be accessed from the *Interuniversity Consortium for Political and Social Research (ICPSR)* at the *University of Michigan*. The CEX is a monthly rotating panel and each household (i.e. consumer unit) is interviewed once per quarter, for at most five consecutive quarters, although the first interview is used for pre-sampling purposes and is not available for analysis. In each interview the reference period for expenditure covers the three months prior to the interview month. However, the within-interview variation is much lower than the between-interview variation, suggesting that many households provide average monthly expenditures instead. Therefore, I aggregate the expenditures to quarterly expenditures. Income data is asked in the first and last interview (i.e. interviews 2 and 5 in CEX terminology), and financial data is only asked in the last interview. The reference period for income flows covers the twelve month before the interview. All nominal variables are deflated using the CPI-U. To make the results comparable across sub-samples and with studies that use aggregate data, I use survey sample weights.

I impute taxes with the NBER TAXSIM calculator using an iterative procedure to determine the itemization status of each household and to account for deductions that depend on the households AGI; for example health-care or job expenses. The code is available at www.nber.org/~taxsim/to-taxsim/cex-kueng/cex.do.

I follow the literature and exclude housing services, health care and health insurance, and education services from the definition of nondurables and services, since these expenditures have characteristics of durable goods. I correct sample breaks due to slight changes in the questionnaire of the following variables: food at home ('82Q1-'88Q1), personal care services ('01Q2), occupation expenditures ('01Q2), and property taxes ('91Q1). As recommended by the BLS, I sum expenditures that occur in the same month but are reported in different interviews. In addition to the sample selection mentioned in the text, I drop the following cases: interviews with more or less than three monthly observations;

households with zero food or total expenditures; non-consecutive interviews; observations with negative expenditures where there should not be any; households with more than one consumer unit; households for which the family size changes by more than three (e.g. Johnson et al. (2006)); households for which the age of any member increases by more than one or decreases (e.g. Souleles (1999)); and households with negative liquid wealth; households with positive business or farm income; and student housing or household heads that are students. Finally, I drop outliers in terms of the growth rates of total expenditures or nondurables and services, and using the ratio of total annual expenditures to total annual income.[63]

B Details and Robustness

B.1 Robust Inverse The solution to the constrained least squares problem of the inverse mapping (8) is

$$\begin{aligned}\mathbb{E}[\tau|\Delta\text{Bush}] &= \arg\min_x \left\{ ||\mathbb{E}[W_t]x - \hat{\beta}||^2 \ : \ ||\partial x||^2 \leq \varepsilon \right\} \\ &= \left(\mathbb{E}[W_t]'\mathbb{E}[W_t] + \mu\ \partial'\partial\right)^{-1} \mathbb{E}[W_t]'\hat{\beta}.\end{aligned} \tag{26}$$

∂ is either the identity matrix (basic ridge regression) or the $(M-1)$-by-M first difference operator (first-order ridge regression). Similarly, the ridge regression to the inverse problem (4) is

$$\begin{aligned}\mathbb{E}_t\tau &= \arg\min_x \left\{ ||W_t x - (\tilde{\theta}_t + \mathbb{E}[\Lambda_t])||^2 \ : \ ||\partial x||^2 \leq \varepsilon \right\} \\ &= \left(W_t' W_t + \mu\ \partial'\partial\right)^{-1} W_t(\tilde{\theta}_t + \mathbb{E}[\Lambda_t]) \ .\end{aligned} \tag{27}$$

To obtain a better intuition of how the regularization works it is useful to analyze the solution using the generalized singular value decomposition. Since $\mathbb{E}_t[W_t]$ and ∂ have full rank and the null spaces of both matrices intersect only at the zero vector, there exist matrices U, V, Π, Ξ such that U is orthonormal, Y is nonsingular, Π is diagonal with decreasing diagonal elements $1 \geq \pi_i \geq \ldots \geq \pi_m \geq 0$, and Ξ is diagonal with increasing elements $0 < \xi_1 \leq \ldots \leq \xi_M \leq 1$ (see Aster, Brochers and Thurber (2005)). ξ_m and π_m are normalized such that $\xi_m^2 + \pi_m^2 = 1\ \forall\ m$. The generalized singular values are defined as $\gamma_m = \frac{\pi_m}{\xi_m}$. The matrices U, V, Π, Ξ, Y are related to the *two* matrices $\mathbb{E}_t[W_t]$ and ∂ (hence

[63] A more detailed explanation of the consumption data is available upon request from the author.

the name *generalized* singular value decomposition) as follows:

$$\mathbb{E}_t[W_t] = U \begin{bmatrix} \Pi & 0 \\ 0 & I \end{bmatrix} Y^{-1} ,$$

$$\partial = V \; [\Xi \;\; 0] \; Y^{-1} ,$$

$$(\mathbb{E}_t[W_t]Y)' \, (\mathbb{E}_t[W_t]Y) = \begin{bmatrix} \Pi^2 & 0 \\ 0 & I \end{bmatrix} ,$$

$$(\partial Y)' \, (\partial Y) = \begin{bmatrix} \Xi^2 & 0 \\ 0 & 0 \end{bmatrix} .$$

One can show that the robust inverse solution $\mathbb{E}_t\tau$ can be written as

$$\mathbb{E}_t\tau = \sum_{m=1}^{M} \underbrace{\frac{\gamma_m^2}{\gamma_m^2 + \mu}}_{\text{filter } f_m} \underbrace{\frac{u_m'(\tilde{\theta}_t + \mathbb{E}[\Lambda_t])}{\pi_m} y_m}_{\text{direct inverse}} , \tag{28}$$

where u_m is the m-th column vector of matrix U and y_m is the m-th column vector of matrix Y. There are two important facts to take away from this equation. First, the fraction $f_m = \gamma_m^2/(\gamma_m^2 + \mu)$ is a filter factor that stabilizes the inverse solution. Small singular values π_m and hence small generalized singular values γ_m are dampened ($f_m \ll 1$) while large singular values are less affected ($f_m \approx 1$). If $\mu = 0$, then $f_m = 1 \; \forall \; m$ and equation (28) reduces to the direct inverse (respectively to the singular value decomposition of the inverse of $\mathbb{E}_t[W_t]$). Second, since $\mathbb{E}_t[W_t]$ is a lower triangular weighting matrix, the generalized singular values are naturally decreasing in the maturity m, i.e. they are decreasing in m without having to rearrange the columns or rows of $\mathbb{E}_t[W_t]$. Moreover, for maturities up to around 10 years, $\gamma^2 \gg \mu$ and hence $f \approx 1$. Therefore, the regularization affects the solution $\mathbb{E}_t\tau$ only for larger maturities and longer forecasting horizons.

Note that the value of μ does not substantially affect the size of the tax news shocks – defined by equation (22) and used in the household consumption regression – over reasonable ranges. This robustness is due to the fact that computing the expected after-tax lifetime income over 30 years does smooth much of the 'excess volatility' of $\mathbb{E}_t\tau$ caused by the ill-posed inverse problem. Moreover, the forward tax rates that are affected the most by the choice of μ are long-run forecasts. These expected long-run tax rates receive much less weight in the calculation of the expected after-tax lifetime income, which is an annuity value and hence discounts more distant values more heavily.

There are two main criteria in the literature for choosing μ. The first is a heuristic, but more robust criterion called the L-curve approach. The other is based on generalized cross validation (GCV). GCV has a number of desirable statistical properties if the error term is independently and identically distributed, but tends to under-smooth if errors are correlated. Liquidity shocks are not uncorrelated across maturities. A liquidity shock that affects for example the 20-year maturity also affects the maturities at 19 and 21 years. Otherwise, there would be opportunities for maturity-based arbitrage. The L-curve approach on the other hand is not guaranteed to converge and is computationally expensive. I therefore calculate the optimal μ for a number of periods using both approaches. The optimal μ is on average about 0.01 for these dates and does not vary much. Hence, I set $\mu = 0.01$ globally to calculate $\mathbb{E}_t\tau$ for the entire sample from 1977 to 2001. Moreover, I use a separate optimal μ for the two election periods to calculate $\mathbb{E}[\tau|\Delta\text{Bush}]$ and $\mathbb{E}[\tau|\Delta\text{Clinton}]$ since the inversion problem of the regression coefficients has different statistical properties and hence a different optimal value of μ.

[Table A.1 about here.]

B.2 Tax Base and Robustness across Sub-Periods Tax reforms can affect not only the tax rates but also the tax base. Since the effect of a tax reform on the after-tax lifetime income is a combination of changes in the tax rates and the tax base, it is useful to test the robustness of the results with respect to changes in the tax base. Most tax reforms since 1980 only modestly affected the income tax base, with the exception of the Tax Reform Act of 1986 (TRA 1986). Auerbach and Slemrod (1997) discuss this tax reform in detail, showing that the reduction in income tax revenue was compensated by widening the corporate tax base and closing loopholes in the tax code. Although the incidence of the corporate tax is difficult to assess, it is clear that closing tax loopholes affects mainly very high-income households, in particular those who have flexibility in changing the composition of their taxable income, such as self-employed households and business owners. The sample used in this paper excludes self-employed households and the CEX tends to under-samples very rich households. Since both of groups are affected the most from the offsetting extension of the tax base, it is likely that most high- and middle-income households in the sample benefited from the tax reform, even though the TRA 1986 might have been roughly revenue neutral in the aggregate.[64] Nevertheless, since Auerbach and Slemrod conclude that "the effects of the [Tax Reform] Act on saving

[64] Many lower-income households faced an increase in tax liabilities as a result of the tax reform; see for example Figure 12(b) and Hausman and Poterba (1987).

are more difficult to identify because of the many confounding influences of the period and our greater uncertainty about the proper modeling of the savings decision", I test the robustness of the result using different time sub-periods.

A second concern is the fact that the tax reforms in the 1990s affected household very differently depending, increasing taxes for very high-income households, while not affecting or even lowering tax liabilities for lower-income households. Moreover, the short-term break-even tax rates appear to be disconnected from the top tax rate between 1991 and 1993. Both of these reasons might cause the market-based expectations to be a poor measure of households' tax expectations. Therefore, it is worthwhile to test the robustness of the results by excluding the early 1990s.

In Table A.1 I split the sample into three sub-periods. The first period includes the Reagan tax cuts, the second period covers the tax increases under G.H. Bush and Clinton, and the third period includes the G.W. Bush tax cuts. The consumption response of high-income households to tax news shocks in these three sub-periods show that the results in the paper are robust to excluding both the 1980s – including the TRA 1986 – and the early 1990s.

[Table A.2 and Figure A.1 about here.]

B.3 Filtering One might be worried by the fact that a two-sided filter uses not only current and lagged observations, but also future ones. Therefore, the econometrician might overestimate the information set of consumers, thereby underestimating the response to news. To account for this possibility, I use the optimal one-sided Hodrick-Prescott filter suggested by Mehra (2004), and I follow Ravn and Uhlig (2002) in setting the smoothing parameter. One-sided filters only use current and lagged observations, but induce a phase-shift; that is, the filtered series lags the raw data and hence detects a change in the trend only with some delay. This phase-shift, shown in Figure A.1, introduces measurement error in the news shock and might therefore bias the consumption response toward zero. Table A.2 shows the consumption response of high-income households to news shocks using three types of filtering. Column 1 shows that without any filtering, the noise introduced by liquidity shocks biases the consumption response to zero. However, column 2 shows that the results are robust to applying a one-sided filter, although the measurement error caused by the phase-shift of the one-sided filter biases the consumption response toward zero relative to the response using the two-sided filter, shown in column 3.

C Taxation of Bonds

This Appendix provides a short overview of the most important tax rules concerning bonds.[65] Before looking at the tax treatment of different types of bonds I need to introduce some notation and I need to define some terms that might not be familiar to most researchers. I then derive the implications of federal taxation on the pricing of bonds.

Notation I use the following notation to formalize the tax treatment of fixed-income securities.

P_t **:** bond price at time t .

P_t^o **:** adjusted issue price, with $P_{t_o}^o = P_{t_o}$ (issue price).

P_t^b **:** adjusted purchase price, with $P_{t_b}^b = P_{t_b}$ (purchase price).

P_{t_m} **:** redemption value (usually normalized such that $P_{t_m} = 1$).

t_o **:** issue date.

t_m **:** maturity date.

t_b **:** purchase date, with $t_b = t + b$, where b is usually non-positive.

t_s **:** selling date, with $t_s = t + s$, where $0 < s \leq m$.

m_o, m **:** original and remaining maturity of the bond in years, where m and m_o are defined as $t_m = t_o + m_o = t + m$.

A_t **:** accrued interest up to t since last payment at $\hat{t}$, $A_t = \frac{t-\hat{t}}{1/a} C$.

a **:** number of payments per year, i.e. inverse of payment frequency $f = 1/a$. Hence, $m \cdot a$ are the total remaining payments.

c **:** coupon rate applied to the bond's redemption value to determine the coupon payment $C = P_{t_m} \frac{c}{a}$.

$D_t(k)$ **:** before-tax nominal discount function know at t , $D_t(k) \equiv D_{t,k/f}$.

$d_t(k)$ **:** after-tax nominal discount function known at t , $d_t(k) \equiv d_{t,k/f}$, i.e. $d = (1 - \tau)D$.

τ^y, τ^g **:** income and capital gains tax rates of the investor.

Some Jargon Three concepts are important to determine the path of tax liabilities for fixed-income securities.[66]

- The **adjusted issue price** P_t^o defines the original issue discount (OID) and its (continuous) amortization over the asset's lifetime.

[65] ***Appendix C is not intended for publication.*** Essentially the same document entitled "The Taxation of Bonds: A Short Primer" can be downloaded from the author's website.

[66] For a discussion of the tax treatment for investors other than individuals or corporations such as traders and dealers, see Fabozzi and Nirenberg (1991).

- The **adjusted purchase price** (or tax basis) P_t^b defines the market discount (MD) or premium (MP) and its amortization over time as well as the amount of capital gains if the bond is sold prior to maturity.
- The **DeMinimis bound** $DM(P,m)$ determines whether the (continuous) amortization of the OID and the MD, which generates hypothetical interest income in addition to the actual coupon payment, has to be taken into account for taxation. The DeMinimis bound is a function of the bond's maturity m and price P and is defined as

$$DM(P,m) \quad = \quad P \cdot \left(1 - \frac{m}{400}\right) \; .$$

These concepts define four types of bonds:

1. **OID bonds** with $P_{t_o} < P_{t_m}$,
2. **MD bonds** with $P_{t_b} < P_{t_b}^o$, and
3. **(market) premium bonds (MP)**, and more specific
   (a) (pure) premium bonds with $P_{t_b} > P_{t_m}$ and
   (b) acquisition premium bonds[67] with $P_{t_b} \in (P_{t_b}^o, P_{t_m})$ and $P_{t_b}^o < P_{t_m}$.

For tax purposes, the acquisition and the pure market premium bonds are treated very similar so that we only have to analyze three types of bonds separately. The price of OID, MD, and acquisition MP bonds will appreciate until maturity everything else equal, while the price of a pure MP bond will depreciate. Note that a par bond for which $P_{t_o} = P_{t_m}$ is a particular OID bond with OID$= 0$ and has the same tax treatment as a general OID bond.

The prices P_t^o and P_t^b are adjusted using either a ratable method (RM) – i.e. a straight-line method – or a constant yield method (CYM) depending on the date of issue and the owner's tax preferences. The adjusted price according to the CYM is

$$\begin{aligned} P^x_{t_x,k/a} &= P^x_{t_x,(k-1)/a} + P^x_{t_x,(k-1)/a} y_{t_x}/a - P_{t_m} c/a \\ &= P_{t_x} \left(1 + y_{t_x}/a\right)^k - P_{t_m} c/a \sum_{i=1}^{k} \left(1 + y_{t_x}/a\right)^{i-1} \;\; , \end{aligned}$$

where y_{t_x} is the constant yield to maturity at purchase date t_x and $x \in \{o, b\}$.[68] The adjusted price according to the ratable method (RM) is

$$P^x_{t_x,k/a} = P^x_{t_x} + \Delta \frac{k/a - t_x}{t_m - t_x} \; .$$

[67] In practice, an acquisition premium bond is still called a discount bond since it trades below par, i.e. $P_{t_b} < P_{t_m}$.

[68] The constant yield to maturity y_t is defined as the solution to the equation

$$\frac{P_t}{P_{t_m}} = \frac{c}{a} \sum_{k=1}^{m \cdot a} \left(1 + y_t/a\right)^{-k} + \left(1 + y_t/a\right)^{-m \cdot a}$$

where m is the remaining maturity of the bond. If the date t does not coincide with a payment date, then accrued interest has to be added in the way shown below.

Δ is either the OID in which case $\Delta = P_{t_m} - P_{t_o} > 0$, the market discount in which case $\Delta = P^o_{t_b} - P_{t_b} > 0$, the (market) premium in which case $\Delta = P_{t_b} - P_{t_m} > 0$, or the acquisition premium in which case $\Delta = P_{t_b} - P_{t_o} > 0$ with $P_{t_b} < P_{t_m}$. Figure A.3 graphs the concepts together with the corresponding DeMinimis bounds.

[Figure A.3 about here]

The amortized discount or premium (OID, MD, or MP) that has to be included in current income is based on the number of days in the tax year that the bond is held. The tax treatment of the bond – i.e. which tax rate applies, which amortization method is chosen, when the amortization is applied, and how capital gains are defined – depends on the issuer of the bond (corporate, Treasury, or municipal), the issue date, the type of investor (individual or corporation), and the type of the bond listed above (OID, MD, or MP bond).

C.1 Taxation of Taxable Bonds Interest income from Treasury bonds is exempt from state and local taxes in all states except Tennessee but is subject to federal income taxes. Bonds issued by states, which are part of the class of municipal bonds, are exempt from federal income taxes. Moreover, most states also exempt municipal bonds from state and local taxes, either for all investors or at least for instate investors. Table 2 lists the tax treatment of fixed-income interest in all fifty state and Washington D.C.

If not stated otherwise, the following tax rules apply to both Treasury and corporate bonds.[69] However, note that corporate bonds are in general subject to both federal taxation and state and local taxation. Moreover, many investors can deduct at least part of their state and local taxes from their federal income taxes. These issues have to be taken into account when analyzing the effects of taxes on corporate bond prices.

Different tax treatments apply to taxable bonds depending on the types of bond as well as the bond's issue date. The following is a summary of these tax rules and their evolution since 1970.

C.1.1 Original-Issue Discount (OID) Bonds

The DeMinimis rule applies. If $P_{t_o} > DM(P_{t_m}, m_o)$ then the OID is ignored for tax purposes and is taxed as (unexpected) capital gain at sale or maturity. The following rules depend on the bond's date of issue.

- **Issued before 7/2/82 (and after 5/29/69)**
  - Corporate bonds: The OID is amortized linearly (RM) and included in current ordinary interest income.
  - Treasury bonds: The OID is treated as capital gains income at sale or maturity.
- **Issued on or after 7/2/82**
  - The OID is amortized with CYM using annual compounding ($a = 1$).
  - The OID is included in current ordinary interest income.

[69] For short-term non-coupon bearing obligations (e.g. Treasury bills), callable or putable bonds, and more exotic bonds such as stripped or principal obligations, see Fabozzi (2002) and Kramer (2003).

- **Issued after 12/31/84**
  - The OID is amortized with CYM using at least semi-annual compounding or compounding corresponding to the payment frequency ($a \geq 2$).

C.1.2 Market Discount (MD) Bonds

The DeMinimis rule applies to the MD. If $P_{t_b} > DM(P^o_{t_b}, m)$, then the MD is ignored for tax purposes and is taxed as (unexpected) capital gain at sale or maturity. The following rules depend on the bond's date of issue.

- **Issued before 7/19/84**
  - MD is treated as capital gain income at sale or maturity. Hence the adjusted purchase price does not matter for taxation, i.e.

$$MD_{t_s} = 0$$

and the capital gains are

$$\overbrace{(P_{t_s} - P_{t_b})}^{\text{total price change}} - \overbrace{(P^o_{t_s} - P^o_{t_b})}^{\text{accrued OID up to } t_s}$$

- **Issued on or after 7/19/84**
  - The MD is treated as ordinary income at sale or maturity.[70]
  - The adjusted purchase price can be determined with the CYM (or linearly but this is usually not optimal).
  - The amount of accrued market discount that is included in ordinary income as interest if the bond is sold prior to maturity – i.e. if $t_s < t_m$ – is limited to the amount of capital appreciation on the bond $P_{t_s} - P_{t_b}$. Moreover, the accrued market discount cannot be negative.

This complicates the calculations of the MD and capital gains (CG).

$$MD_{t_s} = \begin{cases} \overbrace{(P^b_{t_s} - P_{t_b})}^{\text{expected price change}} - \overbrace{(P^o_{t_s} - P^o_{t_b})}^{\text{accrued OID up to } t_s} & \text{if } P_{t_s} \geq P^b_{t_s} \text{ ,} \\ (P_{t_s} - P_{t_b}) - (P^o_{t_s} - P^o_{t_b}) & \text{if } P_{t_b} + (P^o_{t_s} - P^o_{t_b}) < P_{t_s} < P^b_{t_s} \text{ , and} \\ 0 & \text{if } P_{t_s} \leq P_{t_b} + (P^o_{t_s} - P^o_{t_b}) \text{ ,} \end{cases}$$

and

$$CG_{t_s} = \begin{cases} P_{t_s} - P^b_{t_s} & \text{if } P_{t_s} \geq P^b_{t_s} \text{ ,} \\ 0 & \text{if } P_{t_b} < P_{t_s} < P^b_{t_s} \text{ , and} \\ P_{t_s} - P_{t_b} & \text{if } P_{t_s} \leq P_{t_b} \text{ .} \end{cases}$$

[70] Alternatively the owner can elect to include the amortized portion of the market discount in current ordinary income, but this is usually not beneficial unless there are substantial interest expenses incurred to finance the purchase of the bond against which the accrued MD could be applied.

C.1.3 Premium (MP) Bonds

The amortized (negative) amount can be subtracted from current ordinary interest income thereby reducing ordinary taxable income and the taxpayer can elect to amortize the MP (original, pure market, and acquisition premia) over the lifetime of the bond.[71] The following rules depend on the bond's date of issue.

- **Issued before 9/28/85**
  - The MP can be amortized linearly (RM), which is preferred.
- **Issued on or after 9/28/85**
  - The MP must be amortized based on the CYM.

For MP bonds the adjusted issue price P_t^o (and hence the OID) does not matter for tax purposes and for asset pricing; only the new asset basis, i.e. the adjusted purchase price P_t^b , matters. The reason for this is that the MP has to be accrued against current coupon income, while the MD can be deferred. Hence, for MD bonds there are two asset bases, the adjusted issue price which determines the amount of accrued OID that has to be added to the coupon interest in each period, and the adjusted purchase price which determines the decomposition of the bond price appreciation at sale into interest income and capital gains. Moreover, the option to defer the MD introduces a real tax option.[72]

C.2 Taxation of Tax-Exempt Bonds Despite the name, not all income from tax-exempt bonds is exempt from all federal taxes.[73]

C.2.1 Original-Issue Discount (OID) Bonds

- The DeMinimis rule does *not* apply.
- The amount of accrued OID is tax-exempt interest income.
- The OID must be amortized using the CYM (or linear which is not beneficial) to increase the tax basis (adjusted issue price) in order to determine the amount of capital gains if sold prior to maturity.

C.2.2 Market Discount (MD) Bonds

- Unlike the OID, the MD is not tax-exempt.
- The amortization can be deferred to the sale or maturity date (which is beneficial).
- The DeMinimis rule applies for the MD. If $P_{t_b} > DM(P_{t_b}^o, m)$, then the MD is ignored for tax purposes and is taxed as (unexpected) capital gain at sale or maturity.

[71] Alternatively, the taxpayer can choose not to amortize the MP in which case the amortized MD at sale or maturity will be treated as a capital loss, but this is suboptimal since $\tau^g \leq \tau^y$ for all taxpayers. Moreover, the election whether or not to amortize a MP applies to every MP on any current or future bond of the taxpayer.

[72] Constantinides and Ingersoll (1984) provide a pricing model for this option as well as the option introduced by the differential taxation of short- and long-term capital gains.

[73] For more details, see Temel (2001).

The following rules depend on the bond's date of issue.

- **Issued before 5/1/93**
  - The MD is treated as capital gain at sale or maturity.
- **Issued on or after 5/1/93** (OBRA 1993, section 13206)
  - The MD is treated as ordinary income at sale or maturity, i.e. the same rules apply as for taxable bonds after 7/18/84 apply.
  - The MD is amortized using the CYM (or linearly which is not preferred).

C.2.3 Premium (MP) Bonds

- Unlike the OID, the MP is not tax-exempt (neither original nor market premium).
- The MP must be amortized and included in current taxable income thereby lowering the amount of tax-exempt interest income (lowering the amount of accrued OID in case of an OID bonds and lowering the tax-exempt part of the coupon for a bond originally selling at or above par). I.e. while the coupon interest is tax-exempt, the amortized market premium is not a tax-deductible expense.
- The MP must be amortized using the CYM.

C.2.4 Callable Bonds

- A redemption of a callable bond by the issuer prior to maturity at a price above par is considered a sale and the difference generates capital gains.

C.3 Valuation of Bonds using After-Tax Cash Flows At any point in time, equilibrium requires that the marginal investor is indifferent between holding and selling the bond. Moreover, any future sale of the bond, i.e. any plan to hold the bond for a certain period and then selling it prematurely, has to result in the same current value. Hence, for any future sale price P_{t_s} , the value has to equal the buy-and-hold strategy

$$
\begin{aligned}
P_t &= \mathbb{E}_t\left[\sum_{k=1}^{m\cdot a} C_k D_{t,k/a} + d_{t,m} P_{t_m}\right] \\
&= \mathbb{E}_t\left[\sum_{k=1}^{(t_s-t)a} C_k D_{t,k/a} + D^*_{t_s} P_{t_s}\right] \quad ,
\end{aligned}
$$

where $\mathbb{E}_t[\cdot]$ is the marginal investor's expectation conditional on his information set at date t. $D^*_{t_s}$ and C_k take into account the special tax rules applying at sale before maturity and the adjustment to bond discounts and premia, respectively, depending on the type of bond and the marginal investor's tax preferences.[74] $t_s - t$ is the expected holding period of the bond.

[74] In the following there is assumed to be no accrued interest. However, allowing for transactions between payment dates is straightforward.

C.3.1 Original-Issue Discount (OID) Bonds

Taxable bonds Without loss of generality, assume that the DeMinimis rule does not apply, i.e. $P_{t_o} \leq DM(P_{t_m}, m)$. Otherwise, the bond is equivalent to a par bond with a small predictable capital gain at sale or maturity equal to $P^o_{t_s} - P_{t_o}$ respectively $P_{t_m} - P_{t_o}$. The amortized OID which has to be included in each period's taxable income is[75]

$$P^o_t \frac{y_{t_o}}{a} \ .$$

The price of a taxable bond is

$$\begin{aligned} P_t &= \mathbb{E}_t \left[\sum_{k=1}^{m \cdot a} \left(C + \overbrace{(P^o_{t,(k-1)/a} y_{t_o}/a - C)}^{\text{accrued OID}} \right) (1 - \tau^y_{t,k/a}) d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &\equiv \mathbb{E}_t \left[y_{t_o}/a \sum_{k=1}^{m \cdot a} P^o_{t,(k-1)/a} (1 - \tau^y_{t,k/a}) d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &= \mathbb{E}_t \left[y_{t_o}/a \sum_{k=1}^{(t_s - t)a} P^o_{t,(k-1)/a} (1 - \tau^y_{t,k/a}) d_{t,k/a} + [P_{t_s} - \underbrace{(P_{t_s} - P^o_{t_s})}_{\text{capital gain}} \tau^g_{t_s}] d_{t_s} \right] \ . \end{aligned}$$

Note that for a bond selling at par – which has $P_{t_m} = P_{t_o}$, $y_{t_o} = c$ and $P^o_t = P_{t_m}$ $\forall t$ – the above equation reduces to

$$\begin{aligned} P_t &= P_{t_m} \ \mathbb{E}_t \left[y_{t_o}/a \sum_{k=1}^{m \cdot a} (1 - \tau^y_{t,k/a}) d_{t,k/a} + d_{t,m} \right] \\ &= P_{t_m} \ \mathbb{E}_t \left[y_{t_o}/a \sum_{k=1}^{(t_s - t)a} (1 - \tau^y_{t,k/a}) d_{t,k/a} \right] + \mathbb{E}_t \left[\left(P_{t_s} - (P_{t_s} - P_{t_m}) \tau^g_{t_s} \right) d_{t_s} \right] \ . \end{aligned}$$

Tax-exempt bonds The price of a tax-exempt bond is

$$\begin{aligned} P_t &= \mathbb{E}_t \left[C \sum_{k=1}^{m \cdot a} d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &= \mathbb{E}_t \left[C \sum_{k=1}^{(t_s - t)a} d_{t,k/a} + \left(P_{t_s} - (P_{t_s} - P^o_{t_s}) \tau^g_{t_s} \right) d_{t_s} \right] \ . \end{aligned}$$

75 For corporate bonds, the adjustment is linear before 7/2/82 as mentioned above.

C.3.2 Market Discount (MD) Bonds

Taxable bonds Without loss of generality, assume that the DeMinimis rule does not apply, i.e. $P_{t_b} \leq DM(P^o_{t_b}, m)$. Otherwise, the bond is equivalent to a par bond with a small predictable capital gain at sale or maturity equal to $P^b_{t_s} - P_{t_b}$ respectively $P_{t_m} - P_{t_b}$. Suppose that the bond traded at an OID and was purchased below the adjusted issue price to generate an additional market discount $M_{t_b} = P^o_{t_b} - P_{t_b} > 0$.

The price of a taxable bond issued **before 7/19/84** is

$$P_t = \mathbb{E}_t\left[y_{t_o}/a \sum_{k=1}^{m\cdot a} P^o_{t,(k-1)/a}(1-\tau^y_{t,k/a})d_{t,k/a} + [P_{t_m} - \left(P^o_{t_b} - P_{t_b}\right)\tau^g_{t,m}]d_{t,m} \right]$$
$$= \mathbb{E}_t\left[y_{t_o}/a \sum_{k=1}^{(t_s-t)a} P^o_{t,(k-1)/a}(1-\tau^y_{t,k/a})d_{t,k/a} + [P_{t_s} - \left((P_{t_s} - P_{t_b}) - (P^o_{t_s} - P^o_{t_b})\right)\tau^g_{t_s}]d_{t_s} \right] .$$

For a bond issued **on or after 7/19/84** the price is

$$P_t = \mathbb{E}_t\left[y_{t_o}/a \sum_{k=1}^{m\cdot a} P^o_{t,(k-1)/a}(1-\tau^y_{t,k/a})d_{t,k/a} + [P_{t_m} - \overbrace{(P^o_{t_b} - P_{t_b})}^{\text{market discount}}\tau^y_{t,m}]d_{t,m} \right]$$
$$= \mathbb{E}_t\left[y_{t_o}/a \sum_{k=1}^{(t_s-t)a} P^o_{t,(k-1)/a}(1-\tau^y_{t,k/a})d_{t,k/a} + [P_{t_s} - MD_{t_s}\tau^y_{t_s} - CG_{t_s}\tau^g_{t_s}]d_{t_s} \right] ,$$

where MD_{t_s} and CG_{t_s} are defined above.

Tax-exempt bonds Assume that the DeMinimis rule does not apply, i.e. $P_{t_b} \leq DM(P_{t_m}, m)$. Otherwise, the bond is an OID bond with a small predictable capital gain at sale or maturity of $P_{t_s} - P^b_{t_s}$ respectively $P_{t_m} - P^b_{t_m}$. Moreover, we allow for the possibility of an OID.

The price of a tax-exempt bond issued **before 5/1/93** is

$$P_t = \mathbb{E}_t\left[C \sum_{k=1}^{m\cdot a} d_{t,k/a} + [P_{t_m} - \overbrace{(P^o_{t_b} - P_{t_b})}^{MD_{t_b}}\tau^g_{t,m}]d_{t,m} \right]$$
$$= \mathbb{E}_t\left[C \sum_{k=1}^{(t_s-t)a} d_{t,k/a} + [P_{t_s} - \left((P_{t_s} - P_{t_b}) - (P^o_{t_s} - P^o_{t_b})\right)\tau^g_{t_s}]d_{t_s} \right] ,$$

and issues **on or after 4/30/93**

$$P_t = \mathbb{E}_t\left[C \sum_{k=1}^{m\cdot a} d_{t,k/a} + [P_{t_m} - (P^o_{t_b} - P_{t_b})\tau^y_{t,m}]d_{t,m} \right]$$

$$= \mathbb{E}_t \left[C \sum_{k=1}^{(t_s-t)a} d_{t,k/a} + [P_{t_s} - MD_{t_s}\tau^y_{t_s} - CG_{t_s}\tau^g_{t_s}]d_{t_s} \right] .$$

C.3.3 Premium (MP) Bonds

Taxable bonds The amortized MP at coupon payment date t is

$$AMP_t = \begin{cases} P^b_t \frac{y_{t_b}}{a} & \text{, amortized with the CYM on or after 9/28/85, and} \\ \frac{1}{m \cdot a}(P_{t_b} - P^o_{t_b}) & \text{, amortized with the RM before 9/28/85.} \end{cases}$$

The price of a taxable MP bond is

$$\begin{aligned} P_t &= \mathbb{E}_t \left[\sum_{k=1}^{m \cdot a} [C + \overbrace{(AMP_{t,(k-1)/a} - C)}^{\text{accrued MP in addition to coupon}}](1 - \tau^y_{t,k/a})d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &\equiv \mathbb{E}_t \left[\sum_{k=1}^{m \cdot a} AMP_{t,(k-1)/a}(1 - \tau^y_{t,k/a})d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &= \mathbb{E}_t \left[\sum_{k=1}^{(t_s-t)a} AMP_{t,(k-1)/a}(1 - \tau^y_{t,k/a})d_{t,k/a} + [P_{t_s} - (P_{t_s} - P^b_{t_s})\tau^g_{t_s}]d_{t_s} \right] . \end{aligned}$$

Tax-exempt bonds The price of a tax-exempt MP bond is

$$\begin{aligned} P_t &= \mathbb{E}_t \left[\sum_{k=1}^{m \cdot a} [C + (AMP_{t,(k-1)/a} - C)(1 - \tau^y_{t,k/a})]d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &\equiv \mathbb{E}_t \left[\sum_{k=1}^{m \cdot a} \left(AMP_{t,(k-1)/a} - (AMP_{t,(k-1)/a} - C)\tau^y_{t,k/a} \right) d_{t,k/a} + P_{t_m} d_{t,m} \right] \\ &= \mathbb{E}_t \left[\sum_{k=1}^{(t_s-t)a} \left(AMP_{t,(k-1)/a} - (AMP_{t,(k-1)/a} - C)\tau^y_{t,k/a} \right) d_{t,k/a} + [P_{t_s} - (P_{t_s} - P^b_{t_s})\tau^g_{t_s}]d_{t_s} \right] . \end{aligned}$$

C.3.4 Dealing with Accrued Interest

Accrued interest is added to the purchase price, but is taxable as ordinary income for the seller at sale date t while the same amount is subtracted from the coupon at the next payment date for the buyer. Hence, the equilibrium value at each point in time of a bond trading between interest payments is determined by setting the value of keeping and selling the bond equal for the marginal investor, i.e.[76]

$$P_t + A_t(1-\tau_t^y) = \mathbb{E}_t\left[(C-A_t)(1-\tau_{t,1/a}^y) + C\sum_{k=2}^{m\cdot a}(1-\tau_{t,k/a}^y)d_{t,k/a} + P_{t_m}d_{t,m}\right] ,$$

which can be rewritten as[77]

$$P_t = \mathbb{E}_t\left[-A_t + A_t\tau_{t,1/a}^y d_{t,1/a} + (1-d_{t,1/a})A_t\right] + \mathbb{E}_t\left[C\sum_{k=1}^{m\cdot a}(1-\tau_{t,k/a}^y)d_{t,k/a} + P_{t_m}d_{t,m}\right] .$$

Therefore, in order to account for accrued interest, we have to add the term

$$-A_t + A_t\tau_{t,1/a}^y d_{t,1/a} + (1-d_{t,1/a})A_t$$

to the present value of a bond trading before payment date.

[76] Here we assume an original issue par bond such that no capital gains or market premia or discounts apply. However, these adjustments are straightforward.

[77] It is sometime assumed that the third term of the right hand side is zero to obtain the approximation

$$P_t \approx \mathbb{E}_t\left[-A_t + A_t\tau_{t,1/a}^y d_{t,1/a}\right] + \mathbb{E}_t\left[C\sum_{k=1}^{m\cdot a}(1-\tau_{t,k/a}^y)d_{t,k/a} + P_{t_m}d_{t,m}\right] .$$

D Tables

Table 1: Historical bond default rates 1970-2006 [in %]

Rating categories	Municipal Bonds		Corporate Bonds	
	Moody's	S&P	Moody's	S&P
Aaa/AAA	0	0	0.52	0.6
Aa/AA	0.06	0	0.52	1.5
A/A	0.03	0.23	1.29	2.91
Baa/BBB	0.13	0.32	4.64	10.29
Ba/BB	2.65	1.74	19.12	29.93
B/B	11.86	8.48	43.34	53.72
Caa-C/CCC-C	16.58	44.81	69.18	69.19
Investment Grade	0.07	0.2	2.09	4.14
Non-Investment Grade	4.29	7.37	31.37	42.35
All	0.1	0.29	9.7	12.98

Source: Moody's and S&P, taken from Representative Barney Frank's request to accompany the Municipal Bond and Fairness Act H.R. 6308, September 9 2008, accessed on 4/7/2010 via http://frwebgate.access.gpo.gov.

Table 2: Personal state income taxes on interest income.

Type of Bond :	**In-State Municipal**	**Out-of-State Municipal**	**Treasury**	**Corporate**
Alabama	exempt	taxable	exempt	taxable
Alaska		*no personal income tax*		
Arkansas	exempt	taxable	exempt	taxable
Arizona	exempt	taxable	exempt	taxable
California	exempt	taxable	exempt	taxable
Colorado	exempt	taxable	exempt	taxable
Connecticut*	exempt	taxable	exempt	taxable
Delaware	exempt	taxable	exempt	taxable
Florida		*no personal income tax*		
Georgia	exempt	taxable	exempt	taxable
Hawaii	exempt	taxable	exempt	taxable
Idaho	exempt	taxable	exempt	taxable
Illinois	*taxable*	taxable	exempt	taxable
Indiana	exempt	*exempt*	exempt	taxable
Iowa	*taxable*	taxable	exempt	taxable
Kansas	exempt	taxable	exempt	taxable
Kentucky	exempt	taxable	exempt	taxable
Louisiana	exempt	taxable	exempt	taxable
Maine	exempt	taxable	exempt	taxable
Maryland	exempt	taxable	exempt	taxable
Massachusetts*	exempt	taxable	exempt	taxable
Michigan	exempt	taxable	exempt	taxable
Minnesota*	exempt	taxable	exempt	taxable
Mississippi	exempt	taxable	exempt	taxable
Missouri	exempt	taxable	exempt	taxable
Montana*	exempt	taxable	exempt	taxable
Nebraska	exempt	taxable	exempt	taxable
Nevada		*no personal income tax*		
New Hampshire	exempt	*exempt*	exempt	taxable
New Jersey*	exempt	taxable	exempt	taxable

Type of Bond :	**In-State Municipal**	**Out-of-State Municipal**	**Treasury**	**Corporate**
New Mexico	exempt	taxable	exempt	taxable
New York*	exempt	taxable	exempt	taxable
North Carolina	exempt	taxable	exempt	taxable
North Dakota	exempt	taxable	exempt	taxable
Ohio	exempt	*exempt*	exempt	taxable
Oklahoma	exempt	taxable	exempt	taxable
Oregon*	exempt	taxable	exempt	taxable
Pennsylvania*	exempt	*exempt*	exempt	taxable
Rhode Island	exempt	taxable	exempt	taxable
South Carolina	exempt	taxable	exempt	taxable
South Dakota		*no personal income tax*		
Tennessee	exempt	taxable	*taxable*	taxable
Texas		*no personal income tax*		
Utah	*taxable*	taxable	exempt	taxable
Vermont	exempt	taxable	exempt	taxable
Virginia	exempt	taxable	exempt	taxable
Washington		*no personal income tax*		
Washington D.C.	exempt	taxable	exempt	taxable
West Virginia*	exempt	taxable	exempt	taxable
Wisconsin*	*taxable*	taxable	exempt	taxable
Wyoming		*no personal income tax*		

Source: Temel (2001), updated by the author.
* The following states tax corporations on all interest income: Connecticut, Massachusetts, Minnesota, Montana, New Jersey, New York, and Oregon. Pennsylvania exempts corporations from all taxes on interest. West Virginia and Wisconsin tax corporations on their interest income from municipal bonds, but exempt interest from Treasury bonds.

Table 3: Break-even tax rate responses to changes in election probabilities.

Dependent variables: Break-even tax rates $\theta_{t,m}$ for the most commonly traded maturities m [raw data in %].

	Maturity							
Break-Even Tax Rate (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Bush Contract in 2000 [cents]	0.019	-0.018***	-0.031***	-0.033***	-0.028***	-0.024**	-0.006	0.003
	(0.012)	(0.007)	(0.007)	(0.007)	(0.010)	(0.011)	(0.009)	(0.013)
Price of Clinton Contract in 1992 [cents]	0.121**	0.075*	0.122***	0.076***	0.084***	0.090***	0.035**	0.040**
	(0.051)	(0.044)	(0.039)	(0.025)	(0.021)	(0.021)	(0.015)	(0.017)

Notes:

- Regression results using daily election probabilities for the presidential election of 2000 and 1992 respectively. The tax reform enacted in 1993 (OBRA 1993) increased the statutory top income rate by 8.6% from 31% to 39.6% retroactively to January 1, 1993. The tax reform enacted in 2001 (EGTRRA 2001) reduced the statutory top income rate by 4.6% from 39.6% to 35% over 5 years and the reform in 2003 (JGTRRA 2003) accelerated the phase-in period to three years.
- The contracts yield 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election.
- Newey-West HAC robust standard errors in parentheses:
  *** Significant at the 1 percent level.
  ** Significant at the 5 percent level.
  * Significant at the 10 percent level.

Table 4: Consumption response of high-income households.

	nondurables and services	total expenditures
tax news shock	-1.147***	-0.223
	(0.377)	(0.525)
age	-0.012	0.152***
	(0.032)	(0.047)
$age^2/1000$	0.056	-1.259**
	(0.365)	(0.529)
Δ adults	1.960***	1.768***
	(0.239)	(0.373)
Δ kids	0.772***	0.215
	(0.268)	(0.375)
monthly FEs	Yes	Yes
R^2	0.020	0.012

Notes: The sample consists of households with federal AGI above the 50$^{\text{th}}$ percentile of households with positive federal AGI. Depending on the tax year, this corresponds roughly to the top income quartile of all households. Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table 5: Consumption response in the full sample of affected households.

	nondurables and services	total expenditures
tax news shock	-0.449**	-0.550**
	(0.198)	(0.269)
age	-0.016	0.100***
	(0.023)	(0.033)
$age^2/1000$	0.105	-0.851**
	(0.265)	(0.372)
Δ adults	2.241***	2.186***
	(0.185)	(0.279)
Δ kids	1.097***	0.813***
	(0.203)	(0.278)
monthly FEs	Yes	Yes
R^2	0.017	0.009

Notes: Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table 6: Consumption response as a function of the size of the tax news shock.

	nondurables and services			total expenditures		
Size of news shock:	50% largest (in abs. value)	25% most negative	25% most positive	50% largest (in abs. value)	25% most negative	25% most positive
	(1)	(2)	(3)	(4)	(5)	(6)
tax news shock	-1.125***	-0.910**	-0.880*	-0.562	-0.897*	0.184
	(0.359)	(0.418)	(0.511)	(0.461)	(0.533)	(0.685)
age	0.001	0.034	-0.009	0.187***	0.106	0.206***
	(0.043)	(0.053)	(0.052)	(0.062)	(0.074)	(0.077)
$age^2/1000$	-0.051	-0.524	0.138	-1.829***	-0.894	-1.884**
	(0.494)	(0.609)	(0.592)	(0.709)	(0.852)	(0.885)
Δ adults	2.156***	1.835***	2.497***	2.728***	2.589***	2.489***
	(0.324)	(0.407)	(0.398)	(0.398)	(0.498)	(0.513)
Δ kids	1.095***	1.185***	0.797*	1.016**	0.712	1.319**
	(0.351)	(0.422)	(0.462)	(0.444)	(0.554)	(0.582)
monthly FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.020	0.018	0.020	0.014	0.013	0.012

Notes: Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table 7: Consumption response as a function of liquid wealth.

LW=Liquid Wealth TE=Total Expend.	nondurables and services LW>2% of TE	 LW∈ $(0, 0.2\%)$ of TE	 LW=0	total expenditures LW>2% of TE	 LW∈ $(0, 0.2\%)$ of TE	 LW=0
	(1)	(2)	(3)	(4)	(5)	(6)
tax news shock	-0.510*	0.457	-0.486	0.357	1.013	-1.226***
	(0.301)	(0.861)	(0.346)	(0.442)	(1.227)	(0.428)
age	-0.008	-0.087	-0.054	0.132***	-0.063	0.007
	(0.035)	(0.097)	(0.044)	(0.051)	(0.134)	(0.057)
$age^2/1000$	-0.021	1.029	0.582	-1.099*	0.942	0.133
	(0.384)	(1.136)	(0.499)	(0.569)	(1.559)	(0.641)
Δ adults	2.090***	2.490***	2.069***	1.958***	2.752***	2.173***
	(0.304)	(0.659)	(0.316)	(0.534)	(0.856)	(0.433)
Δ kids	0.991***	-0.089	1.083***	0.298	0.702	1.277***
	(0.373)	(0.568)	(0.341)	(0.458)	(1.122)	(0.453)
monthly FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.021	0.059	0.021	0.016	0.051	0.015

Notes: TE are total annual expenditures. LW is liquid wealth and is defined as the sum of checking and savings accounts. Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table 8: Consumption response as a function of education.

	nondurables and services		total expenditures	
HS=high school	≤ HS	College	≤ HS	College
tax news shock	0.222	-0.870***	-0.404	-0.642
	(0.309)	(0.287)	(0.418)	(0.399)
age	-0.008	-0.031	-0.003	0.161***
	(0.034)	(0.032)	(0.048)	(0.046)
$age^2/1000$	-0.015	0.342	0.204	-1.374**
	(0.384)	(0.368)	(0.532)	(0.536)
Δ adults	2.268***	2.216***	2.389***	2.015***
	(0.249)	(0.270)	(0.364)	(0.414)
Δ kids	1.333***	0.861***	0.951**	0.664*
	(0.277)	(0.297)	(0.404)	(0.383)
monthly FEs	Yes	Yes	Yes	Yes
R^2	0.021	0.020	0.014	0.013

Notes: Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table A.1: Consumption response of high-income households in different sub-periods.

	nondurables and services			total expenditures		
Period:	1980-1988	1989-1994	1995-2001	1980-1988	1989-1994	1995-2001
	(1)	(2)	(3)	(4)	(5)	(6)
tax news shock	-1.139*	-0.138	-1.587***	-1.104	1.276	0.023
	(0.656)	(0.918)	(0.542)	(0.830)	(1.294)	(0.811)
age	-0.005	-0.029	-0.001	0.162**	0.160*	0.126
	(0.052)	(0.060)	(0.059)	(0.077)	(0.085)	(0.086)
$age^2/1000$	-0.060	0.177	0.060	-1.273	-1.410	-1.046
	(0.591)	(0.674)	(0.667)	(0.872)	(0.960)	(0.970)
Δ adults	1.785***	2.650***	1.615***	0.994	2.310***	2.130***
	(0.389)	(0.418)	(0.436)	(0.786)	(0.554)	(0.534)
Δ kids	1.030**	-0.436	1.481***	0.309	-0.451	0.623
	(0.467)	(0.454)	(0.457)	(0.635)	(0.639)	(0.677)
monthly FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.022	0.025	0.015	0.014	0.011	0.009

Notes: Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table A.2: Consumption response of high-income households: different filtering.

	nondurables and services			total expenditures		
Time series filter:	no filter	one-sided	two-sided	no filter	one-sided	two-sided
	(1)	(2)	(3)	(4)	(5)	(6)
tax news shock	0.013	-0.859**	-1.147***	0.095	-0.223	-0.223
	(0.116)	(0.341)	(0.377)	(0.172)	(0.498)	(0.525)
age	-0.014	-0.011	-0.012	0.152***	0.152***	0.152***
	(0.032)	(0.032)	(0.032)	(0.047)	(0.047)	(0.047)
$\text{age}^2/1000$	0.073	0.044	0.056	-1.255**	-1.263**	-1.259**
	(0.365)	(0.365)	(0.365)	(0.529)	(0.529)	(0.529)
Δ adults	1.961***	1.959***	1.960***	1.768***	1.767***	1.768***
	(0.239)	(0.239)	(0.239)	(0.373)	(0.373)	(0.373)
Δ kids	0.767***	0.771***	0.772***	0.214	0.215	0.215
	(0.268)	(0.268)	(0.268)	(0.375)	(0.375)	(0.375)
monthly FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.020	0.020	0.020	0.012	0.012	0.012

Notes: Reported standard errors in parentheses are adjusted for within-household correlations and heteroskedasticity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table A.3: Presidential election of 2000 – full results with controls.

Dependent variables: Break-even tax rates $\theta_{t,m}$ for the most commonly traded maturities m [raw data in %].

	Maturity							
Break-Even Tax Rate (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Bush Contract [in cents]	0.019	-0.018***	-0.031***	-0.033***	-0.028***	-0.024**	-0.006	0.003
	(0.012)	(0.007)	(0.007)	(0.007)	(0.010)	(0.011)	(0.009)	(0.013)
Aa - PreRefunded Muni Spread	0.949**	1.641**	1.869**	1.846***	1.540**	1.711**	1.535***	1.391***
	(0.369)	(0.642)	(0.728)	(0.672)	(0.663)	(0.671)	(0.529)	(0.511)
Baa - Aa Muni Credit Spread	0.430*	0.697***	0.629**	0.716**	0.693*	0.654*	0.421	0.382
	(0.257)	(0.259)	(0.301)	(0.319)	(0.357)	(0.392)	(0.281)	(0.284)
Muni Supply - negotiated offer [in billions]	-0.001	-0.068	-0.042	-0.094	-0.035	0.005	0.028	0.058
	(0.110)	(0.148)	(0.160)	(0.154)	(0.157)	(0.170)	(0.143)	(0.167)
Muni Supply - competitive offer [in billions]	-0.116	-0.066	-0.092	0.012	0.047	0.028	0.064	0.028
	(0.136)	(0.273)	(0.314)	(0.281)	(0.269)	(0.266)	(0.216)	(0.220)
Repeated Muni Prices [weekly]	-0.138	-0.030	-0.069	-0.046	0.031	0.046	0.058	0.060
	(0.185)	(0.221)	(0.271)	(0.284)	(0.311)	(0.312)	(0.245)	(0.265)
Repeated Muni Price Indicator	0.011	-0.026	0.013	-0.009	-0.004	0.019	0.012	-0.001
	(0.068)	(0.069)	(0.089)	(0.076)	(0.093)	(0.100)	(0.075)	(0.057)
Corporate Spread	-0.368***	-0.070	-0.110	-0.091	-0.065	-0.089	-0.099	-0.160
	(0.096)	(0.142)	(0.154)	(0.142)	(0.132)	(0.144)	(0.139)	(0.119)
Off- vs. On-the-Run Treasury Spread	-0.629	-0.761	-0.787	-0.500	-0.907	-1.387**	-1.316**	-0.481
	(0.491)	(0.466)	(0.518)	(0.501)	(0.558)	(0.676)	(0.532)	(0.599)
StDev of 10-Year Treasury [weekly]	3.110*	6.642***	7.491***	7.018***	7.301***	7.119**	6.293***	5.905**
	(1.816)	(2.081)	(2.329)	(2.167)	(2.470)	(2.717)	(2.366)	(2.272)
Volume in Prediction Market [in cents]	-0.008	-0.004	-0.003	-0.003	-0.015	-0.021	-0.025	-0.018
	(0.024)	(0.017)	(0.017)	(0.019)	(0.022)	(0.022)	(0.015)	(0.023)
Units Traded in Prediction Market	-0.179	-0.132	-0.153	-0.121	-0.113	-0.103	-0.042	-0.083
	(0.117)	(0.108)	(0.122)	(0.109)	(0.105)	(0.105)	(0.082)	(0.085)
Observations	131	131	131	131	131	131	131	131

Notes:

- Regression results using daily election probabilities for the presidential election of 2000. The tax reform enacted in 2001 reduced the statutory top income rate by 4.6% from 39.6% to 35% over 5 years and the reform in 2003 accelerated the phase-in period to three years.
- The contract yields 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election.
- Newey-West HAC robust standard errors in parentheses. The regression also includes a time trend, month and trading-day fixed effects, and Treasury interest rates.

  *** Significant at the 1 percent level.
  ** Significant at the 5 percent level.
  * Significant at the 10 percent level.

Table A.4: Presidential election of 1992 – full results with controls.

Dependent variables: Break-even tax rates $\theta_{t,m}$ for the most commonly traded maturities m [raw data in %].

	Maturity							
Break-Even Tax Rate (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Clinton Contract [in cents]	0.121**	0.075*	0.122***	0.076***	0.084***	0.090***	0.035**	0.040**
	(0.051)	(0.044)	(0.039)	(0.025)	(0.021)	(0.021)	(0.015)	(0.017)
Aa - PreRefunded Muni Spread	0.264	0.112	0.142	0.038	0.015	-0.072	-0.026	-0.026
	(0.285)	(0.126)	(0.117)	(0.096)	(0.080)	(0.094)	(0.066)	(0.067)
A - Aa Muni Credit Spread	0.198	-0.287	-0.309	-0.205	-0.265	-0.260	-0.340**	-0.287*
	(0.500)	(0.303)	(0.313)	(0.262)	(0.264)	(0.209)	(0.131)	(0.160)
Muni Supply - negotiated offer [in billions]	0.023	-0.389**	-0.408**	-0.268**	-0.261**	-0.220**	-0.068	-0.070
	(0.287)	(0.174)	(0.172)	(0.127)	(0.104)	(0.092)	(0.084)	(0.089)
Muni Supply - competitive offer [in billions]	-1.517*	0.061	0.155	0.252	0.153	0.073	0.177	0.093
	(0.861)	(0.574)	(0.525)	(0.438)	(0.422)	(0.398)	(0.180)	(0.158)
Repeated Muni Prices [weekly]	-0.683	-1.017	-0.465	-0.635	-0.717	-0.921	0.079	0.256
	(0.902)	(0.638)	(0.583)	(0.673)	(0.618)	(0.575)	(0.278)	(0.449)
Repeated Muni Price Indicator	0.603	0.731***	0.634***	0.458***	0.434***	0.366**	0.226*	0.210*
	(0.438)	(0.232)	(0.180)	(0.149)	(0.148)	(0.143)	(0.122)	(0.113)
Corporate Spread	-1.271	-1.459**	-1.374**	-1.134**	-1.155**	-0.762**	-0.433	-0.617**
	(1.240)	(0.727)	(0.649)	(0.565)	(0.453)	(0.378)	(0.291)	(0.239)
Off- vs. On-the-Run Treasury Spread	-1.898	0.545	-0.700	0.214	-0.133	-0.632	0.248	0.356
	(1.447)	(0.964)	(1.050)	(0.806)	(0.724)	(0.759)	(0.492)	(0.611)
StDev of 10-Year Treasury [weekly]	-7.071	-0.283	3.521	7.052**	8.433***	6.481**	-0.754	-0.785
	(7.207)	(3.462)	(3.289)	(2.910)	(2.858)	(2.806)	(1.873)	(2.429)
Volume in Prediction Market [in cents]	0.174	0.317	0.063	-0.007	-0.047	-0.087	-0.008	0.090
	(0.450)	(0.317)	(0.310)	(0.214)	(0.245)	(0.221)	(0.153)	(0.163)
Units Traded in Prediction Market	-1.741	-2.391	-0.250	0.270	0.465	0.765	0.090	-0.724
	(3.882)	(2.652)	(2.584)	(1.787)	(1.999)	(1.807)	(1.247)	(1.328)
Observations	82	82	82	82	82	82	82	82

Notes:

- Regression results using daily election probabilities for the presidential election of 1992. The tax reform enacted in 1993 increased the statutory top income rate by 8.6% from 31% to 39.6% retroactively to January 1, 1993.
- The contract yields 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to an approximately one-percent increase in the perceived probability of the candidate winning the presidential election.
- Newey-West HAC robust standard errors in parentheses. The regression also includes a time trend, month and trading-day fixed effects, and Treasury interest rates.

  *** Significant at the 1 percent level.
  ** Significant at the 5 percent level.
  * Significant at the 10 percent level.

E Figures

Figure 1: Spread between AAA general-obligation and pre-refunded municipal bonds with 7-year maturity.

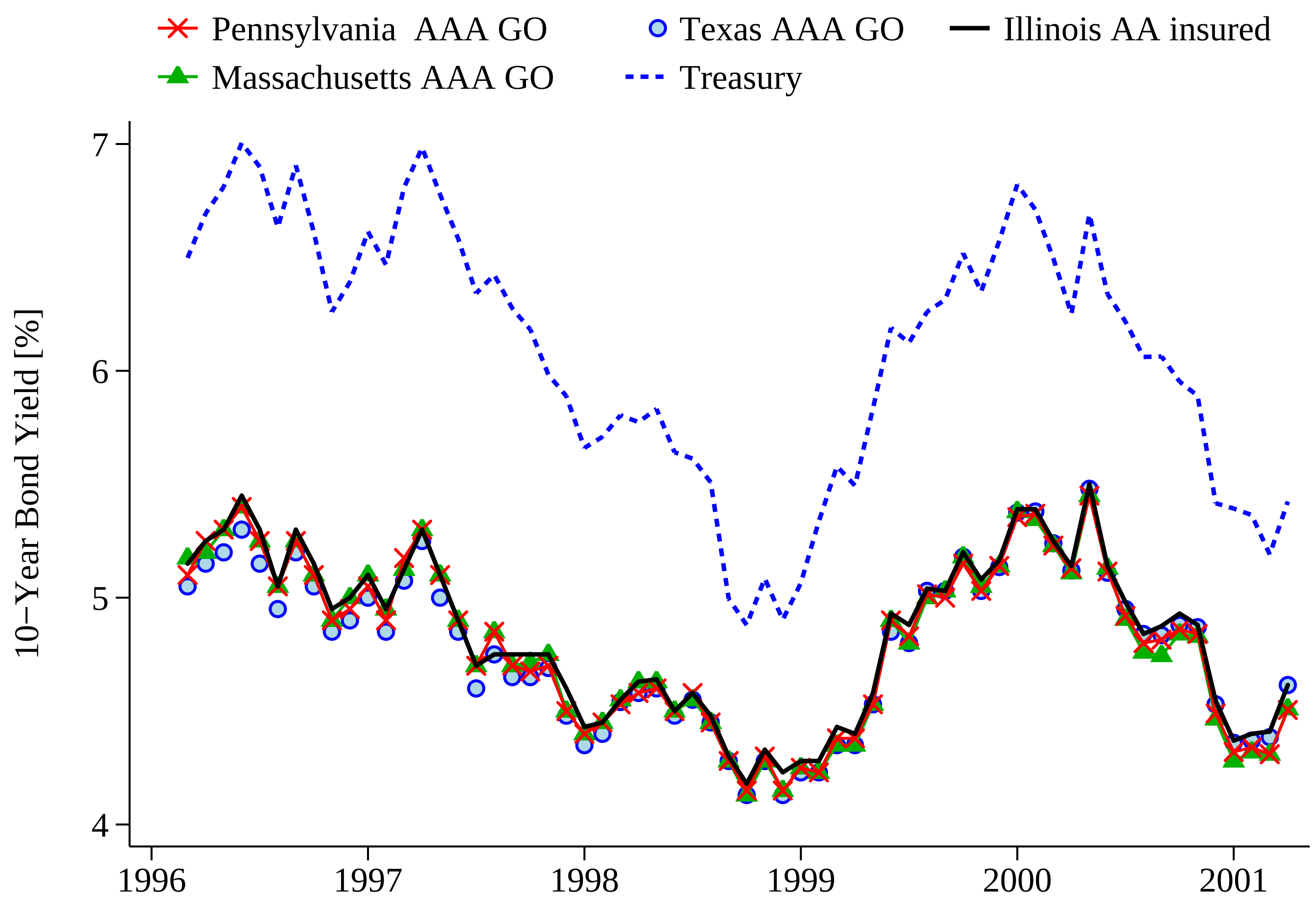


Figure 2: Yields of AAA general-obligation (GO) bonds of states with different tax treatment of in- and out-of-state investors.

The blue dashed line is the 10-year Treasury yield, which is taxable at the federal personal income tax rate but is exempt from state and local income taxes; see Table 2. The other four time series are 10-year bond yields of states that span the spectrum of possible tax treatments of in-state and out-of-state municipal bond investors. The red crossed line is the yield of a AAA general-obligation (GO) bond of the state of Pennsylvania, which exempts both in-state and out-of-state municipal bond investors. The green line with triangle markers is the yield of a AAA GO bond of the state of Massachusetts, which exempts in-state investors from state taxes but taxes out-of-state investors. The black solid line is the yield of a AA insured bond of the state of Illinois, which taxes both in-state and out-of-state investors. I use a AA insured bond because there is no AAA GO for the state of Illinois, which is one of only four states that taxes both in- and out-of-state investors – the others being Iowa, Utah, and Wisconsin, for which I do not have bond yield data. Finally, the blue dots represents the time series of AAA GO 10-year bond yields of the state of Texas, which has no personal income tax rate.

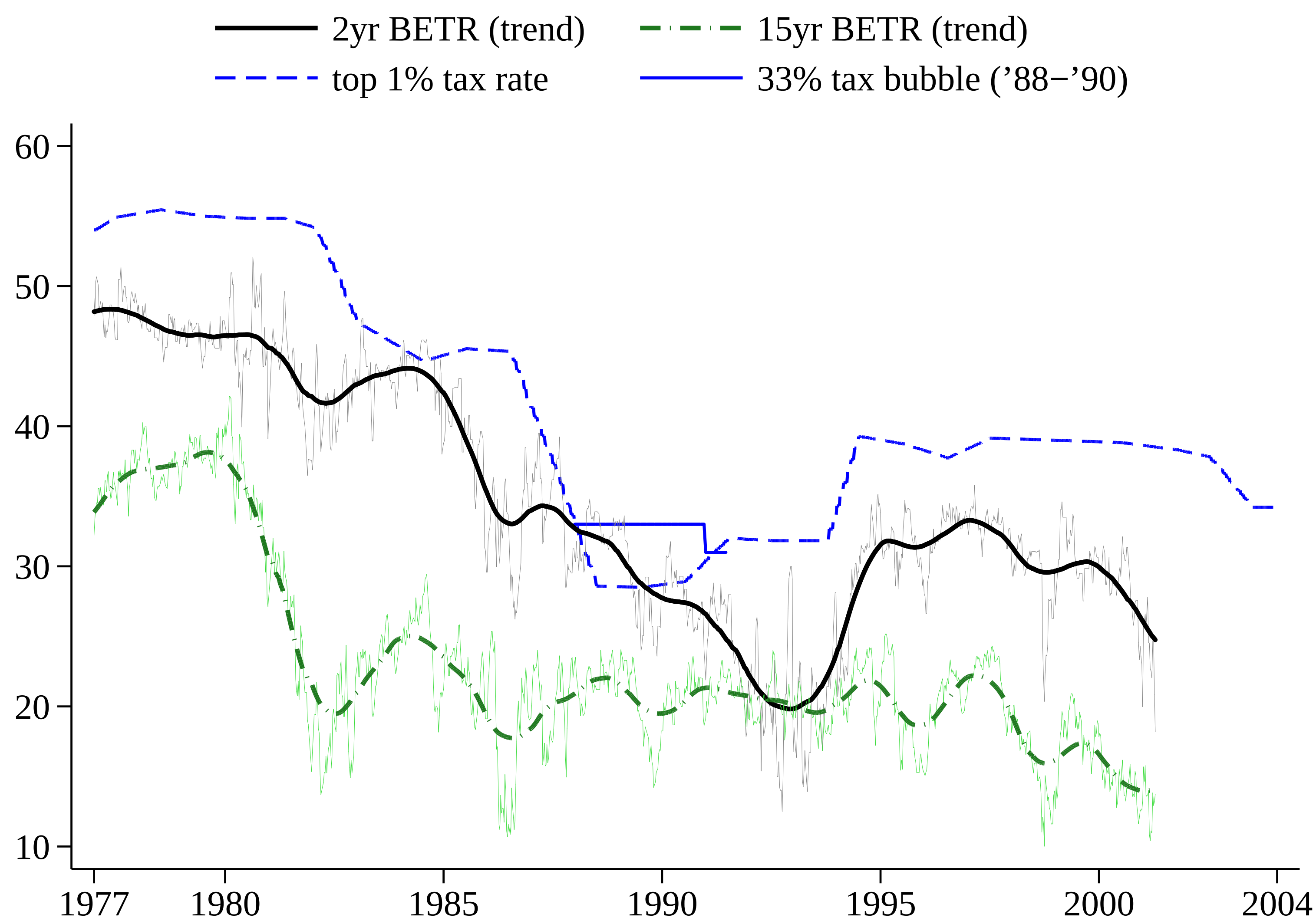


Figure 3: 2-year and 15-year break-even tax rates (BETR) $\theta_{t,2}$ and $\theta_{t,15}$ against the marginal tax rate of the top 1%.

The thin lines are the raw data and the thick lines are the corresponding low frequency components of the 2-year and the 15-year break-even tax rates, respectively, corresponding to equation (3). The blue thin dashed line is the top 1% tax rate taken from Saez (2004). The solid blue line is the '33% tax bubble' during the years 1988-1990; in this period, the top marginal tax rate is higher than the marginal tax rate of the top 1% of the income distribution.

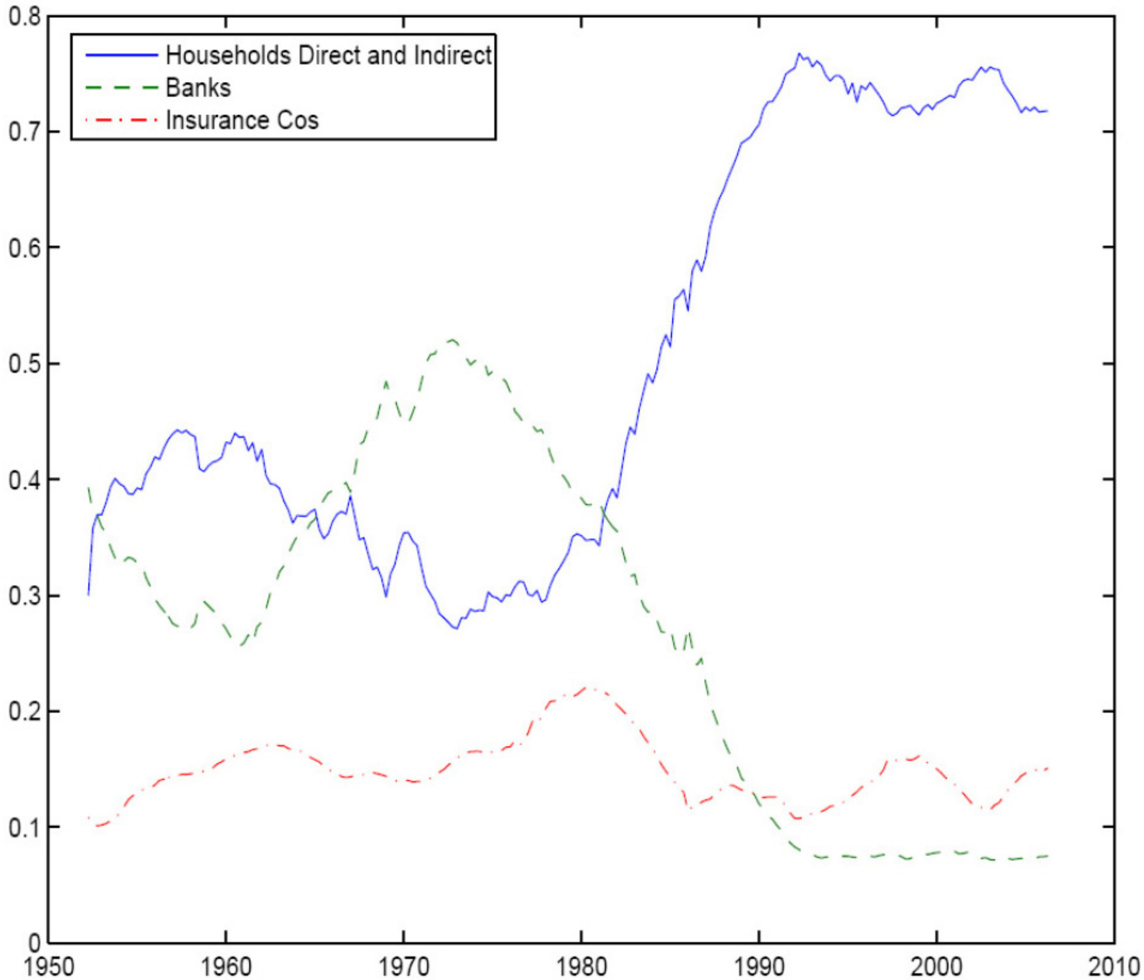


Figure 4: Municipal Debt Ownership

Percentage of outstanding municipal bonds held (i) by households, which includes direct ownership and indirect ownership through mutual funds, money market funds, and closed-end funds, (ii) by banks, which comprise commercial banks and savings institutions, and (iii) by insurance companies, which are life insurance companies and other insurance companies. The figure, taken from Ang et al. (2007), is based on the Flow of Funds Accounts provided by the Board of Governors.

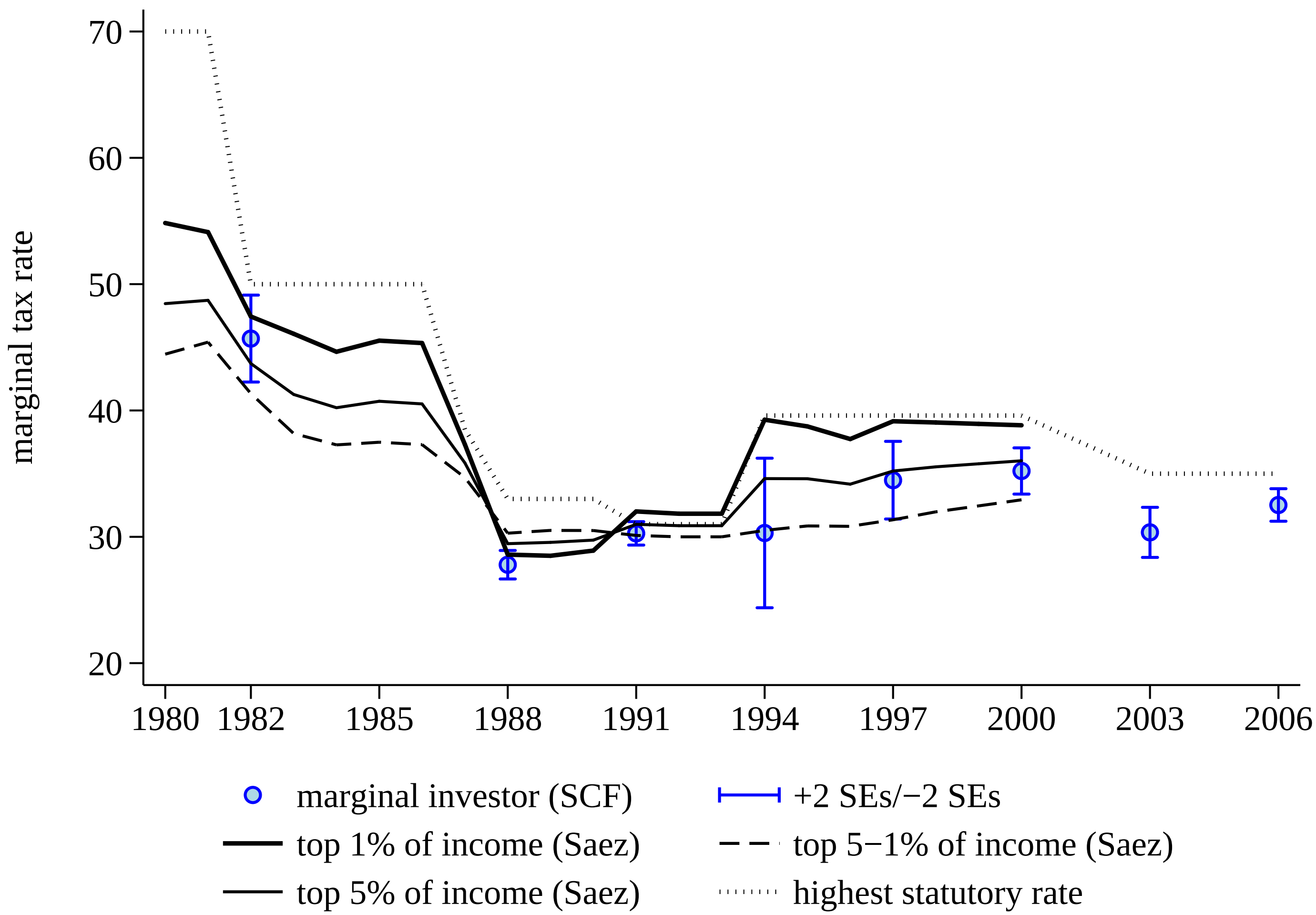


Figure 5: Average Marginal Tax Rate of the Marginal Investors calculated from the Survey of Consumer Finances (SCF).

The blue dots are the estimated marginal tax rate of the marginal investor defined as the asset-weighted average of the effective marginal tax rates over all households that own both taxable and tax-exempt bonds. Two standard error bands are shown around the point estimates of the marginal investor's marginal tax rate. The black lines are the marginal tax rates of different percentiles of the income distribution taken from Saez (2004).

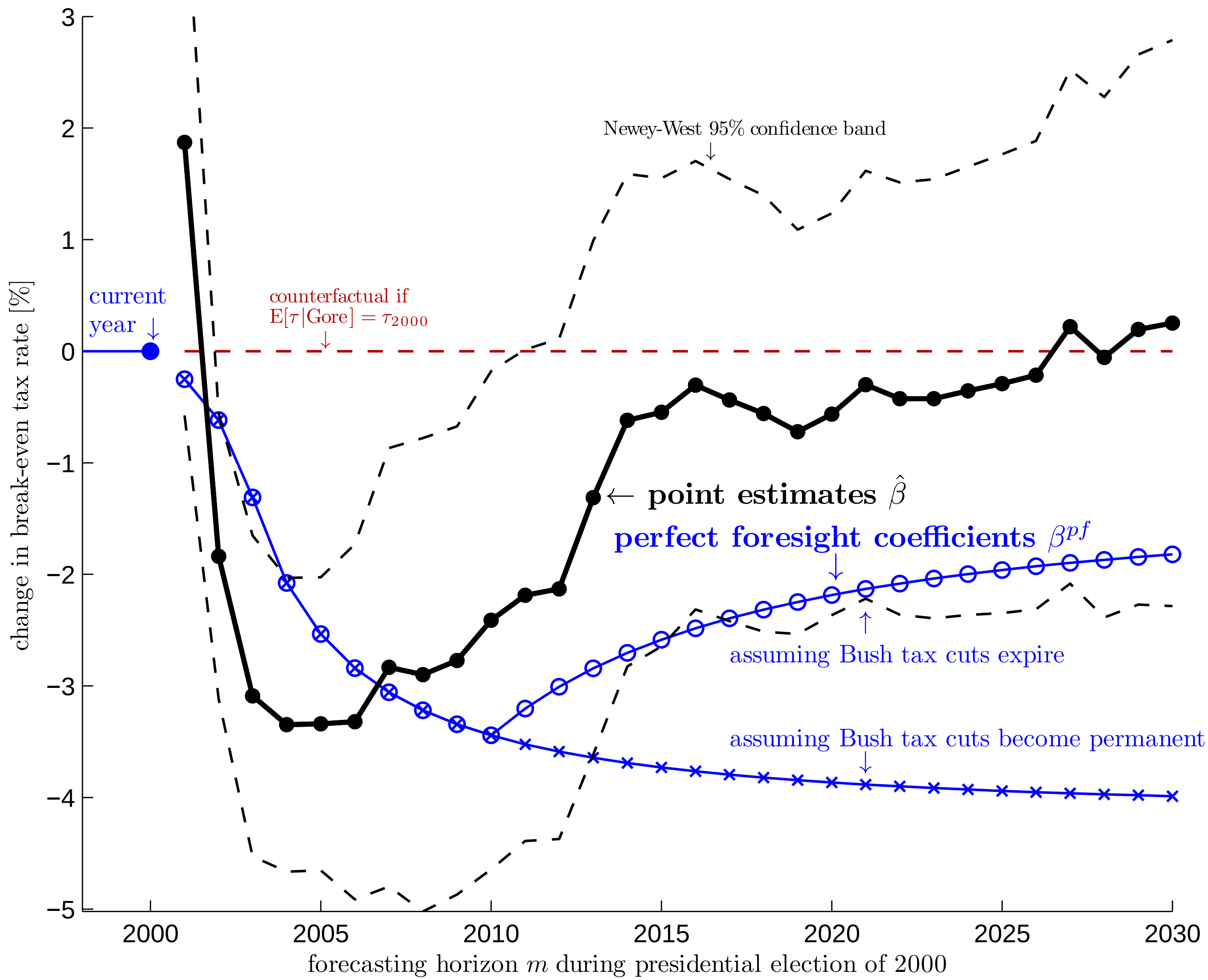


Figure 6: Path of Break-Even Tax Rates during presidential election of 2000.

The black line is the estimated response of the break-even tax rates $\hat{\beta}$ from regression equation (7) to changes in the election probability of George W. Bush during the five months prior to Election Day in 2000; the black dashed lines are 95% Newey-West confidence bands. The blue lines show the population coefficients β^{pf} one should obtain under perfect foresight and assuming that the counter-factual path of tax rates under President Gore is fixed at $\tau_{2000} = 39.6\%$. Two scenarios for the path of future tax rates beyond 2011 are shown, one where the Bush tax cuts expire in 2011 as scheduled and one where they become permanent.

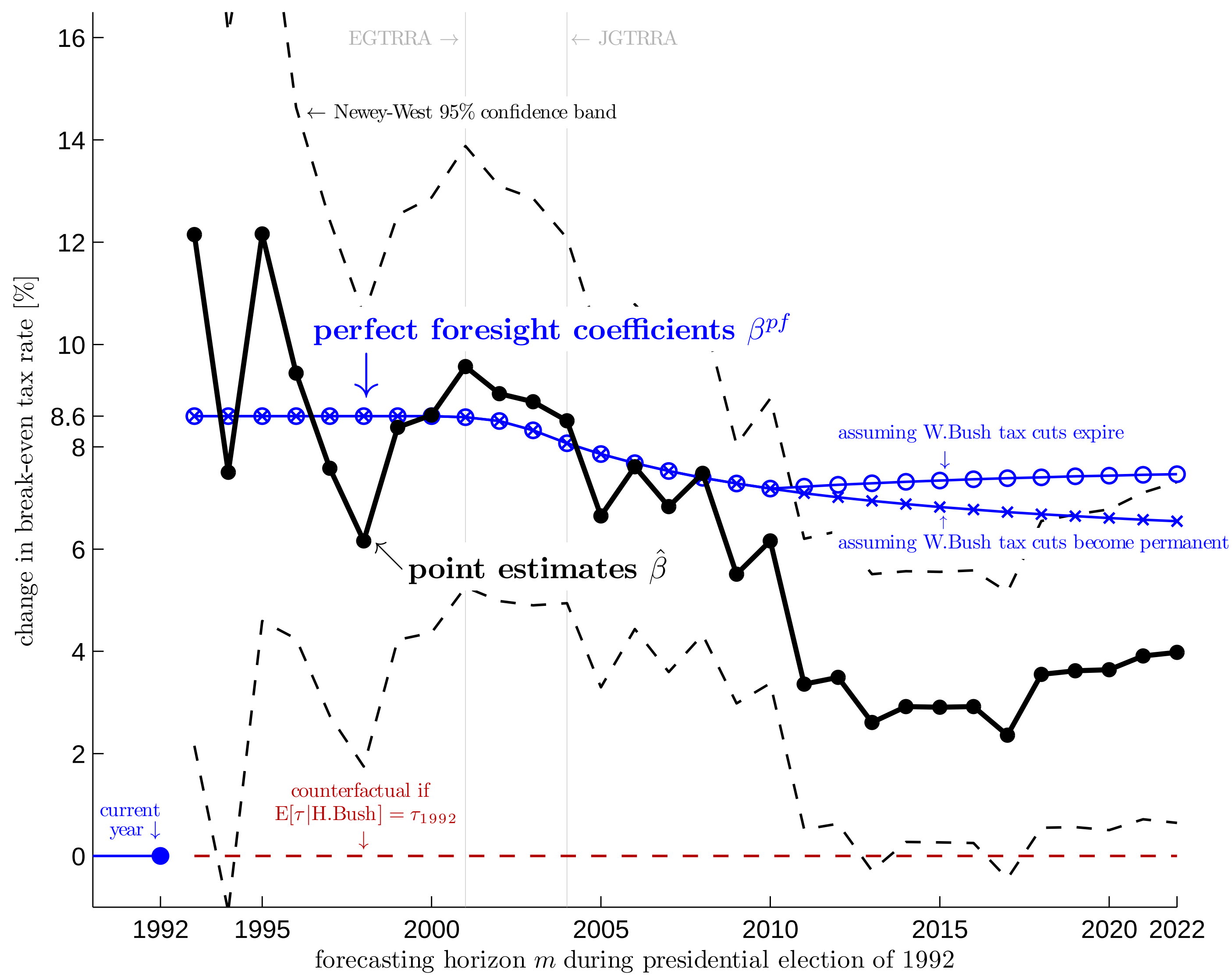


Figure 7: Path of Break-Even Tax Rates during presidential election of 1992.

The black line is the estimated response of the break-even tax rates $\hat{\beta}$ from regression equation (7) to changes in the election probability of Bill Clinton during the three months prior to Election Day in 1992; the black dashed lines are 95% Newey-West confidence bands. The blue lines show the population coefficients β^{pf} one should obtain under perfect foresight and assuming that the counter-factual path of tax rates under President H. Bush is fixed at $\tau_{1992} = 31\%$. Two scenarios for the path of future tax rates beyond 2011 are shown, one where the W. Bush tax cuts expire in 2011 as scheduled and one where they become permanent. The two vertical lines show the enactment dates of the tax reforms in 2001 and 2003, EGTRRA and JGTRRA respectively.

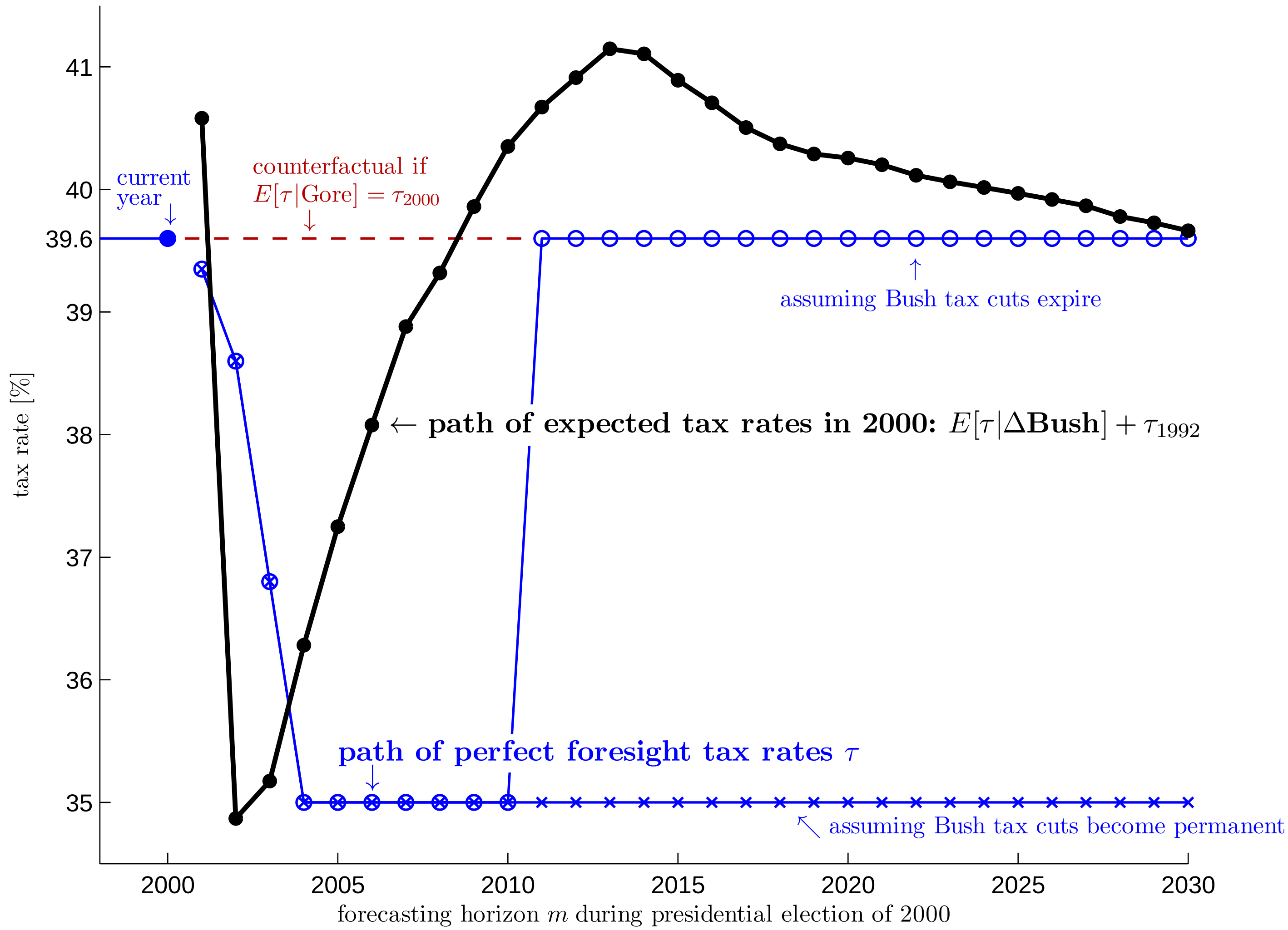


Figure 8: Path of Expected Tax Rates during presidential election of 2000.

The black line is the expected tax path recovered by inverting equation (8) with a ridge regression with optimal regularization parameter $\mu = 0.15$. The top rate in 2000 is added to the expected changes in the tax path to make it comparable to the ex-post realization of the tax path; see Figure 6 for the definition of the two blue lines.

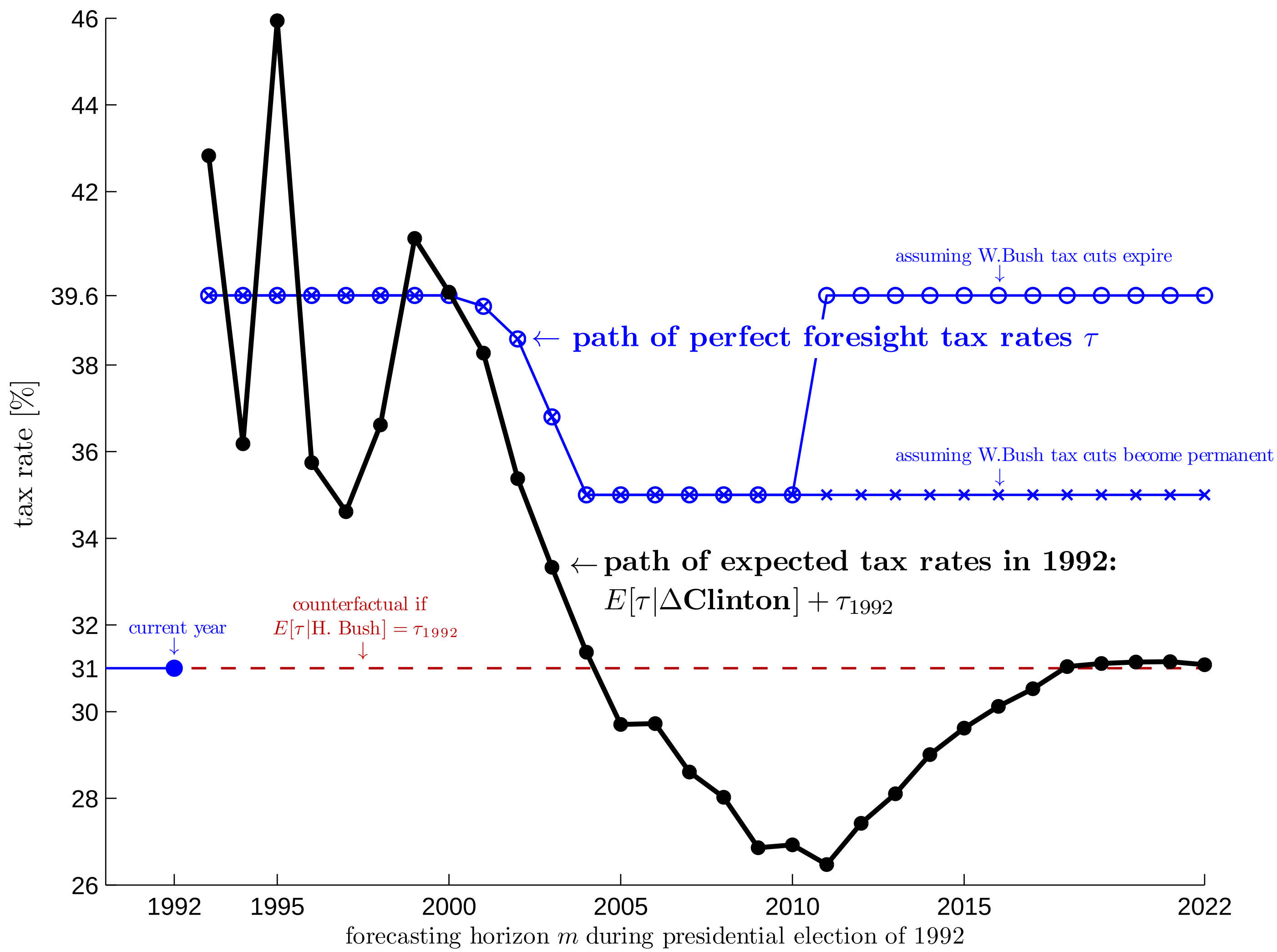


Figure 9: Path of Expected Tax Rates during presidential election of 1992.

The black line is the expected tax path recovered by inverting equation (8) with a ridge regression with optimal regularization parameter $\mu = 0.05$. The top rate in 1992 is added to the expected changes in the tax path to make it comparable to the ex-post realization of the tax path; see Figure 7 for the definition of the two blue lines.

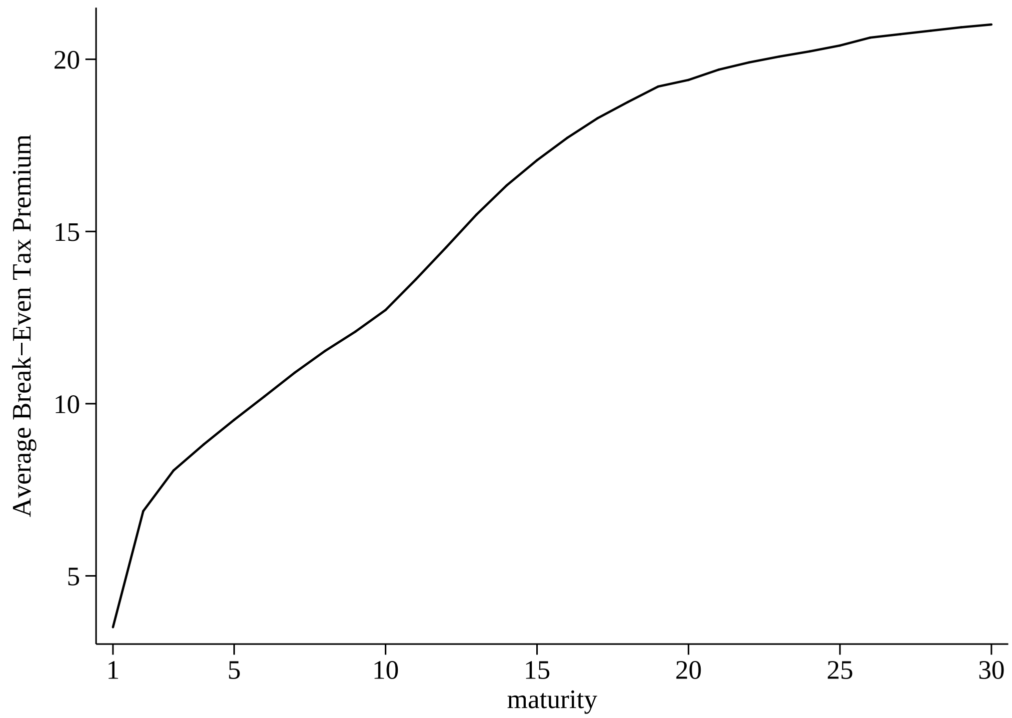


Figure 10: Average break-even tax premium $\mathbb{E}[\Lambda_t]$ as a function of the maturity; see equation (11).

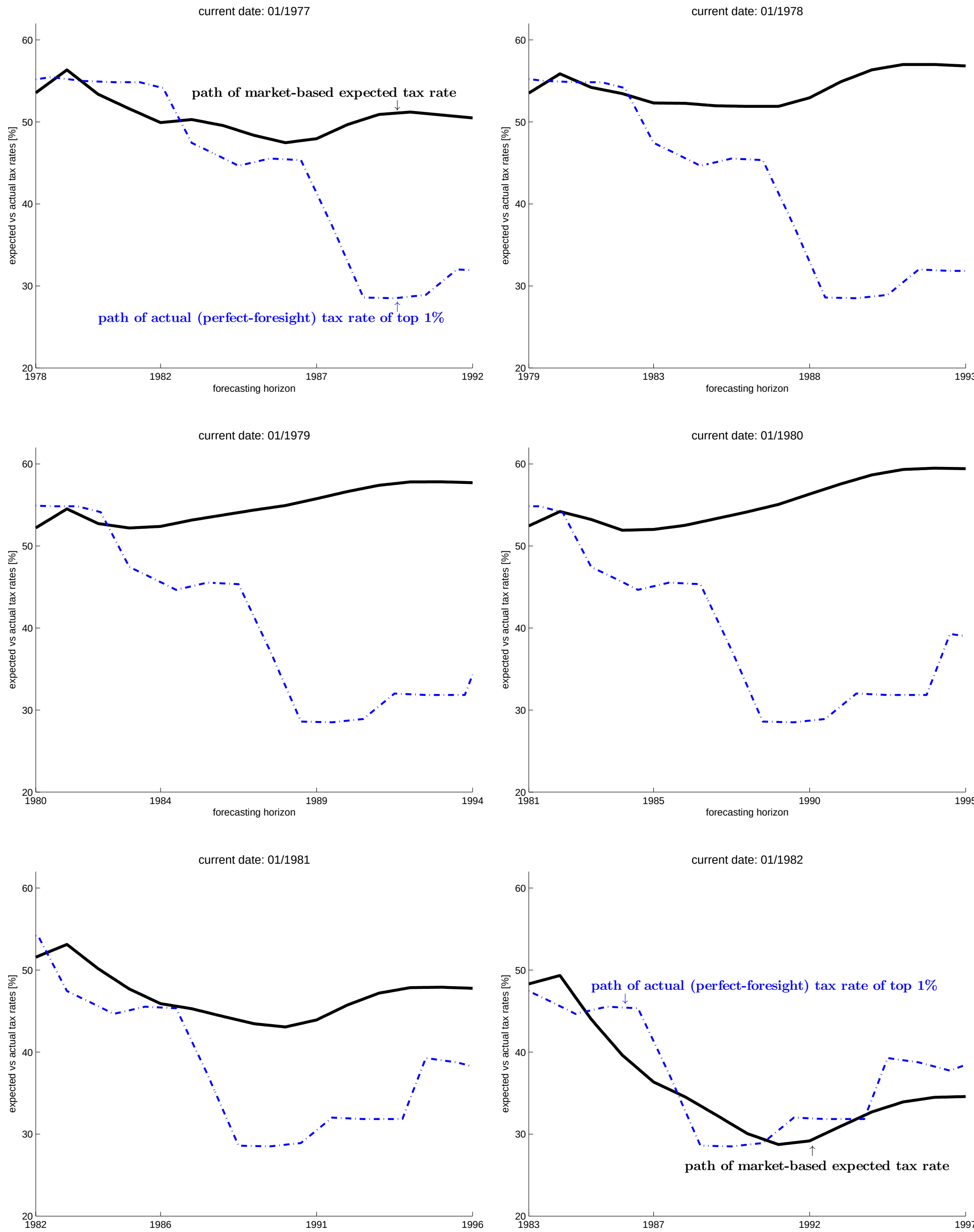
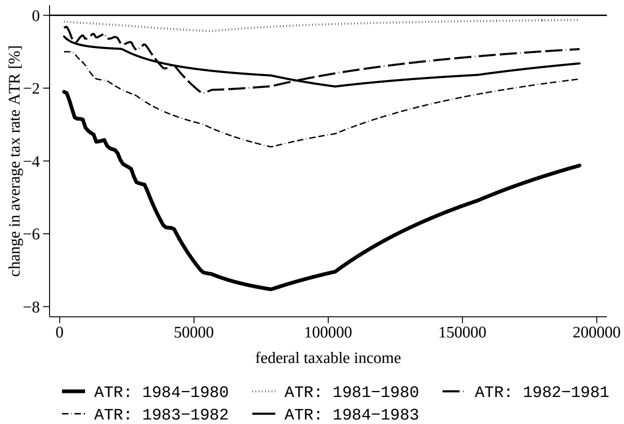
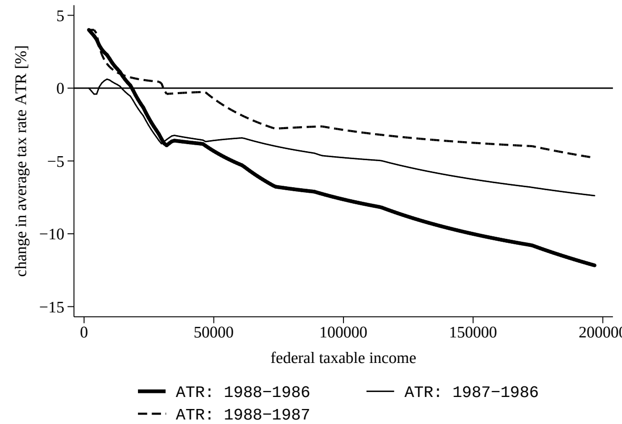


Figure 11: Anticipation of the Reagan Tax Cuts (ERTA 1981 and TRA 1986) between January 1977 and January 1982.

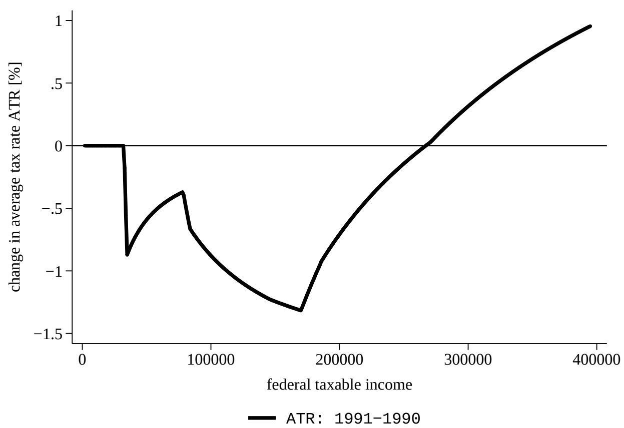
This figure shows the evolution of the path of expected tax rates between 1977 and 1982 in the run-up to the first Reagan tax cut (ERTA 1981). The dashed line, which represents the perfect-foresight tax path, is the marginal tax rate of the top 1% of the income distribution taken from Saez (2004). The bond market did not anticipate the Reagan tax cuts until the election year of 1980. However, the bond prices already incorporate the second Regan tax cut (TRA 1986) by the end of 1981. The web appendix of this paper – https://sites.google.com/site/lorenzkueng/ – contains a video of the evolution of $\mathbb{E}_t[\tau]$ from January 1977 to August 1982 that shows monthly changes in the path of expected tax rates.



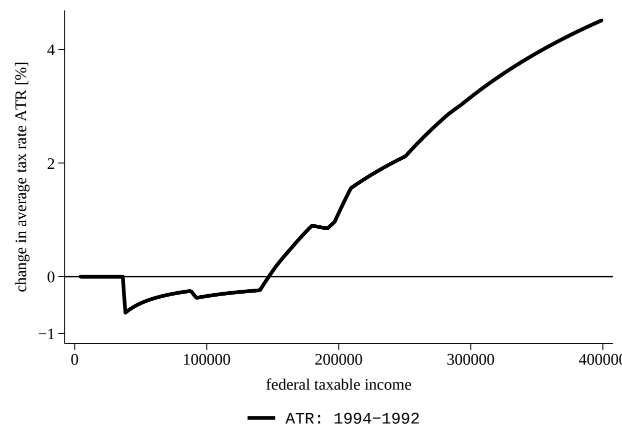
(a) ERTA 1981



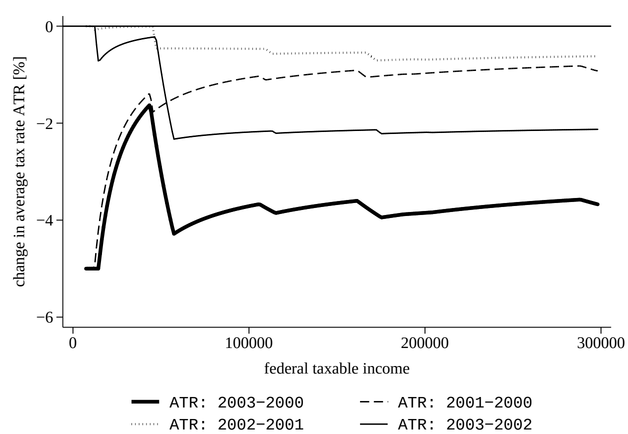
(b) TRA 1986



(c) OBRA 1990



(d) OBRA 1993



(e) EGTRRA 2001 and JGTRRA 2003

Figure 12: Change in the average tax rate caused by income tax reforms between 1980 and 2003.

All figures were generated with the TAXSIM calculator using an income distribution with $100 increments. The tax rates are calculated for married households filing jointly and having no children.

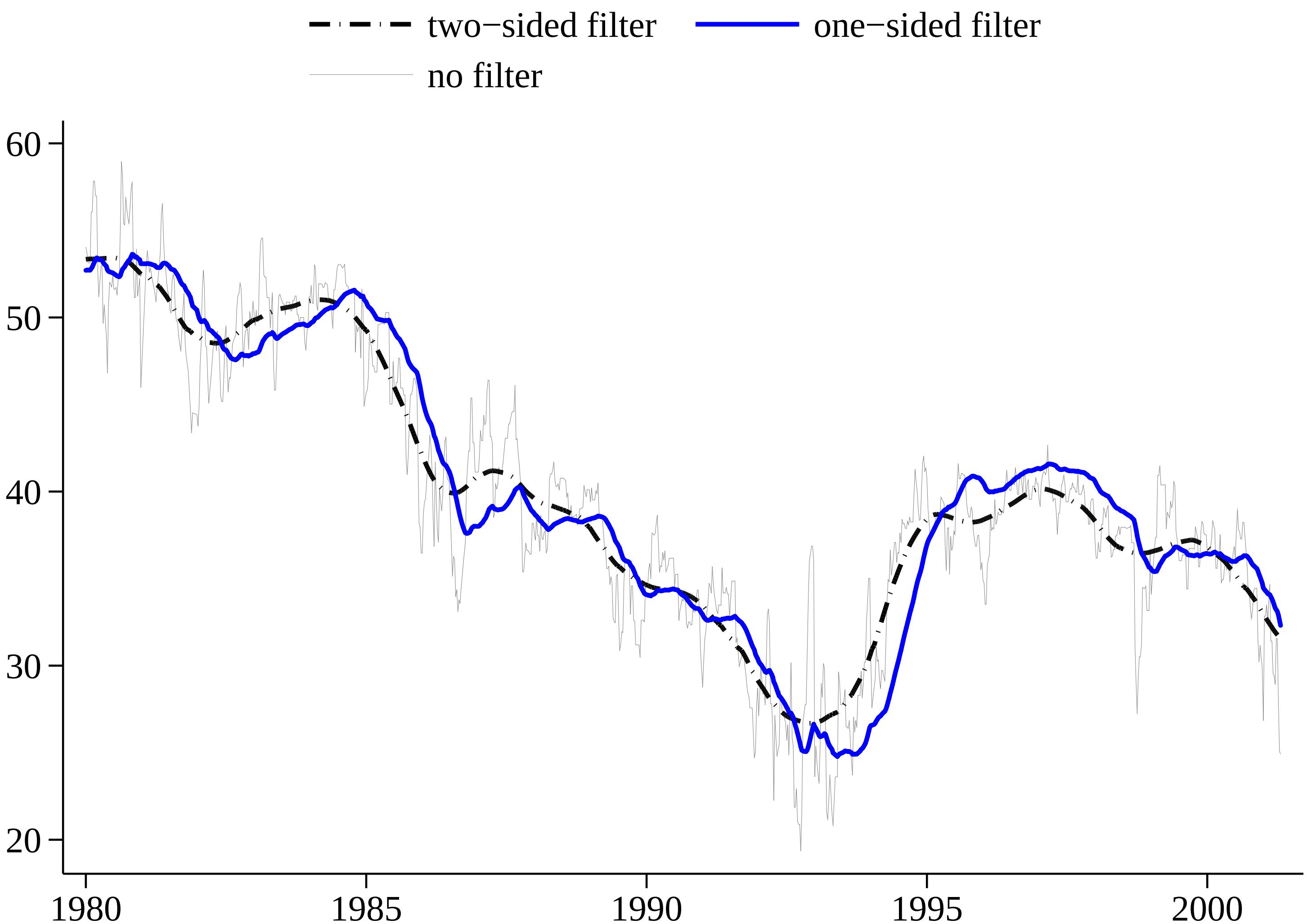


Figure A.1: Different filtering of the time series of 2-year break-even tax rates.

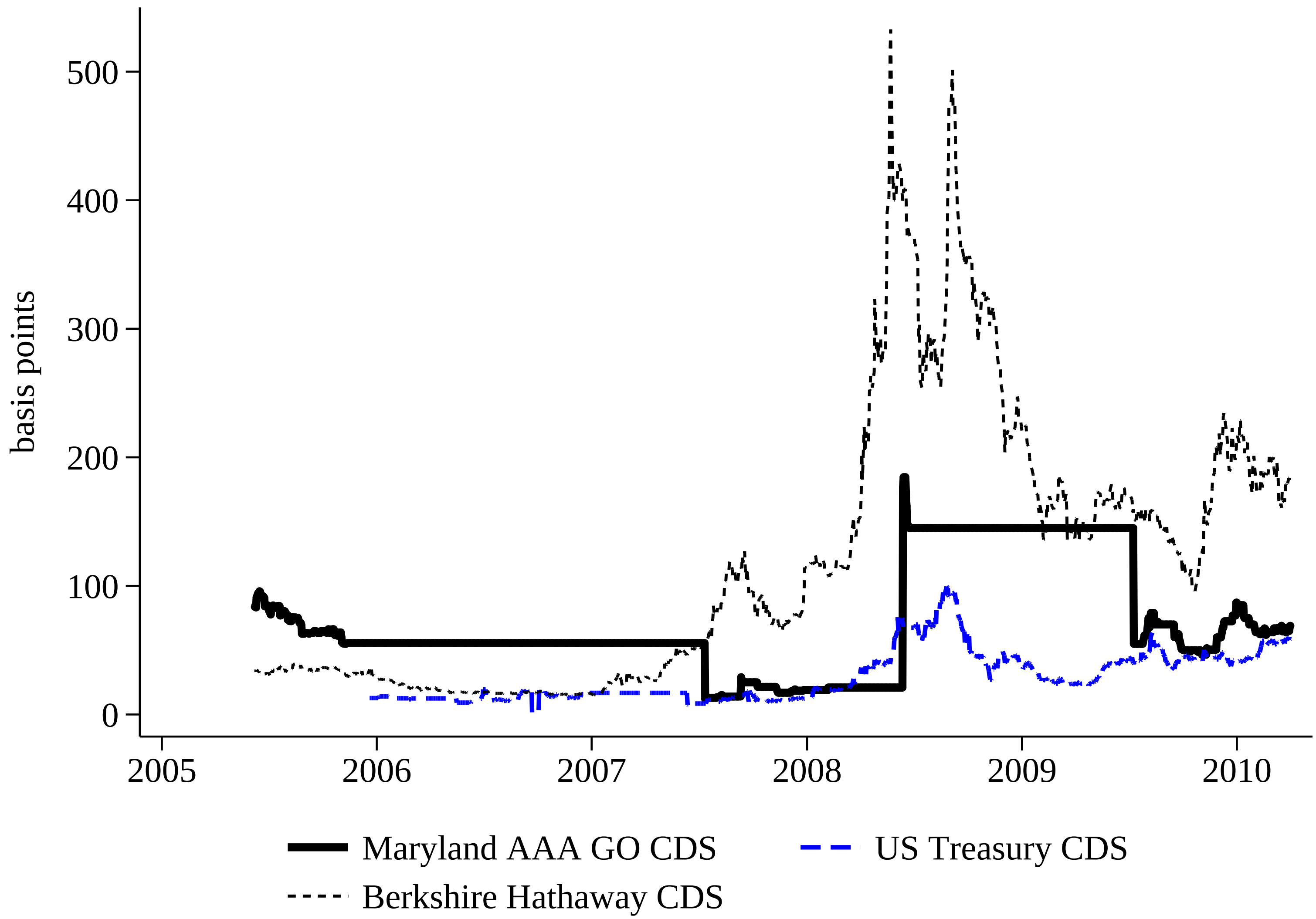


Figure A.2: Credit Default Swap (CDS) of 10-year Treasury, municipal, and corporate bonds.

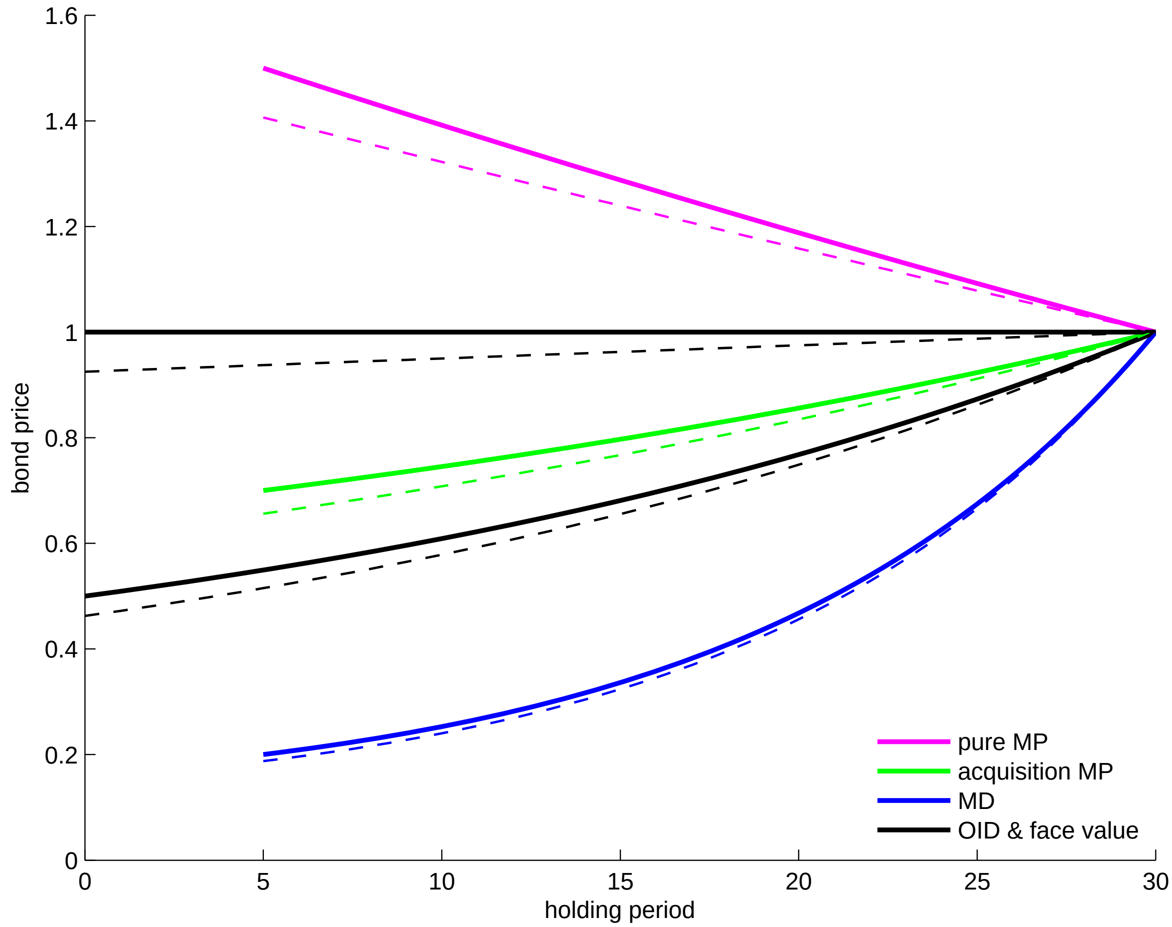


Figure A.3: Evolution of the tax basis of a hypothetical 30-year bond purchased five years after issue.

The two black lines are the adjusted issue prices, with and without OID. The two lines define three regions: (1) Pure premium bonds are purchased at a price above face value – the purple line –, (2) acquisition premium bonds are purchased at a price between the face value and the adjusted issue price – the green line –, and (3) market discount bonds are purchased at a price below the adjusted issue price – the blue line. The dashed lines are the corresponding DeMinimis bounds.