Online Appendix to

"Tax News: The Response of Household Spending to Changes in Expected Taxes"

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A The Marginal Tax Rate of the Marginal Investor: Data

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 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).

B Bond Defaults

B.1 The Markets for Treasury and Municipal Bonds

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.[1]

B.2 Historical Bond Default Rates

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 in-sample default rate than AAA rated corporate bonds. The two rating scales are therefore not comparable.

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

C Discussion on the Tax Reforms Used in the Sample

C.1 Average Tax Rate Changes

Figure A2 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 these 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, panel (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. Panel (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 A2 suggests. This additional variation comes from the fact that different households have different family characteristics, such as the number of children and dependents or the marital status, as well as different deductions, exemptions, and tax credits. 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 year-by-month time fixed effects.

C.2 Changes in the Tax Base

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 analyze changes in the tax base over the sample period more closely. Most tax reforms since 1980 affected the income tax base only modestly, 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 base of the corporate tax 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 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.[2] Nevertheless, since Auerbach and

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

Slemrod conclude that “the effects of the [Tax Reform] Act on saving 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 in the robustness section of the main paper, in particular looking at a subsample that includes only observations after the implementation of the TRA 1986.

D Robust Inverse

The solution to the constrained least squares problem of the inverse mapping $\beta = \mathbb{E}[W_t](\mathbb{E}[\tau|\text{Bush}] - \mathbb{E}[\tau|\text{Gore}])$ is

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

∂ 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 $\tilde{\theta}_t = W_t\mathbb{E}_t\tau - \Lambda_t$ is

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

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

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

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

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

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

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

$$\mathbb{E}_t\tau = \sum_{m=1}^{M} \underbrace{\frac{\gamma_m^2}{\gamma_m^2+\mu}}_{\text{filter } f_m} \underbrace{\frac{u_m'(\tilde{\theta}_t+\mathbb{E}[\Lambda_t])}{\pi_m} y_m}_{\text{direct inverse}} , \tag{3}$$

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 (3) 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 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.

References

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

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

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.

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.

Table A1. Historical bond default rates 1970-2006 (in %)

	Municipal Bonds		Corporate Bonds	
Rating categories	Moody's	S&P	Moody's	S&P
Aaa / AAA	0	0	0.52	0.60
Aa / AA	0.06	0	0.52	1.50
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	0.20	2.09	4.14
Non-Investment Grade	4.29	7.37	31.37	42.35
All	0.10	0.29	9.70	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. The data were accessed on 4/7/2010 via http://frwebgate.access.gpo.gov.

Table A2. Personal state income taxes on interest income, 1977-2010

Bond type:	In-state muni	Out-of-state muni	Treasury	Corporate	Max. tax rate	Period of max. tax
Alabama	exempt	taxable	exempt	taxable	3.65	1988-90
Alaska		*no personal income tax 1979-2010*			14.5	1977-78
Arkansas	exempt	taxable	exempt	taxable	7.43	2003-04
Arizona	exempt	taxable	exempt	taxable	6.74	1992-93
California	exempt	taxable	exempt	taxable	11.66	1991-95
Colorado	exempt	taxable	exempt	taxable	5.15	1992-98
Connecticut*	exempt	taxable	exempt	taxable	5	2003-10
Delaware	exempt	taxable	exempt	taxable	19.8	1977-78
Florida		*no personal income tax 1977-2010*				
Georgia	exempt	taxable	exempt	taxable	6	1977-86
Hawaii	exempt	taxable	exempt	taxable	10.01	2009
Idaho	exempt	taxable	exempt	taxable	8.28	1991-99
Illinois	taxable	taxable	exempt	taxable	3	1990-2010
Indiana	exempt	exempt	exempt	taxable	3.4	1988-2010
Iowa	taxable	taxable	exempt	taxable	7.39	1988-90
Kansas	exempt	taxable	exempt	taxable	6.91	1983-84
Kentucky	exempt	taxable	exempt	taxable	6.18	1991-2005
Louisiana	exempt	taxable	exempt	taxable	4.14	1988-90
Maine	exempt	taxable	exempt	taxable	10.19	1991-92
Maryland	exempt	taxable	exempt	taxable	7.5	1977-78
Massachusetts*	exempt	taxable	exempt	taxable	6.25	1991
Michigan	exempt	taxable	exempt	taxable	6.35	1983
Minnesota*	exempt	taxable	exempt	taxable	9.65	1983
Mississippi	exempt	taxable	exempt	taxable	5.07	1992-2005
Missouri	exempt	taxable	exempt	taxable	6.07	1994-2005
Montana*	exempt	taxable	exempt	taxable	9.02	1988
Nebraska	exempt	taxable	exempt	taxable	11.19	1977, 1979
Nevada		*no personal income tax 1977-2010*				
New Hampshire		*no personal income tax 1977-2010*				
New Jersey*	exempt	taxable	exempt	taxable	10.75	2009
New Mexico	exempt	taxable	exempt	taxable	8.26	1977-80
New York*	exempt	taxable	exempt	taxable	15	1977-78
North Carolina	exempt	taxable	exempt	taxable	8.5	2001-05
North Dakota	exempt	taxable	exempt	taxable	5.41	1993-2005
Ohio	exempt	exempt	exempt	taxable	9.03	1984
Oklahoma	exempt	taxable	exempt	taxable	6.65	1991-92
Oregon*	exempt	taxable	exempt	taxable	13	1977-78
Pennsylvania*	exempt	exempt	exempt	taxable	3.07	2004-10
Rhode Island	exempt	taxable	exempt	taxable	11.79	1983
South Carolina	exempt	taxable	exempt	taxable	7.08	1991-2005
South Dakota		*no personal income tax 1977-2010*				
Tennessee		*no personal income tax 1977-2010*				
Texas		*no personal income tax 1977-2010*				
Utah	taxable	taxable	exempt	taxable	7.75	1987
Vermont	exempt	taxable	exempt	taxable	14.88	1977-78
Virginia	exempt	taxable	exempt	taxable	5.82	1991-2005
Washington		*no personal income tax 1977-2010*				
Washington D.C.	exempt	taxable	exempt	taxable	11	1982-86
West Virginia*	exempt	taxable	exempt	taxable	12.7	1984
Wisconsin*	taxable	taxable	exempt	taxable	11	1983
Wyoming		*no personal income tax 1977-2010*				

Notes: The tax status is an update of Temel, Judy W., *The Fundamentals of Municipal Bonds* , 5 ed., John Wiley & Sons, 2001. Maximum state income tax rates 1977-2010 are based on the NBER TAXSIM calculator.

* 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.

Figure A1 – Average break-even tax premium $\mathbb{E}[\Lambda_t]$ as a function of the maturity.

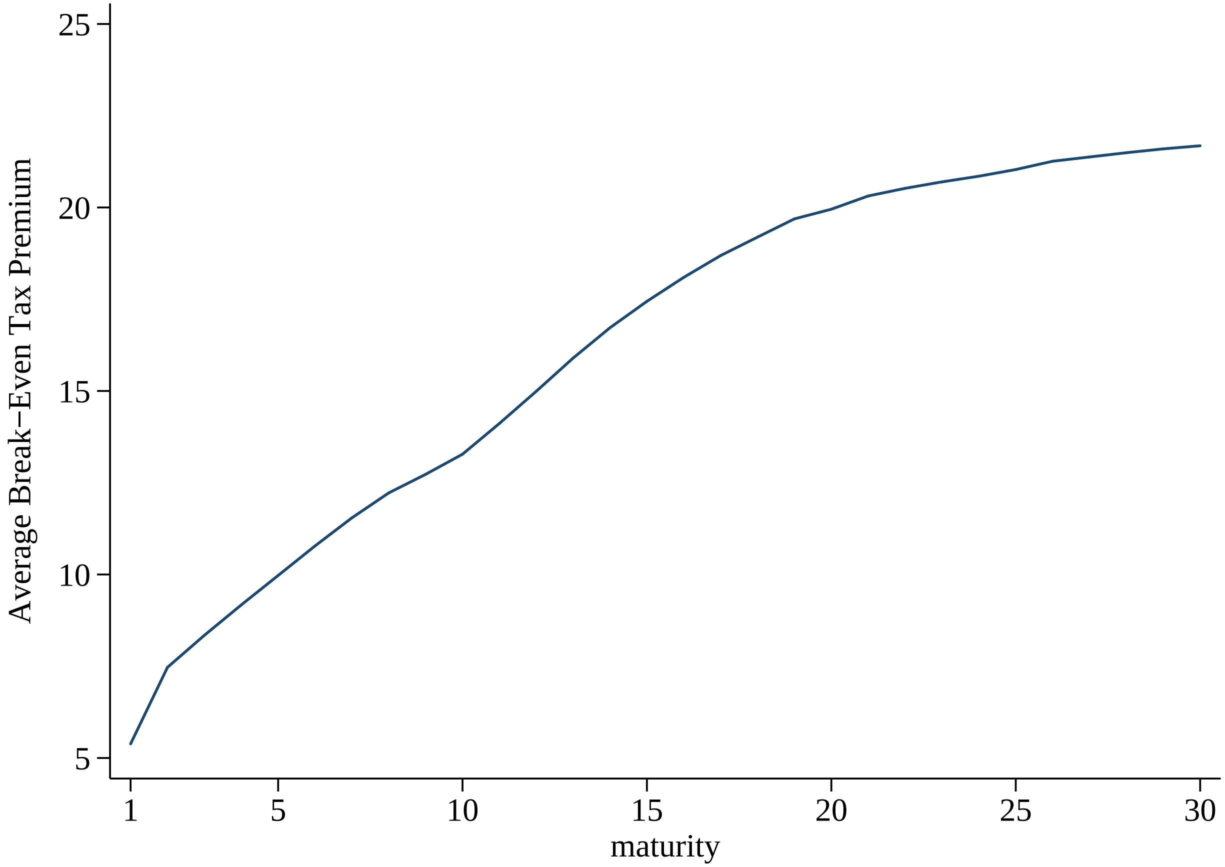
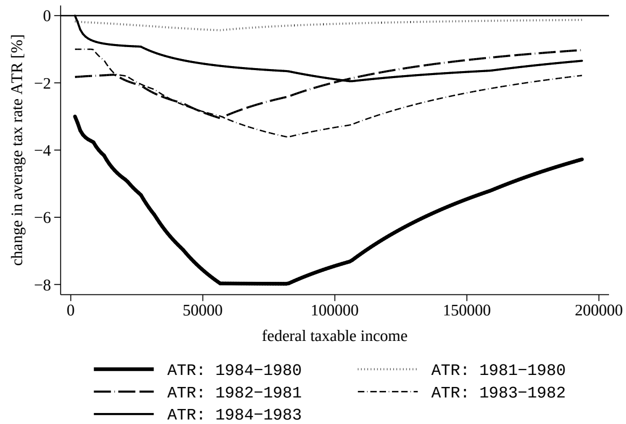
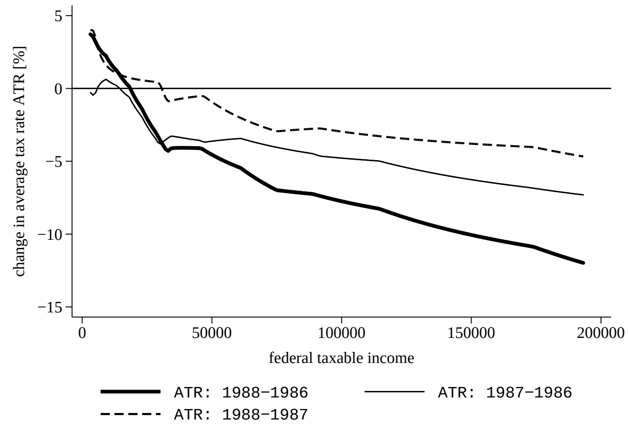


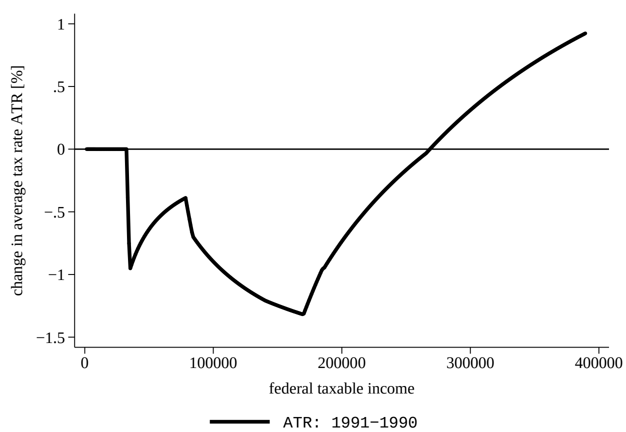
Figure A2 – Change in the average tax rate caused by income tax reforms between 1980 and 2003.



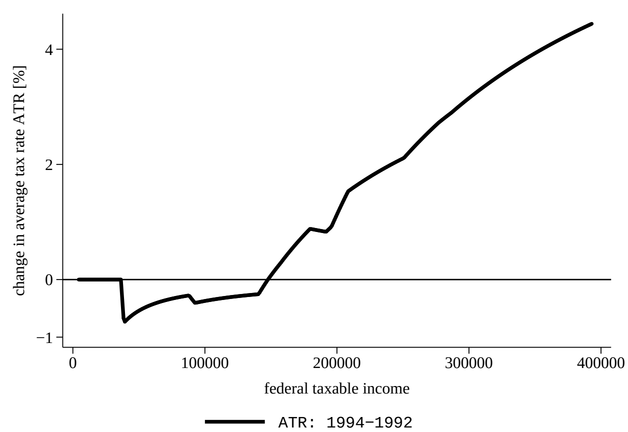
(a) ERTA 1981



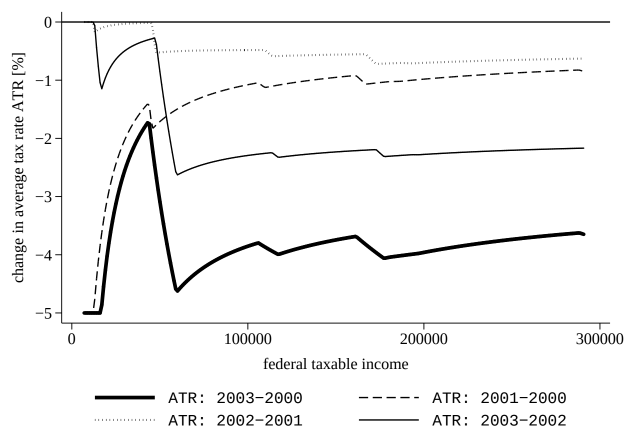
(b) TRA 1986



(c) OBRA 1990



(d) OBRA 1993



(e) EGTRRA 2001 and JGTRRA 2003

Notes: 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.