
Effective Tax Functions for the US Individual Income Tax: 1966-89

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1. Introduction

This paper builds on our earlier research on ways to summarize complex income and tax information through the use of effective tax functions. In Gouveia and Strauss (1994), we analyzed publicly available IRS Statistics of Income cross sections of tax returns from 1979 to 1989. Here we expand the years covered and examine all the annual cross sections of returns from 1966 through 1989. Also, we examine systematically the longitudinal aspects of our annual summaries of the federal individual income tax.

The analysis conducted for each year of data follows the same procedure. The initial step is the construction of the variables “Economic Income” and “Tax liability”. The information in each data set was explored so as to have the most comprehensive measure of income possible, and one that is not based on imputations or assumptions. Once the variables are constructed we estimate the statistical relationship between income and taxes, i.e. the effective tax functions. The functional form used for the econometric estimates is inspired by the theory of “incentive compatible equal sacrifice”¹. The departure point is a constant relative risk aversion utility function that generates a non-linear regression of the form given by equation (1) below,

$$atr = b - b(sy^p + 1)^{-1/p} + \varepsilon \quad (1)$$

where atr is the average tax rate, y is economic income, b , s , and p are parameters, and ε is the stochastic component of the regression.

The parameters b and p have economic interpretations. The expression $p+1$ is the constant relative risk aversion coefficient and $1/(p+1)$ is the inter-temporal elasticity of substitution assuming preferences take the form of additive utility functions. The parameter b is the asymptotic marginal income tax rate. In classical equal sacrifice theory, this asymptotic marginal rate is 100% when utility is isoelastic. We can loosely interpret b as the weight given to incentives in the design of the effective tax function. The lower b is the more incentives matter.

Once (1) is estimated, we can extract some information from the parameters. First, we can graph the annual effective tax functions, and examine visually how they evolve over time. Second, we can focus on a by-product of the regression, the measure of fit, R^2 . We have argued elsewhere that this measure can be interpreted as a “quick” index of classical horizontal inequity (HI). The next step in the analysis of annual results is to use the regression and the data to compute a set of indexes. This set includes the simple and the income weighted average effective marginal tax rates, a progressivity index, and the aggregate fiscal revenue income elasticity.

The fourth step takes advantage of the fact that for each of these dimensions we have a time series of measures. This allows us to examine systematically how they these measures evolve over time. This examination will focus both on the statistical properties of the time series and on the fiscal policy events' effect on the measures.

2. The results from the regression estimates

Equation (1) is estimated by Non-linear Least Squares, using the sample strata weights to correct for heteroskedasticity. Table 1 shows the main results. Standard errors are not shown to avoid information overload, but all parameters are significant at the 1% confidence level or better.

Figure 1 shows the evolution of the parameter b , and compares it with the maximum statutory marginal tax rate each year. As one would expect, effective maximum marginal tax rates are lower than their statutory counterparts. The asymptotic marginal rates do not follow a time profile in parallel with the statutory rates.

Table 1: Estimates of Regression Parameters

Years	P	S	B	R ²
1966	0.619	0.046	0.426	0.401
1967	0.591	0.044	0.446	0.395
1968	0.609	0.055	0.430	0.396
1969	0.633	0.055	0.450	0.368
1970	0.850	0.069	0.294	0.450
1971	0.980	0.060	0.263	0.527
1972	1.057	0.055	0.250	0.531
1973	0.957	0.055	0.271	0.442
1974	0.773	0.047	0.349	0.397
1975	0.843	0.039	0.354	0.350
1976	1.054	0.034	0.301	0.579
1977	0.909	0.030	0.372	0.371
1978	0.909	0.030	0.372	0.371
1979	0.817	0.022	0.479	0.558
1980	0.829	0.023	0.455	0.558
1981	0.938	0.031	0.331	0.499
1982	0.918	0.031	0.298	0.492
1983	0.89	0.033	0.262	0.445
1984	0.899	0.029	0.262	0.373
1985	0.8	0.031	0.275	0.386
1986	0.887	0.032	0.236	0.327
1987	0.726	0.023	0.342	0.358
1988	0.752	0.029	0.276	0.372
1989	0.768	0.031	0.258	0.255

One of the possibilities offered by our approach is that we can plot the effective average tax function and see how it changes over time. One advantage of plotting the effective tax functions is that, in an informal way, such an exercise allows a separation of the shape of the tax function from the characteristics of the income distribution.

However, there is a previous issue that must be addressed. All estimates of tax functions were based on cross sections of data in which taxes and incomes were measured at current prices.

This means that in order to compare graphs pertaining to different years one must perform a rescaling of the income data.² Naturally, one can deflate all income by the CPI and get a series of graphs where all incomes are measured in real income for a standard reference year. However, given that real income has been growing, one can argue that it may be incorrect to compare a given level of real income in 1966 with the same real income in 1989. For example the mean real income in 1966 would be well below the mean in 1989 (the ratio would be 63.7%). In other words, there is a point of view where comparability of taxes across years requires that the location of the income distribution also matters. A simple way to rescale incomes that takes location into account is to use nominal GDP per capita, instead of the CPI, to generate the series of rescaling coefficients. In this case, average incomes in all years all get mapped into 1989 mean income. Figures 2 through 8 show the essential results. Figures 2 to Figure 7 use the CPI. Figure 8 uses nominal per capita GDP.

Figures 2 through 8.

From 1966 to 1969 average rates for all incomes increased. Average rates went down from 1969 to 71, but not exactly back to where they were in 1966, since the function became more concave, decreasing average rates for the bottom and the top of the income distribution and increasing them for the middle income levels. From 1971 to 1979 there was an impressive period of sustained increase in overall average tax rates. This is remarkable because one should expect that tax reduction measures such as the Tax Reduction Act of 1975, the Tax Reduction and Simplification Act of 1977 and the Revenue Act of 1978 would have had the opposite effect (see Pechman pp. 40-41). From 1979 to 1981 the effective tax function rotated, increasing for low and middle incomes and decreasing for high incomes. From 1981 to 1983, there was a large overall reduction of average tax rates, clearly attributable to the Economic Recovery Tax Act of 1981 and its phase-in effects. Between 1983 and 1985 the function seems to be stable. From 1985 to 1987

there was a small rate decrease for low and middle incomes and a small rate increase for high incomes, a result which is probably due to the Tax Reform Act of 1986 and the non-exclusion of capital gains in taxable income.

If one chooses to use relative incomes to compare the tax functions over time, the period by period qualitative changes are much the same as described before. However, the quantitative changes are not the same. Figures 2 and 8 show that a comparison between 1966 and 1989 reveals a qualitative difference. Normalizing by the CPI, the effective tax function in 1989 is very similar to the 1966 tax function for incomes below \$90,000. The 1989 rates are lower for larger incomes. When one uses the evolution of average nominal incomes as the deflator, the result is that in 1989 tax rates for middle incomes are clearly higher than those in 1966, whereas they are lower for higher incomes and about the same for low incomes.

Under the hypothesis used to specify the equal sacrifice model that generated the functional form, the series of parameter estimates for p provides an indirect way to estimate the the inter-temporal elasticity of substitution given by $1/(1+p)$. Figure 9 shows the results.

(Figure 9 here)

The estimates show an elasticity of substitution below one and not entirely out of line with other estimates in the literature coming from the analysis of consumption or asset pricing. They are, for example, very close to Hall (1988).

A by-product of the annual estimation of the effective tax function regression is the series of R^2 's in Table 1. Since the R^2 measures the extent to which average taxes are dispersed around the central values given by the regression, i.e. the extent to which equals are treated unequally³, it is one way we can capture by a simple index the amount of Horizontal Inequity (HI) in the tax system. Naturally, it is not a perfect measure because the distance between equation (1) and the perfectly correct functional form, whatever it may be, also influences it. However, Gouveia and

Strauss (1994) present some evidence about the performance of equation (1) as a functional form, and, based on that evidence, we reassert the interest of the R^2 as a useful and intuitive HI index.

3. Characterizing the Individual Income Tax with Regression Based Indices

The estimates of the effective tax function parameters allow us to calculate marginal effective taxes for each level of income and to compute the average marginal tax for all tax returns. This average can be seen as an index of the disincentives generated by the tax system. Also, it is worthwhile to compute a simple average and an income weighted average. The first may be better suited to discuss incentives in matters of behavior where all taxpayers are similar, as when we consider the distribution of time endowments and labor supply behavior. On the other hand, income weighted rates may be helpful to understand behavior when the marginal tax on the last dollar matters and dollar sizes differ substantially as is the case with saving or portfolio choices. Figure 9 displays the time series of both average marginal tax rates.

The effective tax function can also be used to present measures of progressivity. One classical measure of local progressivity first proposed by Musgrave and Thin (1949) is the elasticity of after tax income with respect to before tax income, also known as residual income elasticity. The lower the elasticity, the more progressive the tax system is. Table 2 shows the average of the residual income elasticities for all years. As one would expect, the system is always progressive since the elasticities are always under one.

Table 2: Tax System Indexes, 1966-1989

Year	Simple Marginal Rate	Weighted Marginal Rate	Progressivity Index	Revenue Elasticity
1966	0.126	0.169	0.953	1.439
1967	0.128	0.172	0.954	1.423
1968	0.150	0.199	0.946	1.400
1969	0.163	0.215	0.940	1.411
1970	0.146	0.187	0.942	1.444
1971	0.135	0.176	0.944	1.468
1972	0.134	0.175	0.944	1.470
1973	0.138	0.182	0.944	1.462
1974	0.144	0.194	0.943	1.456
1975	0.142	0.196	0.941	1.490
1976	0.142	0.196	0.938	1.512
1977	0.143	0.207	0.937	1.537
1978	0.149	0.212	0.935	1.510
1979	0.167	0.222	0.928	1.533
1980	0.175	0.231	0.925	1.515
1981	0.175	0.223	0.928	1.447
1982	0.158	0.202	0.936	1.430
1983	0.142	0.182	0.945	1.403
1984	0.134	0.177	0.947	1.412
1985	0.134	0.176	0.949	1.394
1986	0.133	0.173	0.95	1.349
1987	0.132	0.184	0.949	1.416
1988	0.13	0.177	0.952	1.357
1989	0.131	0.174	0.953	1.349

The last index we will consider is the income elasticity of the aggregate fiscal revenue. The revenue elasticity tells us what the percentage increase in total revenue generated by that 1% income change will be. Since the system is progressive, the elasticity is higher than one, but its size changes due to statutory changes, behavioral adjustments to tax laws, etc.. This elasticity is relevant particularly when one takes into account that prior to TRA86, when the parameters of the tax system were indexed, one force driving revenue was the inflation rate. A 1% unexpected (or

not anticipated by the legislator) increase in inflation generates a larger than 1% in tax revenues and thus an increase in the real tax burden.

5. Times series Analysis of the Indexes

We now turn to take advantage of the fact that we have nearly a quarter century of consistently measured evidence on the nature of the federal effective tax function. Here we seek to go beyond measurement and search for explanations. While the sections before were concerned with establishing facts and measuring some important characteristics of the individual income tax system, in this section we ask what determines these characteristics over time.

Naturally, the answer to this question involves tax law. But that is not enough, both because tax legislation is endogenous, if we think about the issues in a political economy context, and because, even with a fixed legislative environment, taxpayers may change behavior as they learn and innovate tax avoidance techniques.

A different but not opposite question about the patterns measured over time involves the nature of the dynamics we observe in the data. Are there natural long-run levels for the indices studied, in which case we should observe in the data some sort of “reversion to the standard” process? In time-series parlance, is the best estimate of tomorrow’s effective tax function simply this year’s effective tax function plus or minus a stochastic term? Is it the case that we have hysteresis in the tax parameters’ processes and every shock or every change permanently impacts on the variable? It is immediate that the types of political economy explanations which we utilize must be, at the outset, consistent with the dynamic nature of the data.

Assume a simple model where macroeconomic variables act as shifters of the political equilibrium. We ran OLS regressions (not shown) where the indices are explained by a set of aggregate variables (inflation, the growth rate of real GDP, and unemployment), a dummy for the party in the White House, and a time trend. The only variable that seems to have a systematic, statistically significant effect on any of the endogenous variables is the inflation rate. The

diagnostic statistics for the residuals and the results of regressions with lagged endogenous variables raise the suspicion that the endogenous variables may have a non-trivial stochastic nature, that is, that these variables may have unit roots.

Table 3: Augmented Dickey-Fuller Tests for Unit Roots

Series	Test Statistics	P-values	Number of lags
Regression Parameter p	-3.452	0.045	4
Regression parameter s	-3.185	0.088	5
Regression parameter b	-2.709	0.232	2
GDP growth rate	-3.757	0.019	3
Inflation	-1.146	0.921	4
Unemployment	-0.955	0.950	3
Marginal Tax Rate	-1.404	0.860	3
Weighted Marginal Tax Rate	-1.351	0.875	3
Progressivity	-1.307	0.886	3
Revenue Elasticity	-1.405	0.860	2
Horizontal Inequity	-1.533	0.818	2

Table 3 shows the results of Augmented Dickey Fuller tests on the regression parameters, the tax system indexes, and on a set of explanatory variables. Such tests tell us where the data are integrated or not. Table 3 shows that we cannot reject the hypothesis that all variables have unit roots with the exception of the per capita GDP real growth rate and the regression parameter p . The parameter p is a preference structural parameter (it is the intertemporal elasticity of substitution up to a monotonic transformation). The fact that the p series is stationary can be seen as a sign of stability in preferences, a property we would expect a structural parameter to have. In that light, the stationarity of p is evidence that the modeling approach taken in this paper is sound.

The fact that other variables have unit roots means that the OLS regression results for inflation are not to be trusted. Inflation *appears* to be statistically significant; however, since it has a unit root that generates spuriously high significance levels for the OLS coefficients. In order to test if there is indeed a significant relationship *between* the tax system indices and the inflation rate, we conducted Engle-Granger tests of co-integration. The results are displayed in Table 4.

Table 4: Engle-Granger Cointegration Tests

Variable	Inflation cointegrating coefficient	Test Statistic	P-value	Number of lags
Marginal Tax Rate	-0.359	-2.547	0.494	5
Weighted Marginal Tax Rate	-0.492	-1.943	0.795	5
Progressivity	0.218	-1.462	0.928	5
Revenue Elasticity	-1.127	-1.946	0.793	3
Horizontal Inequity	-1.052	-2.514	0.512	2

The tests do not reject the null hypothesis of no-cointegration, confirming that the statistical significance of the relationship between inflation and the tax system indices in Table 3 had a spurious nature. Similar results hold for the unemployment rate. Also, although we do not present the results, we have that there is no co-integrating vector for any of the indices and the pair inflation and unemployment.

These results force us to see the evolution of the tax system indices as one where all changes have a permanent character. They also lead us to think about statutory tax changes as shocks to the vector of indices. In a loose sense this means that a tax reform can be thought of as a “significant residual” that gets incorporated in the variable in a permanent way.

The unit root results also imply that the most fruitful way to statistically explain the indices is to focus on the first differences of the variables. While we find that attempts to explain tax system indices over time flounder on the shoals of co-integration, we can also explore whether *changes* in tax system indices over time can be explained in a meaningful way by major tax reform matters. That is, by taking first *differences* in the tax system indices, we can free the time series of integration (i.e. render the series stationary). Then, we can test various major tax reform regimes to ascertain if, in fact, the political efforts invested in rewriting the Internal Revenue Code led to measurable differences in, say, effective tax function parameters as well as others found in Table 1.

Figures 10 and 11 show the time series of the first differences for the regression-based indices.⁴

Figures 10 and 11 here

Visual inspection of these changes reveals that there are a few key periods for the evolution of the indexes, but that these periods are not always the same across indices. For the marginal tax rates and the progressivity index, there are two periods where the changes in each variable are much larger than the respective sample standard deviation. The first period is 1968-1970, where all three indices went from large positive changes to large negative changes, an observation consistent with the effective tax functions graphs seen earlier. The 1968 values could be the result of the Revenue and Expenditure Control Act of 1968 and the Vietnam War surcharges. The changes are then positive and large in 1979, most likely due to the unexpected inflation shock of the second oil crises. Finally, the changes are large and negative from 1981 to 1983, a result most likely due to the ERTA 81. Interestingly, there do not seem to be substantial effects of TRA 86.

For the income elasticity of fiscal revenue we find that the key periods are different. There is a large shock in 1981, ERTA again, but there is a large positive followed by a large negative shock in 1987 and 1988, no doubt a sequel to TRA 86. While apparently TRA 86 had a minute impact on average marginal tax rates it did have a large impact on the revenue elasticity. While it is tempting to interpret the positive shock of 1987 as the result of the base broadening of TRA 86, the immediate drop in 1988 is not as easy to explain, except to say that the 1987 data may have been very much influenced by temporary effects.

Finally, in terms of changes in the Horizontal Inequity index, we find that the two main shocks occurred in 1976-77 and in 1979. The 1979 result could again be interpreted as saying that the inflationary shock of that year caught everybody by surprise and that somehow neutralize the impact of tax avoidance practices that may drive a large part of the measured HI in the tax system.

6. Summary and Conclusions

We have sought in this paper to extend both in terms of data and inference methodology our earlier work characterizing the federal tax system through the statistical estimation of annual effective tax functions. We find that the regression asymptotic marginal tax rate to be below the top statutory rate across 1966-89, and that there have been major shifts in the effective tax function as well. In general the US tax system has displayed continuing progressivity and rather variable levels of horizontal inequity.

Major tax reforms appear to have system effects on the tax system that lasts a few years. However, when we view the various parametric summaries of the annual tax system, which can be derived from our annual effective tax function estimates as time series data, in conjunction with various macro-economic measures of economic performance, we find, surprisingly, that many of the characteristics of the federal tax system display only a spurious relation to measures

of economic performance. All indices are found to be integrated time series. Future research is intended to explore how tax reform regimes affect *changes* in the various global measures of the tax system which the estimation of effective tax functions permits us to capture, and how long such changes may persist.

Figure 1

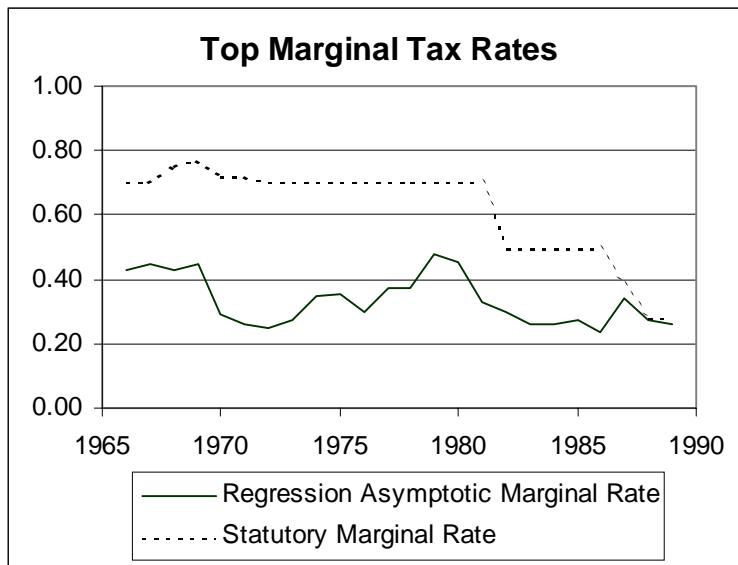


Figure 2

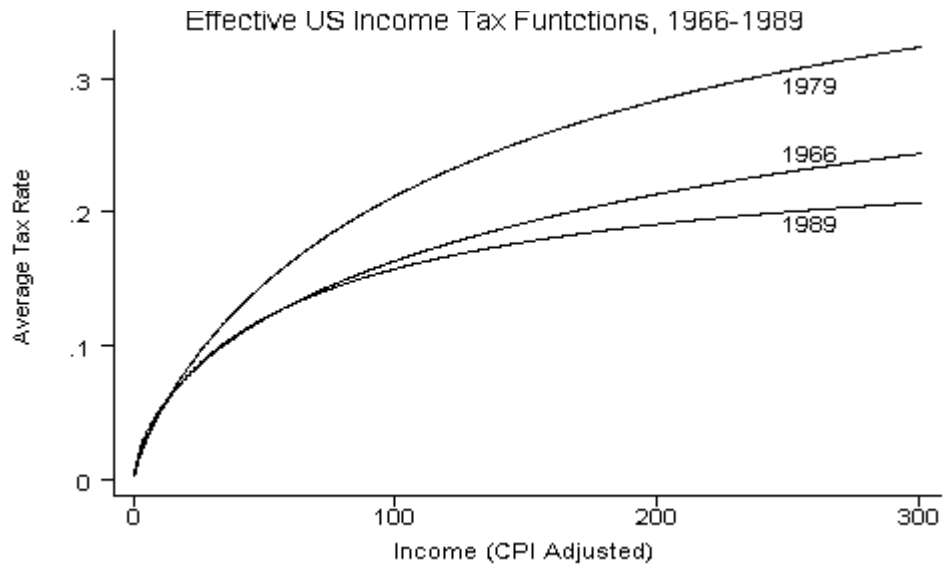


Figure 3

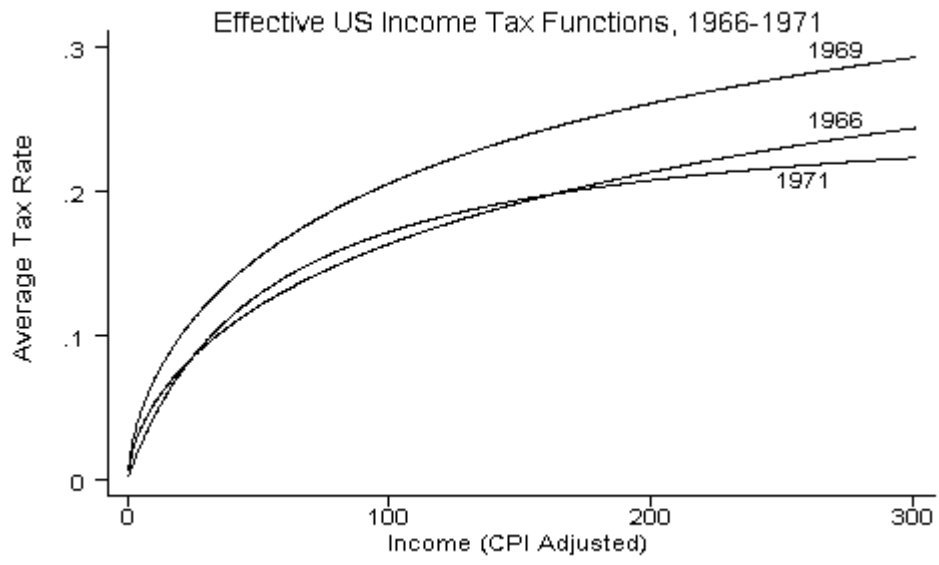


Figure 4

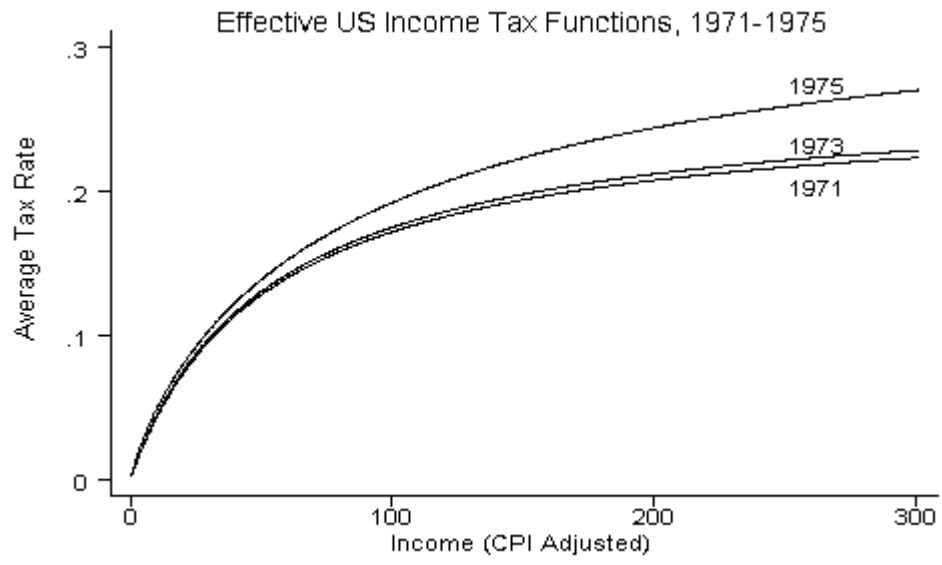


Figure 5

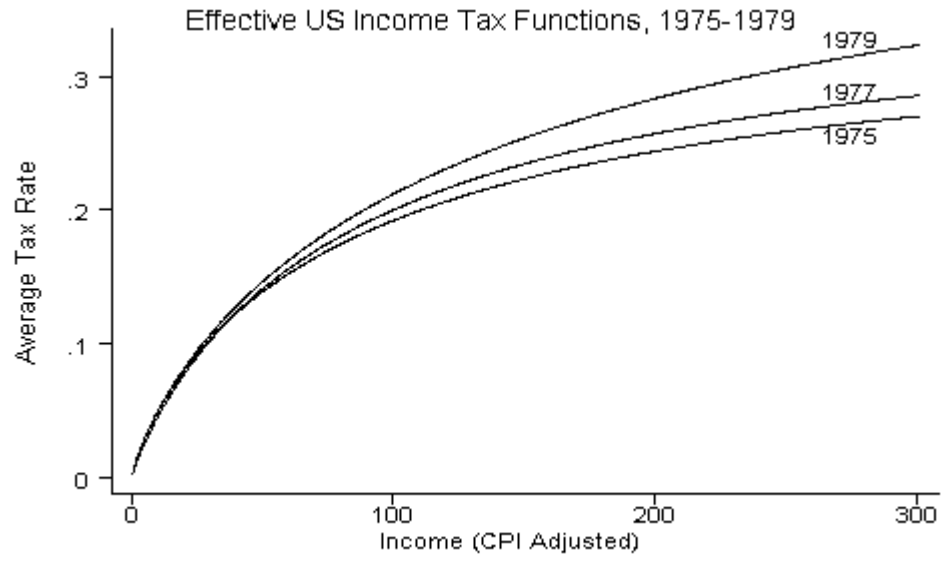


Figure 6

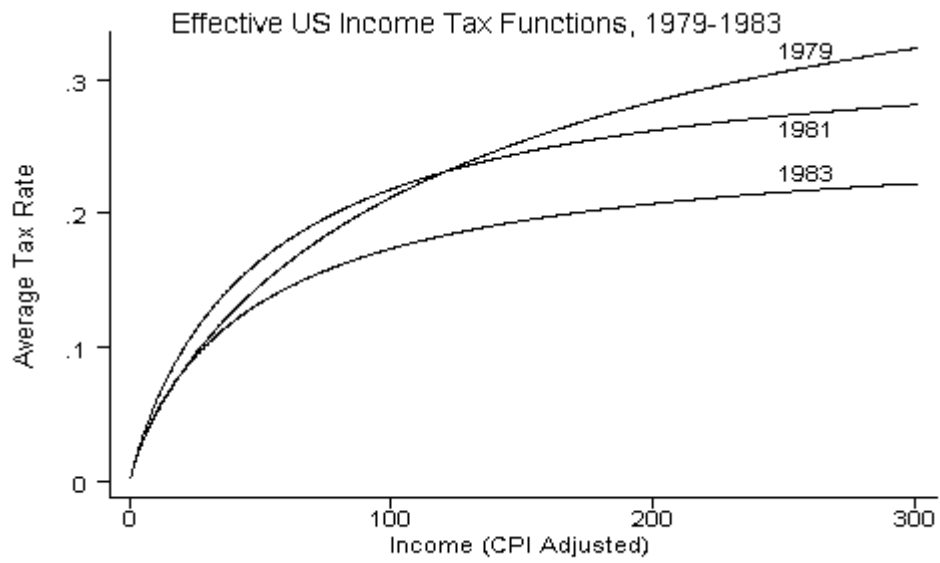


Figure 7

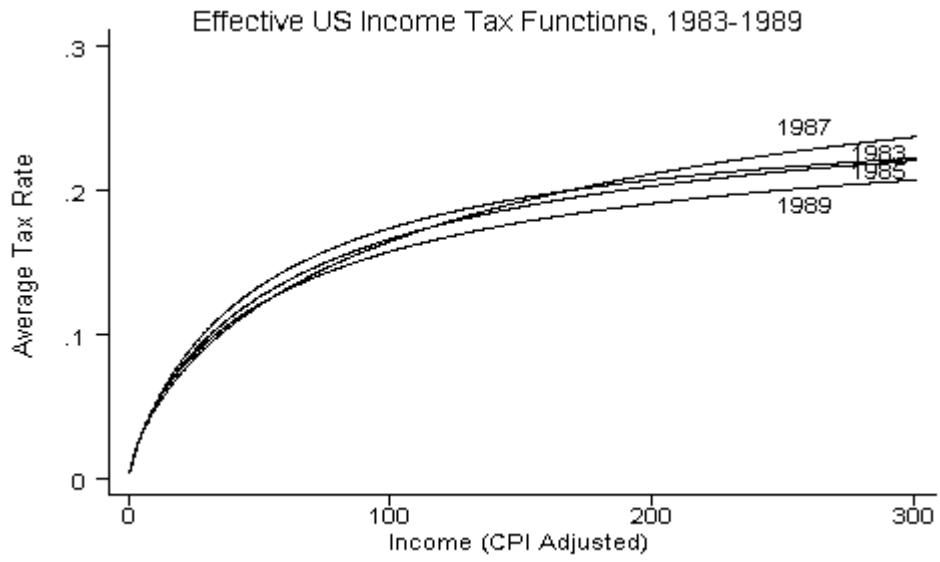


Figure 8

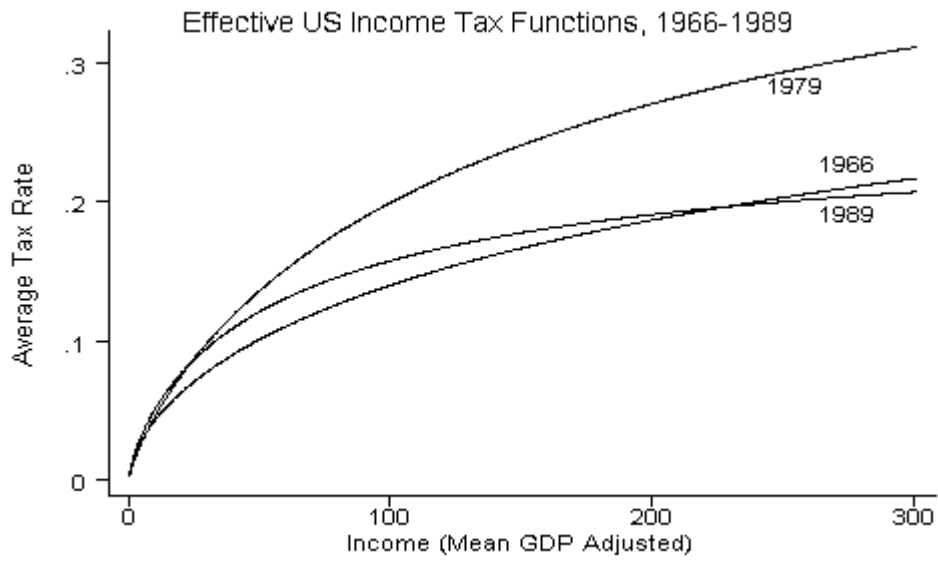


Figure 9

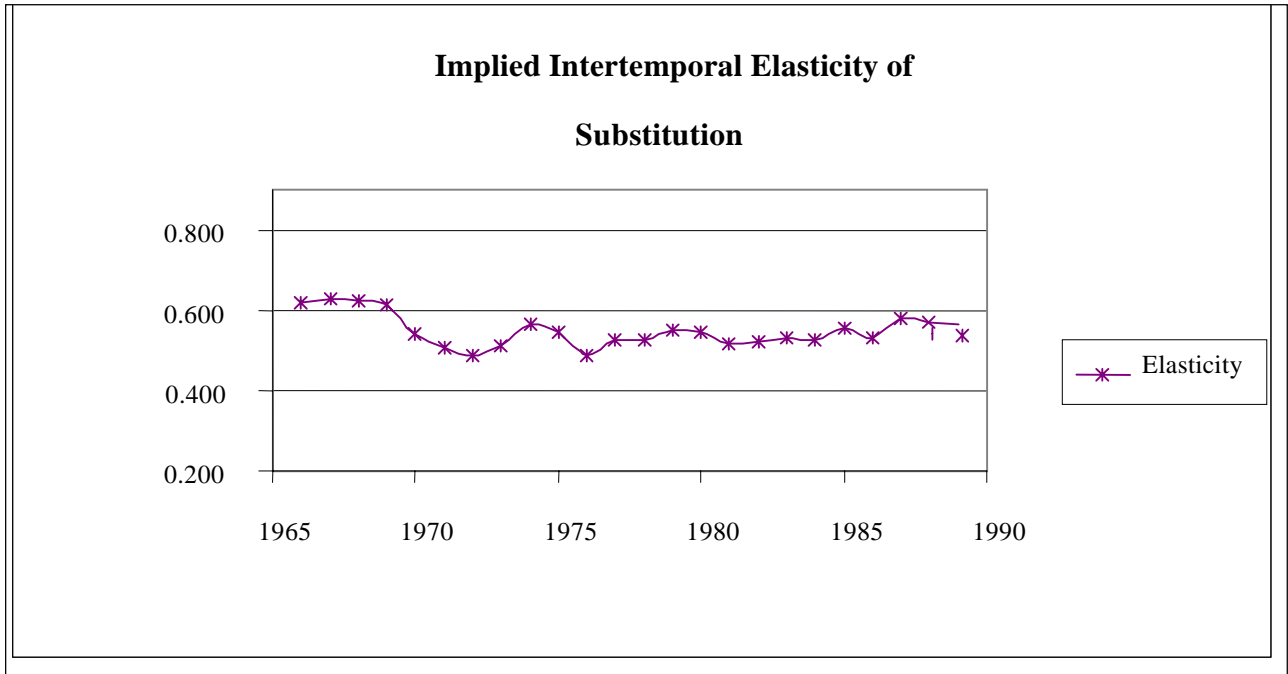


Figure 10

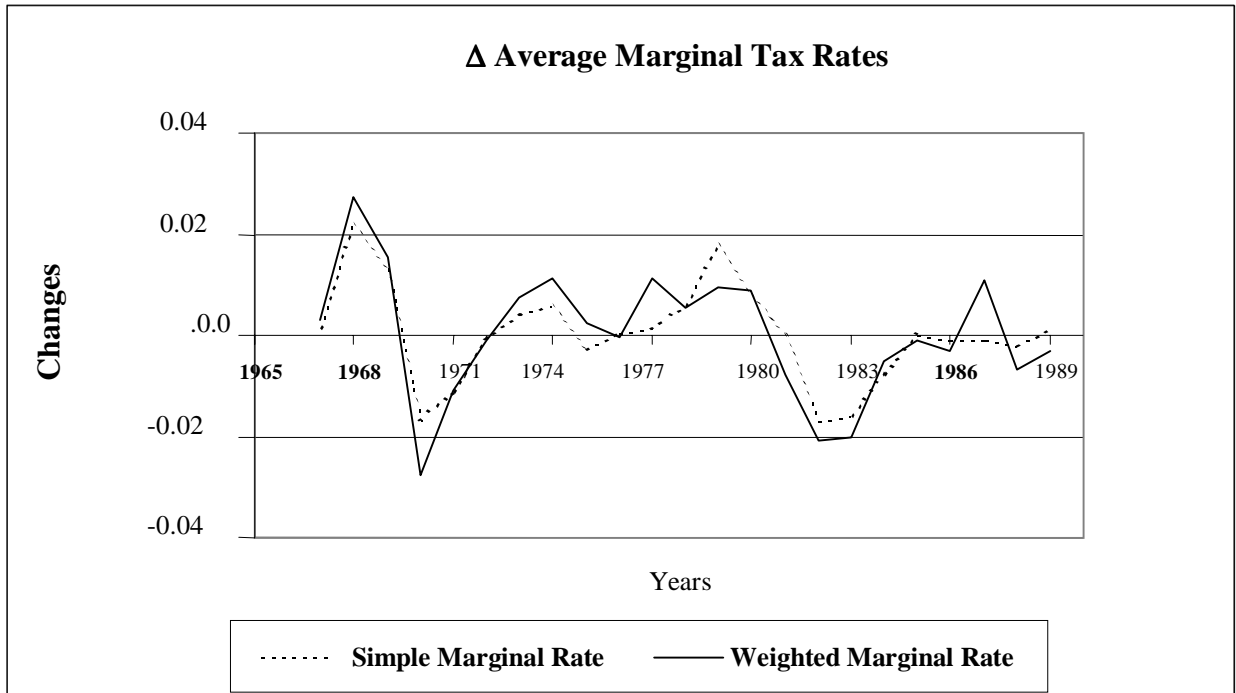
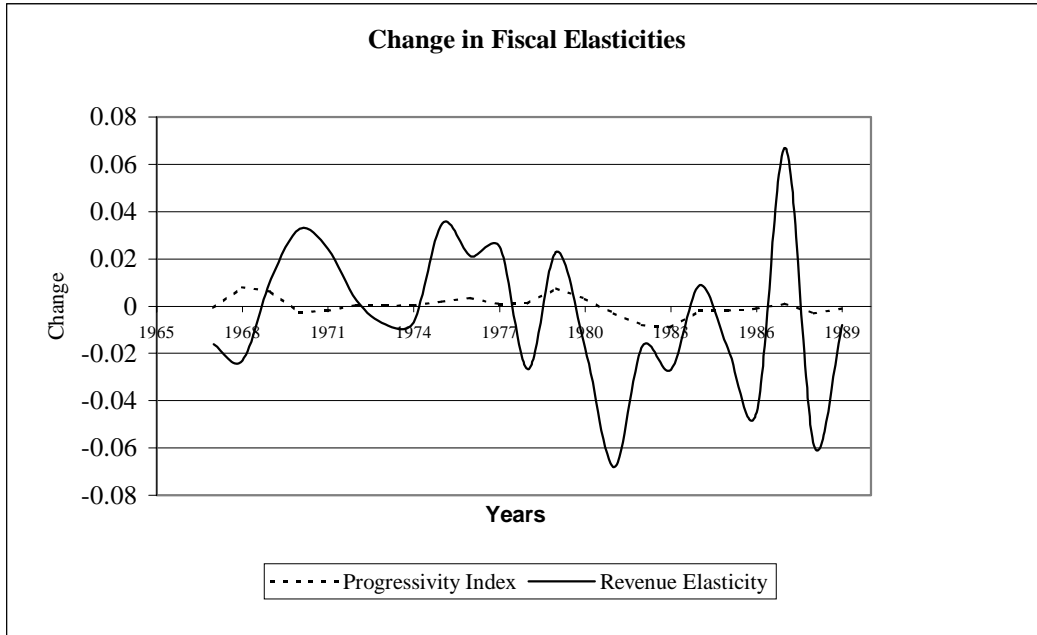


Figure 11



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Endnotes

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¹ For more on equal sacrifice see Young (1988) and Berliant and Gouveia (1993).

² The other variable in the graphs, the average tax rate, does not need to be adjusted in order to be comparable over time.

³ Naturally it would be better if we could define equals in terms of households and equivalence scales, but it is difficult to do that with the data available in the SOIs.

⁴ In order to facilitate the visualisation of the data, we have reversed the sign of changes in the progressivity index. This means that a positive change in the graph corresponds to an increase in progressivity.