

NEW TESTS OF THE LIFE CYCLE AND TAX DISCOUNTING HYPOTHESES*

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We first test a version of the permanent income consumption function recently suggested by Barro. The results support the theory except that consumption expenditures show sensitivity to transitory income. Next we use the consumption model to test the tax discounting hypothesis, which is strongly supported.

This support for tax discounting disagrees with results from some earlier studies using more traditional specifications of the consumption function. However, we show that when certain obviously inadequate estimation procedures are corrected, the traditional models also support tax discounting. This uniform support for tax discounting suggests that the sensitivity of consumption to transitory income is not due to liquidity constraints.

1. Introduction

Recently, Robert Barro (1983) has proposed a specification of the consumption function that distinguishes carefully between permanent and transitory gross income, permanent and transitory tax liabilities, average and marginal tax rate effects, and the various effects of interest rates. We first estimate this model and then use it to test both the permanent income and tax discounting hypotheses.

A recurring problem in estimating consumption functions is construction of a time series for permanent income. Recent work by Beveridge and Nelson (1981) has refined greatly the procedures for extracting estimates of permanent income from the history of current income. We use their methods here to construct not only series on permanent and transitory gross income but also series on permanent and transitory tax liabilities and on permanent and transitory price movements. In addition, Seater (1985) has constructed a series on marginal federal tax rates. Thus we have at our disposal measures of most of the variables that Barro's theory predicts to be relevant.

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Our results generally support the model. Normal and transitory government expenditures, marginal tax rates, and short-term interest rates all have negative effects, as predicted. Normal income has the predicted positive effect. Surprisingly, long-term interest rates tend to have a positive effect; we suggest a possible reason for this below. The main disagreement with the theory is the significantly positive effect of transitory income on consumption, even when the latter is measured as expenditures on non-durables and services. This sensitivity of consumption to current or transitory income has been found by others, but our more complete model allows us to discard some of the most common explanations for the result. One prominent remaining explanation for this sensitivity is liquidity constraints, which leads directly to the second part of our paper.

If liquidity constraints have significant effects on consumption, then the tax discounting hypothesis should fail. Liquidity-constrained households should increase their current consumption in response to a reduction in current taxes or an increase in transfers. We find, however, that neither taxes nor transfers (nor the market value of government debt nor Social Security wealth) has a significant effect on consumption. Thus, our results agree with the tax discounting hypothesis and therefore raise doubts about whether liquidity constraints really are responsible for the significant effects of transitory income on consumption expenditure. If liquidity constraints are not responsible for such effects, it is not clear what is.

Because our results on tax discounting disagree with those reported in some earlier studies, we re-examine those studies. The earlier studies suffer from several methodological weaknesses, the most serious of which turns out to be failure to correct adequately for simultaneity bias. When such correction is made, the earlier studies yield results that support tax discounting, just as our own results do.

Overall, then, our results suggest that Barro's expanded permanent income model of consumption works well, that consumption expenditure displays unexplained sensitivity to transitory income, and that consumption expenditure behaves as if the tax discounting hypothesis were correct.

2. The new specification

In this section we describe and test the combined Barro and Beveridge-Nelson specification of consumption expenditure. We then use that model to test the tax discounting hypothesis.

2.1. Barro's model

Barro (1983) has postulated the following consumption function:

$$C = C \left(\underset{+}{Q}^P, \underset{-}{G}^P, \underset{-}{G}, \underset{-}{r}, \dots \right), \quad (1)$$

where C is real consumption, Q^P is permanent real gross income, G^P is permanent real government expenditure on goods and services, G is current real government expenditure on goods and services, r is the after-tax real rate of interest, and the sign under a variable is the sign of the consumption function's derivative with respect to that variable.

According to the permanent income hypothesis, consumption depends on permanent disposable income. Consequently, the positive effect of Q^P in (1) is straightforward. As is well known, the true cost of government is its expenditure, not its current tax collection. In a permanent income model, it is the permanent cost of government that is relevant. This cost, then, can be measured as the permanent level of government expenditure, which explains the negative effect of G^P in (1). The negative effect of current government expenditure G arises from a completely different source. Given G^P , variation in G has no effect on permanent disposable income; however, government goods might substitute partially for privately produced goods in the household's consumption. The negative effect of G in (1) captures this possibility. Finally, the negative effect of r in (1) arises from intertemporal substitution effects. Changes in r have no wealth effects if Q^P is given.

In Barro's theoretical framework, the consumption function (1) is embedded in a standard commodity market equation,

$$C\left(\underset{+}{Q^P}, \underset{-}{G^P}, \underset{-}{G}, \underset{-}{r}, \dots\right) + I\left(\underset{-}{r}, \dots\right) + G = Q\left(\underset{+}{r}, \underset{+}{G^P}, \underset{+}{G}, \dots\right), \quad (2)$$

where I is real investment demand and Q is current real output. The interest rate's negative effect on investment demand is conventional; the positive effect on output supply reflects intertemporal substitution effects on labor supply. The positive effect of G^P on Q reflects wealth effects on labor supply, and the positive effect of G on Q reflects possible direct productivity effects of government goods and services.

The commodity market is equilibrated by the interest rate. Prices and wages clear the money and labor markets, respectively, but have no effect on the commodity market.

2.2. Construction of permanent variables

Estimation of (1) requires measures of Q^P and G^P . We proxy permanent income Q^P with the normal level of income obtained by application of Beveridge and Nelson's (1981) decomposition method to the time series for Q , measured as real GNP. The procedure is to estimate an ARIMA model for Q and then compute the stochastic steady state values of Q for each period t . These steady state values are the normal levels, denoted Q^* . The true permanent income value Q_t^P usually will differ somewhat from the steady state level Q_t^* because current income generally will not be at its steady state value.

Consequently, the present value of the stream of current income values Q_{t+i} , upon which calculation of permanent income is based, will differ from that for the stream of steady state values Q_{t+i}^* .

The series for Q was transformed to first differences of the logs to achieve stationarity. The best low-order model for Q was

$$D \log Q_t = 0.0182 + 0.401 D \log Q_{t-1}, \quad (3)$$

(0.006) (0.112)

where D is the first difference operator and the sample period is 1910–78. The modified Box–Pierce statistic at twelve lags, suggested by Ljung and Box (1978), is 12.83, which is consistent with white noise residuals. The values of Q^* obtained from (3) are reported in table 1.

Measurement of permanent government expenditure on goods and services is more complicated. First, we split total expenditure on goods and services into two parts, federal on the one hand and state and local on the other hand. Then we split the federal component into two subcomponents, military and non-military. Normal real federal military expenditures, denoted $FMIL^*$, are taken from Barro (1981). Normal real federal non-military expenditures, denoted $FCIV^*$, are estimated the Beveridge–Nelson method; the underlying equation is

$$D \log FCIV_t = 0.033 + 0.304 D \log FCIV_{t-1}, \quad (4)$$

(0.04) (0.116)

with a modified Box–Pierce statistic at twelve lags of 11.33 and the sample period is 1910–78. Finally, real state and local expenditures, denoted $SLGS$, are assumed to depend on a non-linear time trend, federal military expenditures (because wars tend to crowd out state and local expenditures), and on business cycles (because many states have balanced budget requirements which would make expenditures move pro-cyclically with tax revenue). The business cycle variable turned out to have the expected sign but was insignificant, so we dropped it. The final equation was

$$\log(SLGS/Q)_t = - 1.861 - 0.053 TIME_t + 0.00063 TIME_t^2$$

(0.680) (0.025) (0.00023)

$$- 0.146 \log(FMIL/Q)_t, \quad (5)$$

(0.034)

where Q is real GNP, $R^2 = 0.56$, and estimation is by Gallant and Goebel's (1976) method to correct for serial correlation, which in this case was of first order with a lag coefficient of 0.72. The sample period was 1929–78; earlier values of $SLGS$ were unavailable. Normal values for $SLGS$ are obtained from (5) by setting Q and $FMIL$ equal to their normal values already described.

Table 1
Normal and current values of variables.^a

Year	Q^*	Q	G^*	G	P^*	P
1929	319.6	315.7	41.4	35.0	32.3	32.8
1930	261.8	285.7	36.2	38.5	30.2	31.8
1931	244.6	263.5	34.0	40.1	26.0	28.9
1932	201.4	227.0	29.1	38.3	22.7	25.7
1933	214.5	222.1	34.5	37.1	24.1	25.1
1934	246.2	239.2	41.4	42.5	28.5	27.3
1935	269.4	260.0	40.0	43.4	27.7	27.9
1936	315.4	295.5	58.5	52.2	27.4	28.0
1937	313.9	310.2	50.0	49.9	29.7	29.3
1938	282.1	296.6	51.7	54.8	27.4	28.7
1939	329.6	319.8	54.0	57.2	27.5	28.4
1940	354.2	344.2	55.8	59.2	28.9	29.1
1941	434.0	400.4	68.3	91.4	32.3	31.2
1942	497.6	461.7	89.6	185.2	36.2	34.3
1943	572.4	531.6	94.0	264.4	36.8	36.1
1944	583.7	569.1	91.4	294.7	36.8	37.0
1945	543.4	560.4	81.5	259.2	37.7	37.9
1946	421.5	478.2	75.4	80.9	48.3	43.9
1947	455.8	470.3	77.1	62.1	53.4	49.6
1948	493.1	489.8	90.2	71.7	54.6	53.0
1949	483.7	492.1	97.9	83.6	50.8	52.5
1950	554.0	534.8	91.6	84.3	53.1	53.6
1951	598.9	579.4	110.5	120.4	58.7	57.1
1952	603.1	600.8	134.0	147.1	57.2	57.9
1953	626.4	623.6	151.9	157.3	58.1	58.8
1954	598.7	616.0	136.8	142.7	58.7	59.6
1955	673.0	657.5	147.8	138.5	60.4	60.8
1956	667.4	671.6	146.5	135.5	62.8	62.8
1957	678.0	683.8	153.6	147.8	65.1	64.9
1958	665.3	680.9	158.4	155.7	65.3	66.0
1959	735.3	721.8	165.7	156.0	67.2	67.6
1960	732.8	737.3	167.6	158.1	67.9	68.7
1961	754.3	756.6	174.8	168.6	68.1	69.3
1962	814.0	800.2	190.4	179.7	69.9	70.6
1963	837.7	832.6	194.4	184.1	70.7	71.7
1964	888.6	876.4	201.6	189.0	71.8	72.8
1965	947.0	929.3	207.9	195.9	73.8	74.4
1966	1003.2	984.9	215.6	216.6	76.8	76.8
1967	1008.7	1011.4	218.6	238.0	79.0	79.1
1968	1068.6	1058.1	229.4	250.5	83.4	82.5
1969	1085.5	1087.7	234.5	249.9	88.2	86.8
1970	1062.3	1085.6	237.3	246.6	93.1	91.5
1971	1124.6	1122.4	253.9	248.2	97.4	96.0
1972	1205.6	1185.9	270.5	253.1	100.8	100.0
1973	1277.1	1255.0	287.3	255.4	107.9	105.7
1974	1218.3	1248.0	285.2	264.6	120.0	114.9
1975	1199.8	1233.8	289.4	270.4	131.7	125.6

^a Q is real GNP; G is real state, local, and federal government expenditure on goods and services. Both are in billions of 1972 dollars. Q^* and G^* are the normal values for Q and G , computed according to eqs. (3), (4), and (5) in the text. P is the GNP deflator (1972 = 100) and P^* is its normal value, computed according to eq. (9) in the text.

The normal value of total real government expenditure on goods and services, denoted G^* , is simply the sum of $FMIL^*$, $FCIV^*$, and $SLGS^*$. The series for G^* is reported in table 1.

2.3. Estimation

We presume (1) is linear in its arguments:

$$C_t = a_0 + a_1 Q_t^P + a_2 G_t^P + a_3 G_t + a_4 r. \quad (6)$$

In estimating this equation, one would substitute Q^* and G^* for Q^P and G^P . However, before proceeding, several difficulties with the data must be addressed.

First, the theory concerns pure consumption, whereas the data measure consumption expenditures. In most of the permanent income and life cycle literature, it is argued that expenditures will respond to transitory income, even if pure consumption does not, because of the asset qualities of durable goods. In particular, transitory income must be saved and presumably will be distributed among all types of assets, including durable goods. Consequently, expenditure on any consumption good with durable qualities will respond positively to transitory income. The response should be less for expenditure on non-durable goods and services than for total expenditure; but as Darby (1974) has pointed out, it is very difficult to find a measure of consumption expenditure that totally excludes durable elements. Consequently, transitory income, measured as $Q_t - Q_t^*$, should be included as an explanatory variable in the consumption function, irrespective of how consumption is measured.

We find this argument unconvincing. Imagine that a consumer initially expects a constant stream of current income, so that his permanent and current income levels coincide. Then suppose he suddenly learns that this year's current income will have a positive transitory component, that the income of some future year will have a negative component, and that the level of permanent income is the same as before. The usual argument, summarized in the previous paragraph, would predict that this consumer would use some of his current transitory income to buy durable goods; for concreteness, suppose he buys a suit of clothes. Is such a form of saving reasonable?

To begin with, recall that the life cycle/permanent income theory predicts that pure consumption will be smoothed over the planning horizon. In the example under consideration, the consumer's expected permanent income is the same before and after he learns of the transitory income shock, so that his planned pure consumption path must be the same in the two cases. Consequently, if the consumer saves part of his transitory income by buying a suit, he cannot wear the suit or use it in any other way until that future date when the negative transitory income shock occurs; for if he did otherwise, he would

obtain a service flow from the suit and thus would have more pure consumption in his early years than his optimal plan calls for. So, if our consumer wishes to save transitory income in the form of a suit, he must be content to store the suit for some time. In the meantime, he must pay storage costs (closet space, mothballs) and suffer an expected loss of value (i.e., negative rate of return) through changing styles and possible damage. All durables we can think of suffer comparable problems. It would seem much more sensible to expect the consumer to use his transitory income to buy financial assets. Transactions costs of buying these are low, the expected rate of return is positive, and a sufficient variety of such assets exists to make available virtually any degree of liquidity and riskiness.

Thus, it seems to us that all transitory income would flow into financial assets with consumption expenditures of every sort unaffected. If this happens, of course, the resulting increase in the demand for financial assets would drive down the real interest rate, which then would induce an increase in consumption of both durable and non-durable goods. The important point to note here is that it is the drop in the interest rate, not transitory income, that raises consumption. Consequently, in a regression such as (6), which includes the interest rate as an explanatory variable, transitory income should not be significant. In order to test this proposition, we include the variable $Q - Q^*$ as a measure of transitory income.

Second, Q^* is an imperfect measure of Q^P . Because Q^* is generated entirely by current and lagged values of Q , influences other than the history of Q are omitted. Given the recent emphasis in some quarters on 'supply side economics', it would seem especially useful to explore the effect of marginal tax rates on consumption. In general, it is unclear what this effect would be because of opposing income and substitution effects. However, if the substitution effect dominates, then, for any given history of Q an increase in the marginal tax rate will reduce work effort, income, and therefore consumption. (Recall that the effect of the total tax burden, and therefore the average tax rate, is captured by G^P .) To capture any such omitted influences, we include a measure of the marginal federal income tax rate reported by Seater (1985) as an explanatory variable; it is denoted *AMTR*.

Third, because of the way it is generated, G^* is highly collinear with G . Consequently, to capture the effects of current G without having a severe multicollinearity problem, we have replaced G by transitory expenditure, $G - G^*$. Moreover, given G^* , it is this transitory expenditure that gives rise to the effects of changes in G described by the theory, so nothing is lost in substituting $G - G^*$ for G .

Fourth, the simple theory presumes that, once equilibrium is attained, the after-tax real interest rate is expected to be constant. In a more realistic setting, people at any given time might well expect future real shocks and thus also expect the future movements in the real interest rate needed to maintain

equilibrium. Consequently, we include a one-year and a twenty-year rate to capture short- and long-run effects. After-tax real rates are computed by the formulae

$$RS_t = RSNOM_t(1 - AMTR_t) - \Pi_t, \quad (7)$$

$$RL_t = RLNOM_t(1 - AMTR_t) - \Pi_t^c, \quad (8)$$

where RS and RL are the short and long after-tax real rates, $RSNOM$ and $RLNOM$ are the short and long nominal rates, Π is the expected one-year inflation rate, and Π^c is the expected long-term average inflation rate. The nominal interest rates are one- and twenty-year rates on corporate bonds. Inflation rates are computed from a Beveridge–Nelson decomposition of the GNP deflator. The ARIMA model is

$$D \log P_t = 0.017 + 0.451D \log P_{t-1}, \quad (9)$$

where the modified Box–Pierce statistic is 3.13 at twelve lags and the sample period is 1910–78. The one-year inflation rate Π_t is computed directly from (9). The twenty-year rate is computed from the expression

$$\Pi_t^c = (P_t^*/P_t)^{1/20} - 1, \quad (10)$$

where P^* is the normal level of P computed from (9) as described by Beveridge and Nelson.¹ The values of P^* are reported in table 1.

The foregoing considerations lead to the following estimating equation:

$$\begin{aligned} CE_t/POP_t = & b_0 + b_1Q_t^*/POP_t + b_2(Q_t - Q_t^*)/POP_t \\ & + b_3G_t^*/POP_t + b_4(G_t - G_t^*)/POP_t \\ & + b_5AMTR_t + b_6RS_t + b_7RL_t, \end{aligned} \quad (11)$$

where CE is consumption expenditure and POP is the population, and where $b_3, b_4, b_5, b_6, b_7 < 0 = b_2 < b_1$ are expected. The coefficient b_4 measures the substitutability of government for private goods and services; b_3 measures the

¹The calculation in (10) actually yields only that part of long-term inflation not due to deterministic trend. For regression purposes, the deterministic component is of no value because it is constant; consequently, the calculations in (10) are sufficient. See Beveridge and Nelson (1981) on the relation of trend to normal values of variables.

Table 2
Regression results for eq. (11).^a

Dependent variable	Const.	Q^*	$Q - Q^*$	G^*	$G - G^*$	$AMTR$	RS
<i>CETOT</i>	0.420 (0.024) ^b	0.634 (0.025) ^b	0.921 (0.057) ^b	-0.243 (0.096) ^b	-0.336 (0.020) ^b	-1.582 (0.509) ^b	0.062 (0.342)
<i>CENDS</i>	0.371 (0.023) ^b	0.405 (0.024) ^b	0.705 (0.055) ^b	0.130 (0.093)	-0.144 (0.019) ^b	-1.790 (0.489) ^b	-0.551 (0.329)
<i>CETOT</i>	0.730 (0.628)	0.506 (0.161) ^b	0.730 (0.263) ^b	-0.264 (0.127) ^b	-0.268 (0.145)	-1.184 (1.604)	0.789 (1.364)
<i>CENDS</i>	0.417 (0.777)	0.354 (0.199)	0.510 (0.326)	0.105 (0.157)	-0.126 (0.180)	-0.848 (1.986)	-0.372 (1.689)
	<i>RL</i>	<i>T</i>	<i>TR</i>	<i>D</i>	<i>SSW</i>	<i>R</i> ²	<i>DW</i>
<i>CETOT</i>	-0.749 (1.196)					0.99	1.84
<i>CENDS</i>	1.752 (1.149)					0.99	1.54
<i>CETOT</i>	-3.953 (11.160)	0.146 (0.465)	0.698 (1.058)	-0.012 (0.101)	0.000005 (0.00006)	0.99	1.54
<i>CENDS</i>	3.385 (13.822)	-0.176 (0.575)	0.511 (0.817)	0.026 (0.125)	0.00001 (0.00008)	0.99	0.81

^aNumbers in parentheses are standard errors. The sample period is 1929-75. *CETOT* is total consumption expenditure; *CENDS* is expenditure on non-durables plus services (excluding clothing and shoes). Q is real GNP, G is total real government expenditure on goods and services, and Q^* and G^* are the normal levels of these. *AMTR* is the average marginal tax rate. *RS* and *RL* are short and long after-tax real interest rates. *T* is total tax revenue. *TR* is total transfer payments (excluding interest on the debt). *D* is the market value of government debt held by the public. *SSW* is Social Security wealth. All monetary figures are in real 1972 dollars; *AMTR*, *RS*, and *RL* are in percent. *DW* is the Durbin-Watson statistic.

^bIndividual significance at five-percent level.

combination of the direct marginal productivity of government services and the indirect effect on output arising from induced labor supply shifts.²

Regression results for (11) over the period 1929-75 are reported in the first two rows of table 2. One row reports results when *CE* is measured as total consumption expenditures, denoted *CETOT*; the other row reports results when *CE* is measured as expenditures on non-durables and services, denoted

²The effect on C^D of a change in G with G^* fixed is $-\alpha dG$, where α measures the degree to which government services substitute for private goods and services. The effect of a change in G^* with G fixed is $[-(1 - \alpha - \beta) + MPL(\partial L/\partial G^*)]dG^*$, where β is the marginal physical product of government services, MPL is the marginal physical product of labor, and $\partial L/\partial G^*$ is the change in labor supply induced by the change in G^* through the effect of G^* on permanent income. Subtracting αdG^* from the two expressions gives $-\alpha(dG - dG^*)$ and $[\beta + MPL(\partial L/\partial G^*) - 1]dG^*$, so that $b_4 = -\alpha$ and $b_3 = -[1 - \beta - MPL(\partial L/\partial G^*)]$. The relative magnitudes of b_3 and b_4 are ambiguous.

CENDS. The non-durable data exclude clothing and shoes, as suggested by Darby (1974). We also ran regressions over the periods (1929–40, 1947–75) and (1947–75), but the results were not much different from those over the entire period so they are not reported.

Estimation is by two-stage least squares. The variables $Q - Q^*$, $AMTR$, RS and RL are treated as endogenous. Instruments for these include Q_t^* , G_t^* , $G_t - G_t^*$, CAS_t , CAS_{t-1} , CAS_{t-2} , DMR_t , DMR_{t-1} , DMR_{t-2} , D_t , A_t , and B_t where the new variables are

- (i) CAS : wartime casualty rates, used as a predictor of wars by Barro (1981),
- (ii) DMR : unexpected money growth, found by Barro (1977) to cause output movements, where DMR is the residual from a linear version of Barro's money growth equation (see the appendix),
- (iii) D : the market value of the government debt, included as a possible element of perceived net wealth,³
- (iv) A and B : parameters describing the graduated income tax function (see the appendix).

For the *CETOT* regressions, all coefficients are jointly significant ($F_{7,35} = 3286$); all coefficients but those of RS and RL are individually significant. The results for *CENDS* are much the same ($F_{7,35} = 2109$) except that G^* is individually insignificant. This individual insignificance of G^* also occurs in the unreported *CENDS* regressions over the (1929–40, 1947–75) and (1947–75) sample periods, although the sign of the coefficient is negative for the 1947–75 period. The source of this insignificance is unclear. It could be multicollinearity; the correlation between Q^* and G^* is 0.97. However, despite this high correlation, G^* is significant in all *CETOT* regressions, calling into question the severity of any possible multicollinearity problem.

Both the RS and RL coefficients have relatively much smaller standard errors in the *CENDS* equation, where they are nearly significant at the ten-percent level, than in the *CETOT* equation. The same thing happens over the (1929–40, 1947–75) subsample, where the coefficients are nearly significant at the five-percent level. In both cases, the RS coefficient is negative and the RL coefficient is positive. This sign pattern emerges for both the *CETOT* and *CENDS* equations over the 1947–75 subsample. In all cases, RS and RL are jointly significant with the other variables. Thus it appears reasonable to conclude that RS and RL have significant negative and positive effects, respectively, on consumption. This positive effect of RL is surprising. One possible explanation for the positive coefficient on RL is that RL may be capturing changes in the marginal product of capital arising from productivity shocks. Given the history of Q , which is captured in Q^* , a change in the

³ Whether D really is net wealth is discussed below.

anticipated marginal product of capital will increase perceived wealth and therefore consumption, as discussed by Barro (1983).

The estimates for b_4 suggest a substantial degree of substitutability between government and private goods and services, about thirty-percent for total consumption and half that for non-durable consumption. The thirty-percent estimate for total consumption is similar in magnitude to the forty-percent value obtained by Ahmed (1983) for the United Kingdom.

The estimates for b_3 suggest a significant (both economically and statistically) net effect of permanent government expenditure changes on total consumption. The net effect on non-durable consumption is of smaller magnitude and not statistically significant individually (though it is significant jointly).

The values of b_3 and b_4 both are expected to be larger for total than non-durable consumption because the latter is a proper subset of the former. The estimates of both coefficients conform to this expectation.

The one result emerging from the *CETOT* and *CENDS* regressions that clearly contradicts the permanent income theory of consumption is the sensitivity of consumption expenditure to transitory income. As we argued earlier, transitory income should not be significant when interest rates are included as explanatory variables, as they are here. Yet, despite significant coefficients on *RS* and *RL*, $Q - Q^*$ has strongly significant coefficients in both the *CETOT* and *CENDS* regressions.

The significant $Q - Q^*$ coefficients cannot be explained by the more traditional argument that transitory income directly affects expenditure on goods with durable qualities. The traditional argument makes two predictions. First, the coefficient on permanent income should be larger than that on transitory income because an extra dollar of permanent income is entirely spent on consumption, whereas some part of an extra dollar of transitory income will be put into financial assets. Unfortunately, because of the way Q^* is constructed, this prediction cannot be tested. As mentioned earlier Q^* is essentially a steady-state value. Given the equation generating Q^* , it turns out that a change in current Q implies an even larger change in the steady-state level of Q . However, because it takes current Q some time to reach the steady state, the present value of the current income stream will be less volatile than the present value of the steady-state stream. Consequently, permanent income will be less volatile than the steady-state level and therefore than Q^* . As a result, the regression coefficient on Q^* will be pushed down and that on $Q - Q^*$ pushed up to compensate for the exaggerated movements in Q^* , rendering direct comparison of these coefficients meaningless.

The second prediction of the traditional argument concerns the way the coefficients on permanent and transitory income should behave across the *CETOT* and *CENDS* equations. The coefficients on Q^* and $Q - Q^*$ are the marginal propensities to consume out of these two measures of income. Because *CENDS* is a proper subset of *CETOT*, the coefficients on both Q^* and $Q - Q^*$ should be lower for *CENDS* than *CETOT*, and they are.

However, the traditional argument suggests that the $Q - Q^*$ coefficient should fall by much more than the Q^* coefficient in going from *CETOT* to *CENDS* because *CENDS* is relatively free of durables purchases. That the $Q - Q^*$ coefficient does not behave this way is most easily seen by comparing the ratio of the $Q - Q^*$ and Q^* coefficients obtained from the *CETOT* equation with the similar ratio obtained from the *CENDS* equation. The ratios are 1.45 and 1.74. Thus the $Q - Q^*$ coefficient actually increases relative to the Q^* coefficient in going from the *CETOT* to the *CENDS* regression.

This sort of sensitivity to transitory income is not a new finding. However, because our set of explanatory variables and our measures of permanent levels are more complete than usually found in the literature, it becomes less likely that omitted variable problems or mismeasured expectations explain the result. The most likely explanation would seem to be liquidity constraints; but as we soon show, there is indirect evidence against that explanation, too, leaving the sensitivity finding something of a mystery.

2.4. *Tax discounting in the new specification*

If liquidity constraints affect consumption expenditures, then the tax discounting hypothesis should fail. Those taxpayers for whom such constraints are binding would be able to increase their current consumption expenditures if the government reduced current taxes and raised future taxes by issuing debt.⁴

Testing the tax discounting hypothesis in the consumption function specified in (2) is straightforward. If tax discounting is incomplete, then for given levels of G^* and G , consumption expenditure should be negatively related to the amount of tax revenue currently collected. A direct corollary is that the stock of government debt should be viewed as net wealth and therefore should have a positive effect on consumption. The stock of Social Security wealth should be similarly viewed with similar effects. Finally, it is likely that low-income consumers are more subject to liquidity constraints than are high-income consumers, in which case transfer payments should be positively related to aggregate consumption expenditures. These considerations suggest testing the following specification of the consumption function:

$$\begin{aligned}
 CE_t/POP_t = & b_0 + b_1Q_t^*/POP_t + b_2(Q_t - Q_t^*)/POP_t + b_3G_t^*/POP_t \\
 & + b_4(G_t - G_t^*)/POP_t + b_5AMTR_t \\
 & + b_6RS_t + b_7RL_t + b_8T_t/POP_t + b_9TR_t/POP_t \\
 & + b_{10}D_t/POP_t + b_{11}SSW_t/POP_t,
 \end{aligned} \tag{12}$$

⁴Tobin (1980) has suggested several reasons besides liquidity constraints why tax discounting should be incomplete. These are of no relevance to the current discussion and so will not be pursued. It is worth noting, however, that the empirical results reported below are inconsistent with all of Tobin's arguments.

where T is real tax collections, TR is real transfers, D is the real market value of outstanding government debt, and SSW is real Social Security wealth. The expected signs on b_0 through b_7 are as before; the expected signs on b_8 through b_{11} are $b_8 < 0 < b_9, b_{10}, b_{11}$.

Regression results for (12) are reported in the last two rows of table 2. Again, estimation is by two-stage least squares. The variables T , TR , and SSW are added to the list of endogenous variables. The instrument set is the same as before.

The results for both *CETOT* and *CENDS* strongly support the existence of complete tax discounting. In both equations, the new financing variables are insignificant both jointly and individually. The F -statistics for the joint hypothesis that T , TR , D , and SSW all have zero coefficients are 0.51 for *CETOT* and 0.48 for *CENDS*, both far below the five-percent critical level $F(4, 33) = 2.66$. No individual coefficient has a significant t -statistic. In contrast, the coefficients on Q^* , $Q - Q^*$, G^* , $G - G^*$, $AMTR$, RS , and RL are jointly significant in the *CETOT* equation, the F -statistic of 19.4 being well over the critical level $F(5, 33) = 2.50$. For the *CENDS* equation, the F -statistic is 2.43, barely below the critical level.

The foregoing statistical results must be interpreted cautiously for the *CENDS* equation, where the low Durbin–Watson statistic indicates serially correlated errors. We tried to correct for this problem, but the non-linear 2SLS procedure would not converge properly. In any case, the result is a downward bias in standard errors, suggesting that the new financing variables are insignificant in any case. The deterioration in the Durbin–Watson statistic that occurs in *CENDS* equation when the financing variables are added suggests the introduction of a misspecification, which itself is further evidence against inclusion of those variables.

One possible reason for the insignificance of the financing variables is multicollinearity. Table 3 presents the correlation matrix for the set of explanatory variables. Except for D , the financing variables show substantial correlation with each other and with some of the other variables. To see what effect the high correlations among the financing variables had, we repeated the regressions using every possible combination of T , TR , D , and SSW . In no case were the financing variables significant. To see what effect the high correlations between the financing variables and the other variables had, we omitted Q^* and G^* , both individually and jointly. We chose these two because T , TR , and SSW show the greatest correlation with them. The financing variables generally remained insignificant except for T , which generally was significantly positive (the wrong sign). These results strongly suggest that the insignificance of the financing variables is not an artifact of multicollinearity but rather is genuine.

The conclusion from these tests is that the data are strongly consistent with the tax discounting hypothesis. Consequently, they also are inconsistent with the existence of significant liquidity constraints, leaving as an unexplained

Table 3
Correlations of explanatory variables for eq. (12).^a

	Q^*	$Q - Q^*$	G^*	$G - G^*$	$AMTR$	RS	RL	T	TR	SSW	D
Q^*	1.00	-0.17	0.97	0.01	0.83	0.18	0.50	0.98	0.87	0.98	0.35
$Q - Q^*$		1.00	-0.08	-0.25	-0.10	0.27	0.26	-0.03	0.14	-0.03	0.00
G^*			1.00	-0.17	0.79	0.27	0.55	0.97	0.90	0.98	0.25
$G - G^*$				1.00	0.18	-0.26	-0.31	-0.05	-0.30	-0.11	0.55
$AMTR$					1.00	-0.14	-0.07	0.82	0.59	0.82	0.71
RS						1.00	0.69	0.23	0.33	0.21	-0.46
RL							1.00	0.57	0.77	0.54	-0.42
T								1.00	0.91	0.99	0.33
TR									1.00	0.91	0.07
SSW										1.00	0.32
D											1.00

^aSee footnote a to table 2 for definition of variables and sample period.

puzzle the earlier finding of sensitivity of consumption expenditure to transitory income.

3. Further evidence on tax discounting

Much of the existing literature on tax discounting, using more traditional specifications of the consumption function, finds support for the hypothesis; see, for example, Barro (1978), Kochin (1974), Kormendi (1983), and Tanner (1979). However, Feldstein (1978, 1979, 1982), through seemingly trivial changes in specification, obtains results that reject the hypothesis, finding virtually no tax discounting at all. Moreover, because the differences in specification between most work on the one hand and Feldstein's on the other seem inconsequential yet lead to diametric results, there has arisen some despair over the ability of time series evidence to shed any light on this important issue. The reader therefore may be skeptical of the previous section's results.

As it turns out, the conflicting results in the earlier work arise from certain obvious methodological weaknesses. Correction of these leads to well-behaved results that support the tax discounting hypothesis. In this section, we very briefly discuss the estimation problems in some of the earlier literature, the correct procedures, and the results. We also compare the traditional specification with that of the previous section to highlight some remaining weaknesses of the former.

3.1. Two traditional specifications

We examine two versions of the traditional life-cycle specification for consumption expenditure:

$$\begin{aligned}
 CETOT_t/POP_t = & c_0 + c_1(YD_t + RE_t)/POP_t \\
 & + c_2(YD_{t-1} + RE_{t-1})/POP_{t-1} \\
 & + c_3U_t(YD_t + RE_t)/POP_t \\
 & + c_4SUR_t/POP_t + c_5W_t/POP_t \\
 & + c_6DUR_t/POP_t + c_7SSW_t/POP_t, \quad (13)
 \end{aligned}$$

$$\begin{aligned}
 CETOT_t/POP_t = & d_0 + d_1Y_t/POP_t + d_2Y_{t-1}/POP_{t-1} + d_3UY_t/POP_t \\
 & + d_4W_t/POP_t + d_5DUR_t/POP_t + d_6 \\
 & + d_6G_t/POP_t + d_7T_t/POP_t + d_8TR_t/POP_t \\
 & + d_9D_t/POP_t + d_{10}SSW_t/POP_t, \quad (14)
 \end{aligned}$$

where the variables not previously defined are:

- YD = disposable income,
- RE = corporate retained earnings,
- U = unemployment rate,
- SUR = budget surplus of total government,
- W = household net worth,
- DUR = stock of household durables, exclusive of housing,
- Y = national income.

All variables are in real terms.⁵

Eq. (13) is essentially that used by Barro (1978), the only difference being that RE here is added to YD rather than included as a separate term. Eq. (14) is essentially that used by Feldstein (1982), the only two differences being the inclusion of DUR and UY , both omitted by Feldstein.⁶ The main difference between (13) and (14) is that disposable income and government surplus in (13) have been replaced by total income, government expenditure on goods and services, transfers, and total tax receipts in (14).

⁵The price index here has a base year of 1958 for comparability with Barro's (1978) earlier study. The price index used for eqs. (11) and (12) had a base year of 1972.

⁶Feldstein's omission of UY is surprising because twice before (1978, 1979) he referred to its inclusion as 'a useful suggestion'. Its inclusion has some effect on the significance of T and TR , as mentioned below. The inclusion of DUR does not change the results much from Feldstein's.

Barro (1978) argues that tax discounting implies $c_4 > 0 = c_7$ in (13), and he obtains such results. Feldstein (1978) criticizes Barro's estimates on the grounds of simultaneity bias. It may be that *SUR* is endogenous because increases in *CETOT* raise $YD + RE$ and therefore *SUR*. Feldstein 'solves' this simultaneity problem by dropping *SUR* from (13), in which case c_7 becomes significantly positive. Unfortunately, Feldstein's solution replaces possible simultaneity bias with possible omitted variable bias, leaving its validity unclear. Also, if *SUR* really is endogenous as suggested, then so is $YD + RE$ and therefore $U(YD + RE)$; in addition, by its method of construction *SSW* is a function of YD and so potentially endogenous, too. Thus simultaneity bias may remain even when *SUR* is omitted from (13).

Feldstein (1982) addresses simultaneity more directly in estimating (14) where he treats T and sometimes Y as endogenous. Tax discounting implies that d_7, d_8, d_9 and d_{10} all equal zero, an implication often contradicted by Feldstein's empirical results. Unfortunately, he only uses once-lagged values of T and Y as instruments, an unnecessarily restricted set and one which may still be correlated with the error because of the high degree of serial correlation between current and lagged values of Y and T . Moreover, TR and *SSW* are not treated as endogenous.⁷ Consequently, simultaneity bias still may afflict Feldstein's estimates.

3.2. Estimation

In estimating (13) and (14), we treat $YD + RE$, $U(YD + RE)$, *SUR*, *SSW*, Y , G , T , and TR as potentially endogenous. For (13), the instrument set comprises the *DMR* variable described earlier, durables *DUR*, a trend value of government expenditure *GTN* (see the appendix), total investment expenditure *INV*, total tax revenue T , time, wealth W , and lagged income $(YD + RE)_{t-i}$ for $i = 1, \dots, 5$. For (14), T was dropped, government debt D was added, and $(YD + RE)_{t-i}$ was replaced by Y_{t-i} . We also tried eleven subsets of these complete instrument sets in case the results were sensitive to the choice of instruments or in case some of the instruments (notably *INV* and T) were not really exogenous.

Eqs. (13) and (14) were estimated over two sample periods: (1931–40, 1947–74) and (1947–74). These were chosen for comparability with Barro's (1978) original study.⁸ Estimation is by two-stage least squares with first-order serial correlation correction. In the first stage, the potentially endogenous variables were regressed on the various instrument sets. Then we performed

⁷Also, Feldstein uses a measure of *SSW* that Leimer and Lesnoy (1982) convincingly argue is arbitrarily and incorrectly adjusted for changes in the law.

⁸The observations for 1929 and 1930 were lost in creating the *DMR* and *GTN* variables.

specification tests as described by Hausman (1978) to see which of the potentially endogenous variables really were endogenous. Finally, we performed the second-stage regressions using fitted values for those explanatory variables that did not pass the Hausman tests for exogeneity.

For both (13) and (14), the exogeneity tests were sensitive to the instrument set used. Various combinations of the potentially exogenous variables failed the test depending on what set had been chosen, suggesting that at least some of the instruments were imperfect. However, the second-stage results were essentially the same across instrument sets, so we do not dwell here on the first-stage or exogeneity test results. It is important to note that for several instrument sets, including the complete one, the exogeneity tests for (13) suggested that all potentially endogenous variables in fact were exogenous, in which case there is no simultaneity problem in estimating (13). In most other cases, *SUR* either passed the exogeneity test or, when it did not, $YD + RE$ also failed the test. Thus Barro's procedures for estimating (13) may be correct but Feldstein's (1978, 1979) certainly are not. For (14), the tests virtually always indicate endogeneity of at least some variables. *SSW* and once-lagged *Y* show strong tendencies toward endogeneity; *T*, *UY*, and current *Y* show somewhat weaker tendencies. These are not the same variables treated as endogenous by Feldstein (1982), suggesting that his estimates of (14) may be subject to simultaneity bias.

Table 4 reports the regression results for both (13) and (14). Eq. (13) is completely consistent with tax discounting. The coefficient on *SUR* is significantly positive, whereas that on *SSW* is insignificant. Both results are implied by the tax discounting hypothesis. The results from (14) are slightly less consistent with tax discounting. The coefficients on *T*, *D*, and *SSW* all are insignificant, as implied by the hypothesis; but the coefficient on transfers *TR* is significantly positive. The meaning of this significance is unclear. On the one hand, it might imply a limited failure of the tax discounting hypothesis; on the other hand, there is substantial reason to believe that *TR* is acting as a proxy, as discussed below.⁹ In any case, the results from (13) and (14) for the most part agree with those from (11) and (12) and support the tax discounting hypothesis.

The results from (13) and (14) are encouraging methodologically. Earlier literature using (13) and (14) obtained very different estimation results with seemingly minor changes in specification, leading to some despair over the ability of time series evidence to yield reliable results. However, when the various specifications are subjected to rigorous tests, when properly constructed data are used, and when omitted variable and simultaneity biases are

⁹When *UY* is excluded from (14), as in Feldstein (1982), *TR* becomes much more significant in both sample periods, and *T* becomes significant for the longer period. Other results are unchanged. However, as explained in much of the literature – Barro (1978), Feldstein (1978, 1979) – inclusion of *UY* seems more appropriate.

Table 4
Regression results for eqs. (13) and (14).^a

A. Equation (13)										
Sample period	Const.	$YD + RE$	$(YD + RE)_{t-1}$	$U(YD + RE)$	DUR	NW	SUR	SSW	R^2	
1931-40,	110.83	0.54	0.22	0.34	0.16	0.005	0.29	-0.03	0.99	
1947-74	(109.73)	(0.1) ^b	(0.10) ^b	(0.28)	(0.1)	(0.01)	(0.13) ^b	(0.03)		
1947-74	104.00	0.64	0.15	0.30	0.18	0.002	0.32	-0.04	0.99	
	(83.2)	(0.08) ^b	(0.07) ^b	(0.21)	(0.1) ^b	(0.02)	(0.09) ^b	(0.05)		

B. Equation (14)												
Sample period	Const.	Y	Y_{t-1}	UY	DUR	NW	G	T	TR	D	SSW	R^2
1931-40,	278.39	0.54	0.08	0.56	-0.16	0.015	-0.01	-0.05	1.06	-0.02	-0.006	0.99
1947-74	(57.88) ^b	(0.05) ^b	(0.04) ^b	(0.19) ^b	(0.08) ^b	(0.008) ^b	(0.05)	(0.11)	(0.15) ^b	(0.02)	(0.01)	
1947-74	69.46	0.50	0.08	0.45	0.01	0.01	-0.02	0.04	0.66	0.10	-0.01	0.99
	(121.19)	(0.08) ^b	(0.05)	(0.3)	(0.2)	(0.01)	(0.08)	(0.14)	(0.31) ^b	(0.06)	(0.02)	

^aNumbers in parentheses are standard errors. YD is disposable income, RE is corporate retained earnings, U is the unemployment rate, DUR is the stock of consumer durables, NW is a measure of net wealth, SUR is the government surplus, SSW is Social Security wealth, Y is national income, G is government expenditure on goods and services, T is total tax revenue, TR is transfer payments, and D is the market value of privately held government debt. All dollar figures are in real per capita units.

^bSignificance at five-percent level.

corrected, the instability problems disappear. Both (13) and (14) appear to be well-behaved specifications. The coefficient estimates are sensible and internally consistent, and the equations are stable across sample periods. These results illustrate the need to apply appropriate methods to good data.

3.3. Comparison of specifications

Despite the good behavior of both (13) and (14), we prefer (11) to either of them. Neither (13) nor (14) distinguishes between permanent and transitory movements in income or government expenditures; neither one contains marginal tax rates or interest rates as explanatory variables, all of which were significant in the estimates of (11). In fact, these inadequacies probably explain the significance of transfers in (14). The correlation matrix in table 3 shows that TR is highly correlated with Q^* , G^* , and RL and is moderately correlated with $AMTR$, $G - G^*$, and RS , all of which had significant effects in the estimates of (11). Thus, the significance of TR in (14) may have nothing to

do with incomplete tax discounting but rather with its acting as a proxy for omitted or mismeasured variables.¹⁰

4. Conclusions

The results reported herein suggest the following five conclusions:

- (i) The expanded specification of the permanent income consumption function proposed by Barro (1983) fits the data well and suggests that several variables previously ignored in the literature have important effects on consumption expenditure.
- (ii) Consumption expenditures display a puzzling sensitivity to transitory income.
- (iii) Barro's specification yields results strongly consistent with complete tax discounting.
- (iv) More traditional specifications of the consumption function, when properly estimated, also yield results consistent with tax discounting.
- (v) Although the traditional equations are well-behaved, they still are inferior to Barro's specification in their handling of permanent vs. transitory changes and in omitting altogether other significant variables.

Data appendix

1. $Q = Y/P$, where nominal GNP Y (\$ billions) and the GNP deflator P (1972 = 100) are from NIPA.
2. $FCIV = FCIVNOM/GP$, where nominal federal non-military expenditures $FCIVNOM$ (\$ billions) and the government price deflator GP (1972 = 100) are from NIPA.
3. $FMIL^*$ is from Barro (1981).
4. $SLGS = SLGSNOM/P$, where nominal state and local government expenditures (\$ billions) are from the *Economic Report of the President*.
5. $AMTR$ is the $AMTRGNP$ series constructed by Seater (1985).
6. $RSNOM$ over 1929–70 is the nominal interest rate (percent) on one-year corporate bonds (constant maturity). Comparable figures for 1971–75 are not published, so a proxy was constructed by computing the average ratio of the rate on one-year corporate bonds to the rate on one-year Treasury bills (constant maturity) over 1960–70 and then multiplying the rate on one-year Treasury bills (constant maturity) over 1971–75 by this average

¹⁰Kormendi (1983) also finds TR significant and argues that it reflects distributive effects arising from different marginal propensities to consume among agents. Our earlier results with (12), that TR is insignificant, cast doubt on this argument, for distributive issues should arise with (12) just as much as with (14).

ratio. All data are from the Federal Reserve System's *Banking and Monetary Statistics* and *Annual Statistical Digest*.

7. *RLNOM* over 1929–70 is the nominal interest rate (percent) on twenty-year corporate bonds (constant maturity). Comparable figures for 1971–75 were constructed by computing the average ratio of the Moody's rate on corporate bonds to the rate on long-term federal bonds over 1960–70 and then multiplying the rate on twenty-year federal bonds (constant maturity) by this average ratio. All data are from the Federal Reserve System's *Banking and Monetary Statistics* and *Annual Statistical Digest*.
8. *POP*, the total population (millions), is from the *Economic Report of the President*.
9. $CETOT = C/P$, where total nominal consumption expenditure C (\$ billions) is from NIPA.
10. $CENDS = (C - CD)/P$, where CD is the sum of reported consumption expenditure on durables (\$ billions) plus expenditure on clothing and shoes (\$ billions), reported in the *Economic Report of the President*.
11. *CAS* is from Barro (1981).
12. *DMR* is the residual from the following money growth equation:

$$DM_t = a_0 + a_1GFV_t + c_2[U_{t-1}/(1 - U_{t-1})] \\ + c_3DM_{t-1} + c_4DM_{t-2} + e_t,$$

where DM is the growth rate of the nominal money stock M_1 , U is the unemployment rate, and GFV is the difference between actual real per capita federal government expenditure and a forecast of such expenditure generated by the fitted values of the following equation:

$$GF_t = b_0 + b_1CAS_t + G_2TIME + b_3GF_{t-1} + b_4GF_{t-2} + u_t,$$

where GF is total real federal government expenditure per capita (\$ billions). Data are from the *Economic Report of the President*.

13. $D = MVTOTGI/P$ where the market value of federal, state, and local debt in the hands of the public $MVTOTGI$ is reported by Seater (1981).
14. A and B are described and reported in Seater (1984).
15. $T = TAX/P$, where nominal tax revenue of all government TAX (\$ billions) is from the *Economic Report of the President*.
16. $TR = TRANS/P$, where nominal government transfers to individuals $TRANS$ is from the *Economic Report of the President*.
17. $SSW = SS/P$, where nominal Social Security wealth SS is from Leimer and Lesnoy (1982).
18. YD, RE, W, DUR are from Barro (1978).

19. $Y = NI/P$, where nominal national income NI (\$ billions) is from the *Economic Report of the President*.

References

- Ahmed, Shagil, 1983, Temporary and permanent government spending in an open economy: Some evidence for the U.K., Typescript (University of Rochester, Rochester, NY).
- Barro, Robert J., 1977, Unanticipated money growth and unemployment in the United States, *American Economic Review* 67, 101–115.
- Barro, Robert J., 1978, The impact of social security on private saving: Evidence from the U.S. time series (American Enterprise Institute, Washington, DC).
- Barro, Robert J., 1981, Output effects of government purchases, *Journal of Political Economy* 89, 1086–1121.
- Barro, Robert J., 1983, *Macroeconomics* (Wiley, New York).
- Beveridge, Stephen and Charles R. Nelson, 1981, A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle', *Journal of Monetary Economics* 7, 151 – 174.
- Darby, Michael R., 1974, The permanent income theory of consumption: A restatement, *Quarterly Journal of Economics* 88, 228–250.
- Feldstein, Martin S., 1978, Reply, in: Robert J. Barro, ed., *The impact of social security on private saving: Evidence from the U.S. time series* (American Enterprise Institute, Washington, DC) 37–47.
- Feldstein, Martin S., 1979, The effect of social security on private saving: The time series evidence, Working paper no. 314 (National Bureau of Economic Research, Cambridge, MA).
- Feldstein, Martin S., 1982, Government deficits and aggregate demand, *Journal of Monetary Economics* 9, 1–20.
- Gallant, A. Ronald and J.J. Goebel, 1976, Nonlinear regression with autoregressive errors, *Journal of the American Statistical Association* 71, 961–967.
- Hausman, Jerry, 1978, Specification tests in econometrics, *Econometrica* 46, 1251–1272.
- Kochin, Levis A., 1974, Are future taxes anticipated by consumers?, *Journal of Money, Credit and Banking* 6, 385–394.
- Kormendi, Roger, 1983, Government debt, government spending, and private sector behavior, *American Economic Review* 73, 994–1010.
- Leimer, Dean R. and Selig D. Lesnoy, 1982, Social security and private saving: New time series evidence, *Journal of Political Economy* 90, 606–629.
- Ljung, G.M. and G.E.P. Box, 1978, On a measure of lack of fit in time series models, *Biometrika* 65, 297–303.
- Seater, John J., 1981, The market value of outstanding government debt: 1919–1975, *Journal of Monetary Economics* 8, 85–101.
- Seater, John J., 1984, A positive theory of the graduated income tax and its macroeconomic determinants, Typescript (North Carolina State University, Raleigh, NC).
- Seater, John J., 1985, On the construction of marginal federal personal income and social security tax rates in the U.S., *Journal of Monetary Economics* 15, forthcoming.
- Tobin, James, 1980, Asset accumulation and economic activity: Reflections on contemporary macroeconomic theory (University of Chicago, Chicago, IL).
- Tanner, J. Ernest, 1979, An empirical investigation of tax discounting, *Journal of Money, Credit and Banking* 11, 214–218.