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ALTERNATIVE SPECIFICATIONS FOR CONSUMPTION AND THE ESTIMATION OF THE INTERTEMPORAL ELASTICITY OF SUBSTITUTION

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ABSTRACT

This paper documents several advantages associated with using state level consumption data to examine consumption behavior and especially to estimate the Intertemporal Elasticity of Substitution (IES). In contrast to the results of Hall (1988) and Campbell and Mankiw (1989), we provide substantial evidence indicating that the IES is significantly different from zero and probably close to one. Since the overidentifying restrictions of the standard Euler equation are generally rejected, we use these data to explore the nature of these rejections and evaluate an alternative specification of consumer behavior proposed by Campbell and Mankiw (1987, 1989, 1990). We take special care of examining the robustness of our results with respect to problems caused by the mismeasurement of the interest rate. In particular, we identify a common time component in expected consumption growth across states which, under the specifications of the theory, should reflect real interest rate movements. We find that the common time component closely matches the expected real return on Treasury bills as should be expected if the IES is different from zero and if the T-bill rate is an appropriate measure of interest rates.

Keywords: Intertemporal Elasticity of Substitution, Panel Data, Permanent Income Hypothesis, Rule of Thumb Consumers, Measurement Error.

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1. Introduction

The intertemporal elasticity of substitution in consumption (IES) plays a key role in innumerable policy evaluations. Much of the literature that focuses on this parameter is based on the estimation of the first order conditions associated with intertemporal optimization (the Euler Equation Approach). However, as has been emphasized among others by Mankiw (1981), Summers (1982), Hansen & Singelton (1983) and Mankiw, Rotemberg & Summers (1985), most of the existing estimates are problematic since they rely on specifications where the overidentifying restrictions are rejected by the data. In an attempt to offer a characterization of consumption behavior that is not rejected by the data, Campbell and Mankiw suggested a modification to the permanent income hypothesis in which a fraction of consumers follow the rule of thumb consisting of consuming their income.[1] Under this alternative specification, Campbell and Mankiw confirmed Hall's (1988) finding that an IES of zero cannot be rejected by the data.[2] Therefore, there seems to be an emerging concensus that the IES is close to zero even though the appropriate characterization of consumption remains debated.

In this paper we emphasize several of the difficulties associated with previous estimates of the IES and we indicate how state level consumption data can be used to remedy these difficulties. In particular, we use state level data to examine (1) whether the rejections of overidentifying restrictions repeatedly found in the literature represent an important failure of the Permanent Income Hypothesis or whether they are the result of interest rate mismeasurement, and (2) whether the inclusion of rule of thumb consumers as a remedy to these rejections warrants Campbell and Mankiw's conclusion that the IES is close to zero.

There are two main reasons why it is useful to use state level consumption data to examine consumption behavior and estimate the IES. First, these data are especially appropriate to assess whether the documented failures of the permanent income hypothesis

[1] They find that about 45% of all consumption is done by such rule of thumb consumers, with a standard error of about 20%. This is a little higher, but consistent, with studies by Hall and Mishkin (1982), Mariger (1986) and Jappelli (1990), who, using different methods, all find that about 20% of US households are liquidity constrained.

[2] Also taking account of the time aggregation problem, Campbell and Mankiw (1989) find estimates of the IES for the optimizing consumers close to 0.2. By redoing their regressions we find that the corresponding standard error is also 0.2.

may be due to an inappropriate choice of asset return.[3] In order to bypass the need to determine the appropriate asset return, we exploit the panel aspect of the data to identify a common time effect in expected consumption growth across states that we can compare with interest rate movements. This methodology provides a means of examining both the nature of the documented rejections of overidentifying restrictions as well as an indication of whether the interest rates are likely to affect consumption behavior.

The second reason for using state level data is that it provides more precise estimates of the IES than found using nation-wide aggregate data. The gain in precision is of particular importance when we adopt the specification of consumption behavior that includes the possibility of rule of thumb consumers. We show that using aggregate US data, estimates of the IES are very imprecise when rule of thumb consumers are permitted. For example, using non-durable goods as the measure of consumption, almost any value between 0 and 1.5 cannot be rejected.[4]

The main results of the paper can be summarized as follows. First, in contrast to the recent results from aggregate data, using state level consumption data we strongly reject a zero IES. In particular, we find that inferences regarding the IES have probably been biased downward due to the omission of rule of thumb consumers. When we include rule of thumb consumers, we find the IES to be significantly different from zero with point estimates close to 1. Second, the presence of rule of thumb consumers is a simple but robust interpretation of the failure of the permanent income hypothesis and cannot be explained away by a mis-measurement of interest rates. We find that the common component in expected consumption growth across states, after controling for expected income growth, closely matches the expected real return on T-bills.

The remaining sections of the paper are structured as follows. In section 2 we review the Euler equation approach to estimating the IES as well as Campbell and Mankiw's modification that introduces rule of thumb consumers. In section 3, we use aggregate US data to document the failures of the standard Euler equation approach and to indicate

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[3] As shown by Christiano (1989), adding measurement error to the interest rate can lead to low and insignificant point estimates of the IES, which might account for the results by Hall (1988) and Campbell and Mankiw (1989).

[4] Our approach of using regional panel data has some advantages over the use of micro level panel data, as in Runkle (1991) and Zeldes (1989). In particular, PSID data suffer from significant measurement error and a consumption measure that only includes food.

how the introduction of rule of thumb consumers leads to very imprecise estimates of the IES. Section 4 describes our state level data set and presents estimates of the IES based on these data. We also examine whether the failures of the Permanent Income Hypothesis observed in the aggregate data may be due to an inappropriate choice of asset return. Section 5 gathers concluding comments.

2. Empirical Specifications for Consumption Behavior

Much of the literature that examines the IES is based on estimating the first order conditions associated with the following maximization.

$$\max_{\{C_t\}_{t=0}^{\infty}} E_0[\sum_{t=0}^{\infty}(1+\beta)^{-t}\frac{C_t^{1-\sigma}}{1-\sigma}]$$

$$\text{s.t.} \qquad A_t + C_t = Y_t + A_{t-1}(1+r_t).$$

In this maximization, C_t represents consumption, Y_t stands for labor income, A_t represents assets and r_t denotes the real return of an asset held from period $t-1$ to t. Under the assumption that asset returns have a log-normal distribution, the Euler equation derived from this maximization leads to the characterization of consumption growth given by equation (2.1). In (2.1) g_t^c is the growth rate in consumption from $t-1$ to t, E_{t-1} is the conditional expectation operator based on information available at time $t-1$, ϵ_t is an expectational error that is uncorrelated with $t-1$ information and k_1 represents a covariance term which is assumed to be constant over the sample period.

$$g_t^c = k_1 + \frac{1}{\sigma}E_{t-1}[r_t] + \epsilon_t \qquad (2.1)$$

A consistent estimate of $\frac{1}{\sigma}$, which is the IES, can be obtained by replacing $E_{t-1}[r_t]$ by the ex-post real return on an asset and then estimating the equation by instrumental variables. Under rational expectations, any variables dated $t-1$ or earlier are admissible as instruments. However, as emphasized by Hall (1988), instruments dated $t-1$ may be problematic since the variables used for analysis are all time aggregates. Therefore, in all what follows, we only use instruments that are dated $t-2$ or earlier.

If instead of assuming that all consumers in the economy choose consumption in order to satisfy equation (2.1), we follow Campbell and Mankiw and assume that a fraction of consumption is done by "rule of thumb" consumers who simply consume their present income, then the appropriate specification for consumption growth is given by equation

(2.2). In (2.2), λ represents the fraction of consumption that is done by "rule of thumb" consumers, g_t^y represents the growth rate in income and $\theta = \frac{(1-\lambda)}{\sigma}$.[5]

$$g_t^c = k_1 + \theta E_{t-1}[r_t] + \lambda E_{t-1}[g_t^y] + \epsilon_t \tag{2.2}$$

Consistent estimators of θ and λ in equation (2.2) can again be obtained by instrumental variables once the expected return on the asset and the expected growth rate of income are replaced by there realized values. As instruments, any variable dated $t-2$ or earlier should be admissible.

3. Estimates of the Intertemporal Elasticity of Substitution using Aggregate US Data.

In this section we estimate equations (2.1) and (2.2) using aggregate US data. The main objective is to document the difficulties associated with using economy wide data to infer values for the IES. We also use this section to see whether results are sensitive to sample period and consumption measures, since this will be important for assessing the applicability of our results where we use only state level data on non-durable goods consumption over the period 1978-1991.

The estimations are based on quarterly aggregate US data from 1953:I to 1991:I. Campbell and Mankiw (1987, 1989, 1990) also start their sample period in 1953:I. Some earlier studies, such as Hall (1978, 1987) and Flavin (1981), use a sample period starting

[5] Equation (2.2) can alternatively be derived while maintaining the assumption that all consumers are intertemporal maximizers, but dropping the assumption that changes in asset positions are without cost. For example, if we assume that consumer's intertemporal utility function is given by the equation below, where $V(\cdot)$ represents the utility cost of changing assets, then a log linear approximation to the corresponding Euler equation results in an equation identical to (2.2). The only difference is the interpretation of λ. Under an adjustment cost formulation, λ reflects the cost of portfolio adjustment relative to the gains in consumption smoothing. Nevertheless, the relationship between the IES and the parameters in (2.1) remains IES $= \frac{\theta}{1-\lambda}$.

$$\sum_{t=0}^{\infty}(1+\beta)^{-t}\{U(C_t) - V(A_t - (1+r_t)A_{t-1})\}, \quad U''(\cdot) < 0 \quad \text{and} \quad V''(\cdot) > 0$$

in 1947. By starting the period in 1953 we avoid the Korean war, and also circumvent an extreme outlier in the last quarter of 1950.[6]

Three types of consumption variables are considered: non-durables (ND), non-durables plus services (NDS), and retail sales of non-durables. The latter is included since it corresponds to the data on consumption that is available at the state level. Moreover, since the state level retail sales data are available only since 1978, we also provide estimates of the IES for the subperiod 1978:I to 1991:I. We use two measures of aggregate retail sales data: one for the country as a whole (Retail) and one which corresponds to the aggregate consumption of the 19 states in our panel (Retail-19).[7] Consumption is deflated by the CPI for non-durable goods or the CPI for non-durable goods plus services. We use two types of nominal return variables: the 3 month T-bill rate and the stock return on the Standard and Poor 500. A tax rate of 30% on interest and dividend is assumed. The ex-post real return on T-bills is calculated by taking the average 3-month after tax T-bill interest rate, and subtracting the 3-month inflation rate, which depends on the choice of the consumption variable. The real stock return is the 3 month average return accruing from both dividend and capital gains minus the average three month inflation rate.

In the case of equation (2.2), the income variable we use is disposable personal income and is deflated by the overall CPI. However, when retail sales is used for consumption we use personal income as our income variable. This adjustment is made to allow a better comparison with the state level results since disposable income is not available at a quarterly level for individual states.

Table 1 presents estimates derived from estimating equation (2.1). The column Lags indicates how many lags are used for each instrument. For example, three lags means that instruments at $t-2$, $t-3$, and $t-4$ are used. The first point to note is that there is a significant difference between the results based on stock returns and those on T-bills. Similar to Hall (1988), we find that the results based on stock returns always show estimates of the IES that are very close to zero, with small standard errors. However,

[6] In the last quarter of 1950 deseasonalized consumption of non-durables rose by 9.2% annually, leading to significant inflation and a real return on T-bills of -16 % annually for that quarter.

[7] The instruments used are always based on national data, and not on the sum of the 19 states. This is because retail sales data for 1976 and 1977 are available nationally, but not for individual states.

results based on stock returns are potentially questionable since stock returns are hard to predict. In particular, Nelson and Startz (1988) have shown that when instruments are poor, the small sample properties of IV estimates are unreliable. Therefore, we consider the results based on T-bill returns to be potentially more dependable.

The results in Table 1 obtained when using the T-bill rate as the asset variable almost uniformly suggests an IES that is greater than zero. The point estimates are mostly in a range between 0.25 and .4 with standard errors near 0.12. The estimates are slightly higher in the most recent period and for the cases where services are not included in the measure of consumption. Using non-durables consumption and a T-bill return, for the sample period 1947-1983, Hall (1988) found a small and insignificant IES. The difference can be attributed to the outlier in the last quarter of 1950 that was mentioned above. Remarkably we find that while the results are practically the same as those in Table 1 if we start the sample in 1951:I, starting the sample in 1950:IV, or earlier, leads to an IES that is insignificant.[8]

Table 2 presents results corresponding to the estimation of equation (2.2) where rule of thumb consumers are introduced. The last column presents the χ^2 statistic associated with the Lagrange Multiplier test of over-identifying restrictions.[9] Here the return variable is always based on the T-bill rate. The estimate of λ, which represents the fraction of rule of thumb consumers, is always positive and significant.[10] This suggests that the standard Euler equation without rule of thumb consumers is based on a mis-specified model. Moreover, the test statistics in the last column provide some evidence in favor of the permanent-income-cum-rule-of-thumb specification, since the overidentifying restrictions are never rejected even at the 10% level. It is especially important to note that in Table 2 the estimates of the IES are insignificantly different from zero in each

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[8] When we estimate the reverse normalization of the Euler equation, which corresponds to regressing asset returns on expected consumption growth, we find estimates of $\frac{1}{\text{IES}}$ close to one. These estimates are similar to the results of Hansen and Singleton (1983) and Summers (1982) who also estimate $\frac{1}{\text{IES}}$ instead of the IES. The difference in results coming from a choice of normalization is an indication of mis-specification.

[9] This test statistics is T times the R^2 from the regression of the residuals derived from estimating (2.2) by IV on the instruments, which has a $chi^2(k-1)$ distribution with k being the number of instruments. This test is appropriate in our context since we do not find any evidence of autocorrelation in error terms from the IV regression.

[10] We examined whether non-separabilities between either consumption and leisure, present consumption and past consumption or between the consumption of durable and the consumption of non-durable goods could explain this observation. We did not find any evidence in favor of such a hypothesis.

sample period. Only if one uses the entire sample, non-durables consumption, and three instruments does the IES become marginally significant.[11] In view of these results, we may conclude that an IES of zero cannot be rejected if one is ready to accept the possibility of rule of thumb consumers, which is the conclusion reached by Campbell & Mankiw (1989). However, the opposing view of a relatively high values for the IES cannot be rejected either. For example, based on the entire sample period and based on measures of consumption that include only non-durable goods, the IES could take on any value between 0 and 1.5. In the case where services are included in consumption, our estimates of the IES suggest values between 0 and 0.6.

In both Tables 1 and 2, we find that the estimates of the IES are always higher when based only on the consumption of non-durables as opposed to the consumption of non-durables and services. This may be explained by the fact that services include medical expenditures and a flow measure for housing services. For one, most medical services are insured, and insurance companies provide few incentives for consumers to intertemporally substitute, therefore estimating a low IES for services may reflect more the difficulty of providing incentives within medical insurance policies than the actual willingness for consumers to substitute. Second, the *Imputed* cost of housing is the largest item in services and since it does not include expected capital gains or losses, it may also be contributing to the lower estimates of the IES. In effect, since the quantity of housing services is almost fixed in the short run, any desire to intertemporally substitute will have to be reflected in the cost of housing. Consequently, any mis-measurement of the actual cost of housing could greatly impair any evidence of short run intertemporal substitution, and therefore implies that estimating the IES using these measures for services may lead to unreliable estimates.

4. Estimating the IES with State Level Data

The results of the previous section indicate that estimates of the IES that are based on the standard Euler equation specification for consumption (equation (2.1)) are generally

[11] Our results using aggregate data are very similar to those presented by Campbell and Mankiw. For example, based on the sample period 1953-1986 and on the consumption of non-durable goods and services, we estimate the IES to be approximately 0.2 with a standard error of 0.2. However, contrary to Campbell & Mankiw, we do not interpret such results as clear indication that the IES is close to zero.

significantly different from zero with point estimates mostly in a range between 0.25 and 0.4. However, the fact that expected income growth significantly helps predict consumption growth in equation (2.2) signals an important problem with the standard specification of consumption Euler equations. If we accept the introduction of rule of thumb consumers as a reasonable modification to the theory, we find that aggregate US data provide with very little information regarding the value of the IES. Therefore, based on aggregate US data, we believe that it is problematic to infer much regarding the value of the IES.

In this section we use state level consumption data in view of improving our knowledge of the IES. We begin by showing that, conditional on accepting the structural interpretation of equation (2.2), the data strongly suggest that the IES (for non-durable goods) is greater than 0.5 and most probably close to 1. In order to assess the relevance of this result, we further exploit the panel aspect of the data to examine whether the permanent-income-cum-rule-of-thumb interpretation of the data is robust. In particular, we examine whether the presence of rule of thumb consumers may be an artifact caused by the mis-measurement of interest rates and whether the T-bill rate is in fact an appropriate measure of asset returns.

The consumption data we use are state level retail sales data for non-durable goods. These are unpublished data available from the Bureau of the Census. Our data set includes non-adjusted quarterly data from 19 states over the period 1978:I to 1991:I. The states are: California, Florida, Illinois, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Texas, Tennessee, Wisconsin, and Virginia. For all other states, either these data are not available or they are only available since 1987:I. Consumption is deflated using regional consumer price indices for non-durable goods and is transformed to a per-capita basis (state level price indices are not available). For each of these states, we use personal income data from the Bureau of Economic Analysis as our measure of income, which are transformed to a per-capita basis and deflated using the consumer price index for all goods. The income data are by place of residence. The ex-post state asset returns are the average 3 month US T-bill rate minus the holding period regional inflation rate.

Table 3 presents results from estimating equation (2.2) using the state level data. The instruments are different combinations of the real return on T-bills, and the growth of aggregate US personal income, aggregate US consumption of non-durable goods (retails sales data), aggregate US investment and total government spending on goods and services. The variance-covariance structure of the error term allows for heteroscedaticity across states and for arbitrary contemporaneous covariances between states. The serial correlation in the error terms was found to be insignificant and therefore was set to zero. Since the state level consumption data are not deseasonalized, we estimate equation (2.2) with seasonal dummies that are allowed to vary between states.[12]

The results in Table 3 are all quite similar. The estimates of the IES cluster around 1 with a standard error of approximately 0.3, clearly rejecting an IES of zero. Compared with the results using aggregate data, the most important change is in terms of precision. In particular, over the period 1978:I-1991:I the results using aggregate data on non-durable goods indicates values of the IES close to 1, but the estimated standard errors are also close to 1. The improved precision comes from two sources. First, the cross-state variation in expected income growth greatly improves the precision in λ, which directly translates into more precision for the IES. Second, the estimation efficiency is improved by allowing for an arbitrary contemporaneous variance covariance structure of the residuals across states. Potentially, the cross-state variation in real returns could also be contributing to the improved precision due to differences in expected inflation. However, this variation is rather insignificant in our data.

The interpretation of the estimates in Table 3 concerning the IES depend on the validity of the permanent-income-rule-of-thumb specification of consumption growth. In particular, our estimates of the IES rely on interpreting the mis-specification of the standard Euler equation as indication of the presence of rule of thumb consumers instead of other less substantial departures from the permanent income hypothesis. However, it may be the case that the standard Euler equation specification is valid but that the overidentifying restrictions are rejected because of an improper measurement of the interest rate. One of the advantages of panel data is that it is feasible to examine this possibility and test whether the perceived superiority of the rule of thumb specification may be a reflection of measurement problems.

[12] These seasonal dummies can be interpreted as reflecting seasonal taste shocks, which are assumed to be independent of lagged information.

There are at least three reasons which suggest difficulties in appropriately measuring the interest rate. First, because of transaction costs, it is unclear how to determine the relevant marginal return for the representative consumer. Second, without an exact knowledge of the representative consumers's decision periods, uncertainty about the appropriate time-aggregation of the interest rates will be present. Third, consumer heterogeneity may warrant the use of an average rate of return on different assets instead of the rate on only one asset. Note that each of these problems can lead to a mis-measurement error that is not uncorrelated over time and therefore is not necessarily cured by the use of Instrumental Variables.

4.1. Examining Biases due to Inappropriate Measures of Interest Rates

In order to understand the biases that can be caused by an improper choice of interest rate, let us consider the state level counterpart to equation (2.1), given by equation (4.1). Since the retail sales data are not deseasonalized, equation (4.1) explicitly includes seasonal effects. In equation (4.1), subscripts i denotes the state, the variables $S_{i,j}$ represent state level seasonal effects (j = 1to4) and Ω_{t-1} represents the aggregate information set at time $t-1$. The term $\pi_{i,t+1} - \pi_{t+1}$ is the differential between state level inflation and aggregate inflation and reflects the possibility of different real interest rates between state.[13] Even though information sets may differ among states, it is always possible to express all expectations with respect to aggregate variables as long as the aggregate information is assumed to be available in each state.

$$g^c_{i,t} = S_{i,j} + \frac{1}{\sigma}E[r_t/\Omega_{t-1}] - \frac{1}{\sigma}E[\pi_{i,t} - \pi_t/\Omega_{t-1}] + \epsilon_{i,t} \tag{4.1}$$

If we assume we know how to measure the relevant ex-post real interest rate r_t, then we can estimate equation (4.1) by instrumental variables. This has been our maintained hypothesis to date. However, if our choice of interest rate is inappropriate, this could lead to the rejections of the overidentifying restrictions and a bias in favor of finding rule of thumb consumers. To see this, let the conditional expectation of the appropriate real interest rate be given by equation (4.2) and that of an inappropriate interest rate, denoted $\tilde{r}_t$, be given by (4.3).

[13] Note that the estimates presented in Table 3 were obtained by imposing that the coefficient on $E_{t-1}[r_t]$ be equal to the coefficient on $-E_{t-1}[\pi_{i,t} - \pi_t]$.

$$E[r_t/\Omega_{t-1}] = \Omega'_{t-1}\gamma_1 \tag{4.2}$$

$$E[\tilde{r}_t/\Omega_{t-1}] = \Omega'_{t-1}\gamma_2 \tag{4.3}$$

Using equations (4.2) and (4.3), we can rewrite (4.1) as in (4.4).

$$g^c_{i,t} = S_{i,j} + \frac{1}{\sigma}E_{t-1}[\tilde{r}_t] - \frac{1}{\sigma}E_{t-1}[\pi_{i,t} - \pi_t] + \epsilon_{i,t} + \frac{1}{\sigma}\Omega'_{t-1}(\gamma_1 - \gamma_2) \tag{4.4}$$

If $\gamma_1 \neq \gamma_2$, then the error term in equation (4.4) includes all variables in the information set. Consequently, an inappropriate choice of asset return could be the cause of the rejection of the overidentifying restrictions and could be the reason for the better fit of the rule-of-thumb specification.

In order to examine this possibility, it is useful to estimate equation (4.1) by replacing $E[r_t/\Omega_{t-1}]$ by its unrestricted form given in (4.2) and including expected income growth as an additional regressor. On the one hand, if the failure of the standard Euler equations for consumption is due to a mis-measurement of the interest rate, then allowing for expected state income growth in this less restrictive specification should lead to an insignificant coefficient on income. On the other hand, even if λ is significant and the rule of thumb specification is appropriate, an inappropriate choice of interest rates could lead to a bias in the estimates of the fraction of the population that are rule of thumb consumers. Consequently, replacing the expected real interest rate by its unrestricted reduced form should allow us to determine the biases in the estimates of λ that can be due to the difficulty in measuring interest rates.

Table 4 presents the results associated with the estimation of Equation (4.5) for different aggregate information sets Ω_{t-2}. Equation (4.5) modifies (4.1) in the following manner: (a) the expected interest rate is replaced by its unrestricted reduced form to avoid the need of identifying the proper measure for asset returns, (b) expected income growth is included to test for the presence of rule of thumb consumers, (c) the information set is restricted to include only information as of time $t-2$ in order to avoid problems caused by time aggregation and (d) the expected inflation differential is set to zero. The last modification is adopted only because we could not reject that the expected inflation differential between each state was zero based on aggregate information. Nevertheless, none of our results are sensitive to the inclusion of this differential and, correspondingly, when it is included its estimated coefficient is always close to zero and very imprecisely estimated.[14] Our estimation of (4.5) again allows for cross-state correlations in the error terms and for cross-state heteroscedasticity (because of time aggregation, the information set is again constrained to include only information as of $t-2$).[15]

$$g^c_{i,t} = S_{i,j} + \frac{(1-\lambda)}{\sigma}\gamma_1'\Omega_{t-2} + \lambda E[g^y_{i,t}/\Omega_{t-2}] + \epsilon_{i,t} \tag{4.5}$$

It is important to note that the estimation of equation (4.5) requires panel data. With only time series data it is impossible to simultaneously identify an unrestricted time effect and the effect of expected income growth due to collinearity. With state level data, the cross-sectional variation in expected income growth allows us to identify these two components since, for each state, expected income growth is a different linear combination of the variables in the information set.

The first column of results in Table 4 reports the chi-square statistic for the test that the vector $\frac{(1-\lambda)}{\sigma}\gamma_1 = 0$. If the interest rate is predictable ($\gamma \neq 0$) and not all consumers are of the rule of thumb type ($\lambda < 1$), then this test correspond to the null hypothesis that the IES=0. Column 2 presents the estimates of λ and Column 3 is a chi-square statistic associated with the hypothesis that, conditional on expected income growth, the aggregate variables only enter the Euler equations in proportion to the linear combination that predicts the T-bill return, that is, it is a test of whether the T-bill return is an appropriate measure of the interest rate faced by optimizing consumers.

The most important finding form Table 4 is that mis-measurement of interest rates cannot account for the rejection of standard Euler equation specification. In fact, the estimates of λ in all cases are quite significant, with point estimates between 0.3 and 0.5. These point estimates are very close to those reported in Table 3 when the real return on T-bills was assumed to be an appropriate measure of the interest rate. On

14 The estimates presented in Table 3 are also insensitive to adopting the hypothesis that the expected inflation differentials across regions are zero.

15 We found no evidence of serial correlation of the error term.

average, the point estimates of λ are approximately 0.1 smaller when the interest rate is replaced by its unrestricted reduced form compared to when it is obtained by IV estimation. Although these differences are not statistically significant, they may suggest a slight mismeasurement of the interest rate. Together these results confirm the difficulties associated with the pure Permanent Income hypothesis and suggests that the rule-of-thumb specification may possibly be a better description of consumer behavior.

Identifying a Common Time Effect in State Consumption Growth

The chi-square statistic reported in column 1 of Table 4 indicates that there is a significant common time effect , $\frac{(1-\lambda)}{\sigma}\gamma_1'\Omega_{t-2}$, driving state level consumption growth, even after controlling for expected income growth.[16] Under the assumptions of the permanent-income-rule-of-thumb specification, this estimated time effect should reflect the common cross-state substitution pattern that is induced by changes in the intertemporal price of consumption. In order to visually evaluate this claim, Figures 1 and 2 plot both the yearly average of this estimated common time effect ($\frac{(1-\lambda)}{\sigma}\gamma_1'\Omega_{t-2}$) and the yearly average of the expected real return on 3 month T-bills. The unobserved expected return variable should be a linear function of the estimated common time effect and therefore this time effect has been scaled to be comparable with the expected real return on T-bills. The difference between the two figures is the set of variables used as instruments. Figure 1 corresponds to the specification in row 4 of Table 4, where the instruments are the real return on T-bills, US consumption growth, and US income growth. This figure has been chosen as a representation of one of the worst fits within the Table (our criterion for goodness of fit in based on the chi-square statistic in the last column of Table 4). Figure 2 corresponds to the specification in row 2, where the instruments are the real return on T-bills and US consumption growth. This figure has been chosen as one of the best fits. It is clear that the estimated common time effect moves very closely with the expected return on T-bills, and therefore is suggestive of a common response to changes in expected asset returns. In fact, the expected return on T-bills explains over 90% of the variance in this common time effect in Figure 2.

The most telling aspects of Figure 1 and 2 come from the observations in the late

[16] The common time effect is not estimated by the use of time dummies because we want to identify the common component in expected consumption growth and not in realized consumption growth.

seventies and early eighties. In the late seventies, income growth was positive but the common time effect in expected consumption growth is observed below mean potentially because of low interest rate. In contrast, in 1982 income growth was weak, but high expected interest rates seem to drive expected consumption growth high above its mean. At a minimum, the observation that there is a significant common time effect in state level consumption growth and that this common driving force tracks the interest rate very closely, are together substantial evidence in favor of the hypothesis that the IES is different from zero. Therefore, any presupposition of an IES of zero should be required to explain this observation.

The last column of Table 4 presents a chi-square statistic associated with testing whether the common time effect is fully captured by the variations in the expected return on T-bills. This specification test of the permanent-income-rule-of-thumb specification is performed by testing whether equation (4.5) admits the restrictions imposed by setting $\frac{(1-\lambda)}{\sigma}\gamma'\Omega_{t-2}$ proportional to $E[r_t/\Omega_{t-2}]$, where r_t is the real expected T-bill return. Somewhat surprisingly for such a demanding test, the rejections are not very strong. We obseve p-values below 0.05 in only 4 of the 11 cases. This result is consistent with the observation in Figures 1 and 2 of a close relationship between the expected return on T-bills and the estimated common time effect. Moreover, even in the case where the p-value is relatively low, as in row 4, the depiction of this case in Figure 1 suggests that the departure may not be economically very significant. Given that no simple specification of aggregate consumption growth will fit the data perfectly, we interpret these results as being quite supportive of the rule-of-thumb specification inclusive of the use of T-bills as a reasonable measure of interest rates. Therefore, we view the structural interpretation of the results from Table 3 as defensible.

5. Conclusion

The aim of this paper is to provide insight with regards to the value of the intertemporal elasticity of substitution. As we have shown, aggregate data for the entire US economy are rather uninformative on this subject. In contrast, we find that state level data provides an important alternative means of both testing alternative characterizations of consumption behavior and of estimating the IES. In particular, these data indicate that the introduction of rule of thumb consumers is a reasonable and robust addition to the characterization of consumption behavior and that conditional on this interpretation, the IES for non-durable consumption goods is probably close to 1. Moreover, these data have allowed us to document the close relationship between the common time effect in cross-state consumption growth and the expected return on T-bills (after controlling for expected state income growth). Regardless of the exact interpretation of consumption behavior, this observation alone provides considerable evidence of the willingness of consumers to intertemporally substitute in response to interest rate movements.

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TABLE 1
Aggregate US data

Sample	Consumption	return	instruments	Lags	IES (stand.error)
1953:I-1991:I	ND	T-bill	T-bill	3	0.375 (0.124)
	ND	T-bill	T-bill	4	0.370 (0.124)
	ND	T-bill	T-bill,g^c	4	0.334 (0.108)
	ND	stock	stock,g^c	3	0.112 (0.086)
	NDS	T-bill	T-bill	3	0.255 (0.118)
	NDS	T-bill	T-bill	4	0.245 (0.118)
	NDS	T-bill	T-bill,g^c	4	0.229 (0.111)
	NDS	stock	stock,g^c	3	-0.042 (0.061)
1978:I-1991:I	ND	T-bill	T-bill	3	0.486 (0.158)
	ND	T-bill	T-bill,g^c	3	0.358 (0.142)
	ND	stock	stock,g^c	3	0.112 (0.058)
	Retail	T-bill	T-bill	3	0.482 (0.197)
	Retail	T-bill	T-bill,g^c	3	0.453 (0.187)
	Retail	stock	stock,g^c	3	0.124 (0.059)
	Retail-19	T-bill	T-bill	3	0.524 (0.218)
	Retail-19	T-bill	T-bill,g^c	3	0.520 (0.208)
	Retail-19	stock	stock,g^c	3	0.121 (0.062)
	NDS	T-bill	T-bill	3	0.379 (0.164)
	NDS	T-bill	T-bill,g^c	3	0.344 (0.160)
	NDS	stock	stock,g^c	3	0.036 (0.040)

TABLE 2

A) 1953:I-1991:I[a]

Consumption	instruments	Lags	θ (stand.error)	λ (stand.error)	IES (stand.error)	χ^2(df) (p-value)
ND	T-bill,g^c	3	0.211 (0.121)	0.763 (0.252)	0.889 (0.959)	8.54(5) (0.129)
ND	T-bill,g^c	4	0.222 (0.112)	0.717 (0.203)	0.785 (0.590)	9.21(7) (0.238)
ND	T-bill,g^c,g^y	3	0.215 (0.108)	0.596 (0.196)	0.522 (0.319)	12.59(8) (0.127)
NDS	T-bill,g^c	3	0.122 (0.107)	0.463 (0.118)	0.228 (0.147)	5.91(5) (0.315)
NDS	T-bill,g^c	4	0.134 (0.105)	0.469 (0.112)	0.251 (0.190)	6.06(7) (0.533)
NDS	T-bill,g^c,g^y	3	0.116 (0.102)	0.388 (0.111)	0.190 (0.162)	7.66(8) (0.467)

B) 1978:I-1991:I

Consumption	instruments	Lags	θ (stand.error)	λ (stand.error)	IES (stand.error)	χ^2(df) (p-value)
ND	T-bill,g^c	4	0.231 (0.164)	0.848 (0.274)	1.522 (2.696)	3.18(7) (0.468)
ND	T-bill,g^c	3	0.311 (0.204)	1.008 (0.353)	-37 (-1569)	6.894(5) (0.229)
ND	T-bill,g^c,g^y	3	0.295 (0.184)	0.885 (0.203)	2.598 (6.843)	3.11(8) (0.927)
Retail	T-bill,g^c	3	0.360 (0.192)	0.667 (0.281)	1.079 (0.889)	3.20(5) (0.669)
Retail	T-bill,g^c	4	0.260 (0.165)	0.727 (0.261)	0.952 (0.959)	5.26(7) (0.6283)
Retail	T-bill,g^c,g^y	3	0.352 (0.185)	0.596 (0.268)	0.872 (0.576)	7.75(8) (0.459)
Retail-19	T-bill,g^c	3	0.289 (0.174)	0.686 (0.255)	0.920 (0.760)	2.90(5) (0.715)
Retail-19	T-bill,g^c	4	0.260 (0.152)	0.705 (0.241)	0.881 (0.773)	7.08(7) (0.420)
Retail-19	T-bill,g^c,g^y	3	0.274 (0.167)	0.641 (0.242)	0.763 (0.537)	6.67(8) (0.573)
NDS	T-bill,g^c	3	0.288 (0.182)	0.524 (0.180)	0.604 (0.423)	2.78(5) (0.734)
NDS	T-bill,g^c	4	0.223 (0.153)	0.392 (0.125)	0.367 (0.248)	8.05(7) (0.328)
NDS	T-bill,g^c,g^y	3	0.274 (0.166)	0.439 (0.155)	0.488 (0.309)	5.90(8) (0.658)

TABLE 3

Panel of 19 States
1978:I-1991:I

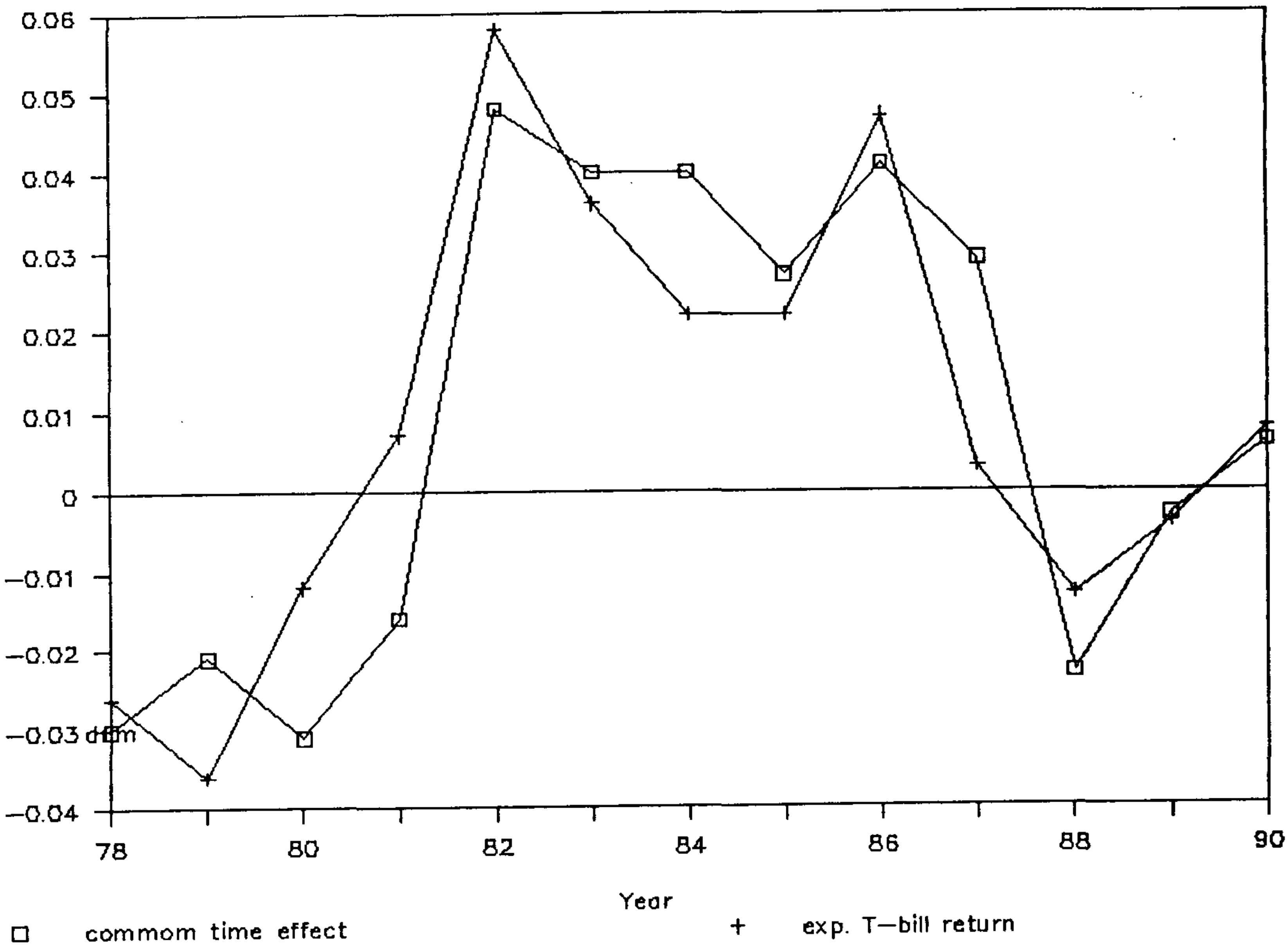
instruments	Lags	θ (stand.error)	λ (stand.error)	IES (stand.error)
T-bill, g^c	4	0.382	0.597	0.946
		(0.120)	(0.099)	(0.344)
T-bill, g^c	3	0.497	0.548	1.100
		(0.137)	(0.102)	(0.349)
T-bill, g^c	2	0.640	0.319	0.940
		(0.151)	(0.131)	(0.256)
T-bill, g^c, g^y	3	0.507	0.537	1.095
		(0.130)	(0.095)	(0.320)
T-bill, g^c, g^{gnp}	3	0.402	0.445	0.725
		(0.119)	(0.097)	(0.222)
T-bill, g^c, g^{Inv}	3	0.508	0.545	1.118
		(0.117)	(0.097)	(0.302)
T-bill, g^c, g^{gov}	3	0.362	0.517	0.752
		(0.116)	(0.097)	(0.252)
T-bill, g^y	3	0.402	0.633	1.095
		(0.138)	(0.112)	(0.439)
T-bill, g^{gnp}	3	0.309	0.551	0.688
		(0.132)	(0.110)	(0.293)
T-bill, g^{Inv}	3	0.452	0.623	1.209
		(0.122)	(0.113)	(0.404)
T-bill, g^{gov}	3	0.331	0.572	0.774
		(0.132)	(0.117)	(0.210)

TABLE 4

Panel of 19 States
1978:I-1991:I

instruments	Lags	Time effect($\chi^2(df)$) (p-value)	λ (stand.error)	T-bill($\chi^2(df)$) (p-value)
T-bill,g^c	4	20.29(8) (0.009)	0.43 (0.12)	11.14(7) (0.133)
T-bill,g^c	3	21.01(6) (0.002)	0.38 (0.12)	6.94(5) (0.225)
T-bill,g^c	2	20.95(5) (0.001)	0.28 (0.15)	5.37(3) (0.147)
T-bill,g^c, g^y	3	33.80(9) (0.000)	0.47 (0.11)	19.9(8) (0.011)
T-bill,g^c, g^{gnp}	3	25.76(9) (0.002)	0.24 (0.12)	14.60(8) (0.067)
T-bill,g^c, g^{Inv}	3	41.00(9) (0.000)	0.38 (0.12)	19.1(8) (0.014)
T-bill,g^c, g^{gov}	3	25.80(9) (0.0021)	0.31 (0.12)	11.6(8) (0.012)
T-bill,g^y	3	28.74(6) (0.000)	0.60 (0.13)	20.62(5) (0.001)
T-bill,g^{gnp}	3	15.22(6) (0.019)	0.45 (0.13)	10.28(5) (0.068)
T-bill,g^{Inv}	3	26.03(6) (0.002)	0.47 (0.13)	11.98(5) (0.035)
T-bill,g^{gov}	3	12.75(6) (0.047)	0.53 (0.13)	8.49(5) (0.114)

Figure 1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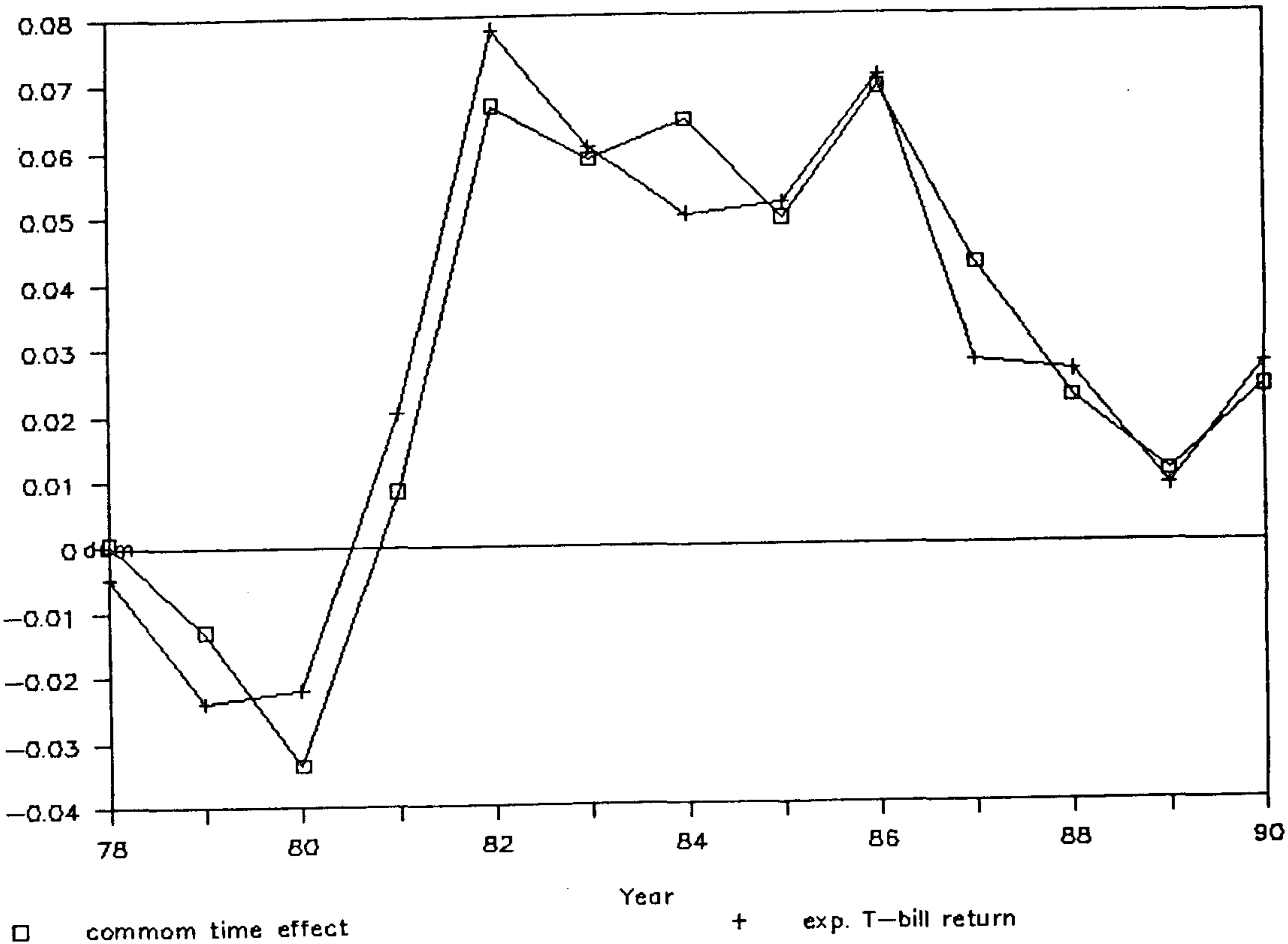
Year
□ commom time effect
+ exp. T—bill return

Figure 2



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Year
commom time effect
exp. T-bill return