THE PERMANENT INCOME HYPOTHESIS AND
CONSUMPTION DURABILITY: ANALYSIS
BASED ON JAPANESE PANEL DATA

Fumio Hayashi

The Permanent Income Hypothesis and Consumption Durability:
Analysis based on Japanese Panel Data

ABSTRACT

The permanent income hypothesis is tested on a four-quarter panel of about two thousand Japanese households for ten commodity groups. Consumption is a distributed lag function of expenditures, and the utility function is additively separable in time. Durability is defined as the persistence of the distributed lag. The permanent income hypothesis implies that, for each commodity group, expected change in expenditures is correlated neither with past expenditure changes on other commodities nor with expected change in disposable income, if its own lags are controlled for. The main results are the following: (1) durability is substantial even for food and services, (2) the permanent income hypothesis applies to almost all (probably more than ninety percent) of the population, and (3) the habit persistence hypothesis is rejected in favor of the permanent income hypothesis.

Fumio Hayashi
Institute of Socio-Economic
    Planning
University of Tsukuba
Sakura, Ibaraki 305, JAPAN

1. INTRODUCTION and SUMMARY

The empirical validity of the permanent income hypothesis[1] is a long-standing issue that has been debated for nearly three decades. At the heart of the debate is the question of whether or not consumption is "too sensitive" to income fluctuations. Its operational meaning was not given until the publication of Hall's (1978) paper which has shown that the permanent income hypothesis implies the marginal utility of consumption is a martingale. Since then quite a few papers have studied the issue of the excess sensitivity of consumption.[2] Many of them have also tried to estimate the fraction of households in the population that follow the permanent income hypothesis rather than simply keep track of disposable income. Although those papers differ in terms of the component of consumption (food, nondurables, services, or durables) and the kind of data set (time-series, cross-section, or panel) that they use, there seems to be a consensus that the permanent income hypothesis applies to 70 to 100 percent of the population.

As impressive as it is, the empirical literature has failed to address two important issues. First, not much attention has been paid to the distinction between consumption and expenditures. Total expenditures are dichotomized into perishables (nondurables and services) and durables. Since the permanent income hypothesis is a theory about the flow of consumption, the empirical literature has either looked at perishables alone or singled out durables for special treatment. However, it is not entirely clear that most commodities labeled as nondurables and services are perishable so that consumption and expenditures can be equated. A good example is dental services.[3] People go to a dentist not because they enjoy the treatment but because they hope that their teeth will be in good shape for some time to come. So dental services are essentially durable expenditures. Another

example is a pleasure trip. It is obviously physically perishable, but it might have a lasting psychological effect on preferences as people derive utility from the memory of a trip. If so, recreational expenditures should be treated as if they are durable expenditures. Second, all the empirical evidence that has been put forth to support the permanent income hypothesis — with a possible exception of Hall and Mishkin (1982) — seems to be also consistent with the habit persistence hypothesis (Brown [1952]) that current consumption is determined by the history of past consumption and current income. If households are forward-looking as is postulated by the permanent income hypothesis, the distinction between permanent and temporary tax changes is a crucial one. That is not the case if households are backward-looking as is postulated by the habit peristence hypothesis. So it is important from the viewpoint of stabilization policies to discriminate the permanent income hypothesis from the habit persistence hypothesis.

This study attempts to address the above two issues as well as obtain a sharper estimate of the fraction of the population that is explained by the permanent income hypothesis. It uses a four-quarter panel of about two thousand households in Japan for ten commodity groups. The unique feature of this data set is that it has information on expectations about expenditures and income. The most striking fact revealed by the data set is that an increase in expenditures tends to be followed by a decrease, i.e., the first-order autocorrelation in expenditure changes are negative. This seems to be inconsistent with the permanent income hypothesis, if consumption is well proxied by expenditures.

The theoretical model in this study makes an explicit distinction between consumption and expenditures by postulating that consumption is a distributed lag function of current and past expenditures. Otherwise the model is a

standard one: the household's objective function is additively separable in time, and the lifetime budget constraint is the only constraint faced by the household. It is shown, under a certain set of restrictions on the household's preferences, that consumption follows a martingale. This means that change in expenditures on any single commodity group depends only on its own past changes and unforecastable events, namely it is an univariate auto-regression. If the commodity is perishable both physically and psychologically (so that expenditures affect the utility only for the current period), there should be no lagged expenditure changes in the univariate autoreg-ression; if the commodity is highly durable, lagged expenditure changes should have coefficients close to unity in absolute value. Thus the theoretical model provides a unified treatment of commodities with differing degrees of durability. This is useful from the viewpoint of macroeconomic stabilization policies, because the implied equation is stated in expenditures, not in consumption, and expenditures are components of aggregate demand.

There are three major empirical findings that emerge from the estimation of the model. First, lagged expenditure changes are significant even for food and services, which suggests that they are not really perishables. Second, if its own lags are controlled for, current change in expenditures is not sensitive to the forecastable part of current income change. That is to say, the martingale hypothesis is valid in consumption, but not in expenditures. Third, current change in expenditures is sensitive to the unforecastable part of current income change. It is hard to reconcile this finding with the habit persistence hypothesis which assumes households are backward-looking.

The plan of the paper is as follows. Section 2 describes the data set and takes a look at sample means, standard deviations, and correlations of relevant variables. Section 3 presents the theoretical model and derives the

equation stated in expenditures. A few econometric issues concerning the estimation of the equation on a short panel are discussed in Section 4. Parameter estimates are presented in Section 5. The paper concludes with a few remarks in Section 6.

2. DATA DESCRIPTION

The data set for the present study is obtained from the 1982 Survey of Family Consumption compiled by the Economic Planning Agency of the Japanese government. This is an interview panel survey in which families reported to visiting interviewers every three months over a four-quarter period (1981:Q2–1982:Q1). More specifically, respondents are asked at the end of each quarter to provide the following information: (i) expenditures on ten different and mutually exclusive commodity groups for the quarter,[4] (ii) "normal" income net of taxes and social security contributions, (iii) "temporary" income net of taxes and social security contributions, (iv) the respondent's expectations (at the end of each quarter) of all the variables in the above three items for the following quarter, and (v) family characteristics (occupation, family size, age of the head, and housing tenure).[5] "Normal" income is equal to after-tax labor income net of bonuses. "Temporary" income is the sum of property income, bonuses, severence pay, and tax returns at the end of a calender year. The survey does not cover one-person households. Although this is not a diary survey, interviewers actually visited the households every quarter and the respondents filled out the questionaire in the presence of the interviewer. There are practically no attritions: for any quarter at least 99.5 percent of the surveyed 5,837 households responded. Information about food, for example, is elicited by the question: "How much did your family

spend on food for the last three months?" and "How much do you expect your family will spend on food for the next three months?"

Of the original sample, only "workers' households," namely households whose head is on a payroll, are selected. They are about 58 percent of the original sample. Farmers and households with unincorporated business are excluded from the sample as their income pattern is distinctly different from that of workers' households who receive semiannual bonuses. If the age of the head either increases by more than a year or decreases, the household is deleted in forming the panel. It became necessary to delete the sample from the entire Tokyo prefecture and other parts of the country, because I could not form a four-quarter panel due to some coding problem. At this stage the sample size became 2,518. From this, households which did not provide relevant information (455 cases) and then households which changed their housing tenure (from a homeowner to a nonhomeowner or from a nonhomeowner to a homeowner) (46 cases) are deleted.[6] This left a sample of 2,017 cases. For this sample I examined the empirical distribution and decided to remove seven cases which reported extreme values.[7] The sample size become 2,010.

The variables used in the analysis are as follows (for a quick reference see Table 8):

C1 = expenditures on food (including liquor and beverages and excluding meals away from home);

C2 = expenditures on rents, fuel and utilities;

C3 = expenditures on clothing and household textiles;

C4 = expenditures on consumer durables (including furniture, electric appliances, musical instruments, cameras, automobiles, bikes, bicycles, sports equipments, and stainless sinks);

C5 = recreational expenses (including vacation expenses, movies,

admission fees, and meals away from home);

C6 = "cultural" expenses (including reading materials, tuition for cultural activities such as flower arrangement, cooking, tea ceremoy, music and dance);

C7 = educational expenses (including tuition, books, supplies and equipments for kindergardens, elementary and high schools, colleges and universities);

C8 = medical expenses not paid by the national health insurance, glasses and medical appliances for personal use;

C9 = "social" expenses (including gifts and contributions);

C10 = other expenditures (including housewares, repairs, personal care services, transportation and communication, telephone charges, private insurance premiums, shoes, unbrellas, and vehicle operations);

YT = "temporary" income consisting of bonuses, income from interests, dividends and estates, insurance payments, severance pay, and tax returns;

YN = "normal" income consisting of regular wages and salaries; the sum of YN and YT is equal to income net of taxes, social security contributions, and national health insurance taxes;

YD = YN + YT, disposable income;

AGE = age of the household head;

FSZ = family size (i.e., the number of persons in the family).

I use subscripts to denote the quarter. For example, $C1_1$ is food expenditures in the first quarter of the panel (1981:Q2), and $C1_4$ is food expenditures in quarter four (1982:Q1). Consumption and income variables are all deflated by the corresponding components of the CPI (consumer price index). Variables C9,

YN and YT are deflated by the overall CPI. A weighted average of the trans-
portation, communication, and miscellaneous components of the CPI is used to
deflate C10. Since prices were very stable during the period covered by the
panel (the inflation rate during the period was 2.8 percent), the choice of
the deflator is immaterial. Panel A of Table 1 displays the means and
standard deviations of the relevant variables.

In the subsequent analysis, I will use consumption expenditures and
income adjusted for family size. This adjustment is done by dividing the
variable by the number of equivalent adults which is estimated by regressing
the log of the variable on family size dummies. The regressions are run on
pooled data. Table 2 reports the results of expenditures and income regress-
ions on pooled data. If the regressions were run for each quarter, the
intercept term would pick up economy-wide shocks and the residual would be
purged of any seasonal and macroeconomic fluctuations. The antilog of the
residual from the pooled regression is taken to be the value of the variable
adjusted for family size. If the (unadjusted) value is zero, its adjusted
value is set at zero also. Put more formally, the family size-adjusted value
of X_t is the ratio of the unadjusted value fo X_t divided by $f_X(FSZ_t)$, where f_X
is a function defined in Table 2 that converts family size in period t, FSZ_t,
into the number of equivalent adults specific to X (X = C1,C2,...,C10).[8] For
example, $f_{C1}(2) = 1.0$, $f_{C1}(3) = \exp(.232)$, $f_{C1}(4) = \exp(.326)$, $f_{C1}(5) =$
$\exp(.423)$, and so forth. These numbers come from the estimated coefficients
of the family size dummies reported in Table 2. The number of equivalent
adults is normalized to unity for two-person families. (Note that the sample
does not include one-person households.) The means and standard deviations
of the family size-adjusted variables thus obtained are displayed in Panel B
of Table 1. Since the R^2 for the regressions reported in Table 2 is uniformly

very low except for food expenditures and since very few households changed
its family size during the period of the survey, this particular way of
adjusting for family size should not (and in fact did not) influence the
results to be reported in this paper in any important way.

The present data set contains information on expectations held by
households. Since the period of the survey is from 1981:Q2 to 1982:Q1,
reported expectations refer to the period of 1981:Q3 to 1982:Q2. I will put
subscript "e" to denote expected values; for example, Cl_t^e denotes the house-
hold's expectation, _formed at the end of period t-1_, of Cl in period t
(t = 2,3,4,5, or t = 1981:Q3 to 1982:Q2.). Exactly the same procedure for
family size adjustment is used for expected values of expenditures. It is
assumed that households can correctly foresee their family size one quarter
ahead, so that actual family size is used to make family size adjustment on
expected values. To be more precise, the family size-adjusted value of X_t^e is
the unadjusted value of X_t^e divided by $f_X(FSZ_t)$, where f_X is the function that
translates family size in period t, FSZ_t, into the number of equivalent adults
specific to X (X = Cl,C2,...,C10; t = 2,3,4,5). Since there is no information
on FSZ_5 in the present four-quarter panel, it is assumed that FSZ_5 is equal to
FSZ_4. I also assume that each relevant component of the CPI is correctly
foreseen by households one quarter ahead, so that actual values of the
relevant deflators are used to convert expected values of expenditures and two
components of income into real terms.

The theory to be presented in the next section is stated in terms of
changes in expenditures. Theoretical considerations apart, it is a good idea
to work with changes since levels of expenditures are likely to have household
specific components that are time invariant. Table 3 displays the means and
standard deviations of changes in the ten (family size-adjusted) commodity

groups and in the two (family size-unadjusted) components of income. As expected, the most volatile commodity group is durables. Both the level and the change of durables goods expenditures have a high standard deviation. This is a consequence of the lumpiness of durable purchases. In fact, in any given quarter, over forty percent of the sample reported zero expenditures on durables.

A quite surprising fact is revealed if one examines the autocorrelation structure of changes which is reported in Table 4. The first-order auto-correlation is uniformly negative and large in absolute value, even for changes in food expenditures. It is not surprising that changes in durable expenditures are negatively autocorrelated because of the lumpiness of durable purchases. However, the fact that an increase in food expenditures tends to be followed by a decrease is unsettling, because one would expect households to smooth out consumption over time. In fact, Hall's (1978) permanent income hypothesis implies that changes in consumption are serially uncorrelated as the level of consumption is changed only when the consumer receives new information. That implication is strongly rejected by the present data.

Several explanation are conceivable for the strong negative autocorre-lation. First, as Table 1 shows, expenditures have seasonality. In particular, expenditures go up in the fourth quarter and come back down in the first quarter of the following year. If the effect of seasonality is multi-plicative rather than additive, then the autocorrelation coefficients in changes will be negative. I performed seasonal adjustment on expenditures and income to re-calculate the sample autocorrelations.[9] This is reported in the right half of table 4. Although the size of autocorrelation involving the fourth quarter is now smaller in general, the strong negative autocorrelation still remains.

The second explanation is measurement error. Survey data on expenditures are necessarily subject to measurement error. If the levels of expenditures are measured with error, changes in measured expenditures will have a moving average term which induces negative autocorrelation. The third explanation is that preferences are subject to taste shocks. This also introduces a moving average term in expenditure changes.[10] Both measurement error and taste shocks may explain some of the negative correlation in expenditure changes. However, I do not think they are the main factor. For one thing, in a separate study that uses monthly diary survey data, it is found that monthly change in food expenditures are strongly negatively correlated.[11] Since it is reasonable to assume measurement error in diary surveys is small, something other than measurement error must be responsible for the negative auto-correlation. Another reason that measurement error and taste shocks are unimportant is provided by the vector autoregression (VAR) model estimated in Table 5.[12] Suppose that change in expenditures is the sum of new information (forecast errors) and a moving average of measurement error and taste shocks. It is plausible that measurement error and taste shocks are uncorrelated with income changes. It is also plausible that income changes are correlated with forecast errors. Then if current expenditure change is regressed on lagged expenditure changes and lagged income changes, both lagged expenditure changes and lagged income changes should be significant. The results in Panel A of Table 5, on the contrary, say that only lagged expenditure changes are significant at the 1% significance level except for C9 (social expenses). The significant contemporaneous correlation between expenditure changes and income changes reported in Panel B of Table 5 implies that expenditure changes are not dominanted by measurement error and taste shocks.

It is the basic theme of this paper that the main factor that lies behind

the significant negative autocorrelation in expenditure changes is the durability of commodities. The next section sets up an optimization model that is capable of explaining the negative autocrrelation.

3. THEORY

As is made clear in the previous section, the standard permanent income hypothesis (Hall [1978]) is inconsistent with the data. Here I present a modified version of the standard theory. The key feature will be the durability of commodities. Consider a household whose intertemporal decision problem is to maximize

$$(3.1) \qquad E_t[\sum_{k=0}^{T} u(\bar{C}_{t+k})\delta^k]$$

subject to the budget constraint

$$(3.2) \qquad \sum_{k=0}^{T} [\prod_{v=0}^{k} (1 + R_{t+v-1})^{-1}(Y_{t+k} - p'_{t+k}C_{t+k})] + A_t = 0,$$

where E_t is the expectation operator associated with the subjective probability distribution (assumed by the household) of future variables that are uncertain to the household, δ is the rate of subjective time preference, R is the nominal interest rate, T is the length of the remaining life, C is a vector of real _expenditures_ on n commodity groups, p is the associated price vector of dimension n, $\bar{C}$ is a vector of _consumption_ of the n commodities, $u(\cdot)$ is the instantaneous utility function, Y is after-tax nominal labor inocme, and A_t is nominal nonhuman wealth (assets) at the beginning of period t.[13] Note that a distinction is made between consumption $\bar{C}$ and expenditures

C. The j-th component of $\bar{C}_t$, namely $\bar{C}_{jt}$, is linked to the j-th component of C_t by

$$(3.3) \qquad \bar{C}_{jt} = \sum_{k=0}^{M} (\rho_{jk} \, C_{j,t-k}) \qquad (j=1,2,\ldots,n).$$

That is, current consumption is a distributed lag function of current and past expenditures. This is a generalization of the usual formula for durable goods where $\bar{C}_{jt}$ is service flows from the stock of durables and the distributed lag coefficients ρ_{jk} $(k=0,1,2,\ldots)$ are of the Koyck type.

The first-order condition for this household's optimization problem is:

$$(3.4) \qquad E_t\left\{ \sum_{k=0}^{M} \left[\delta^k \frac{\partial u(\bar{C}_{t+k})}{\partial \bar{C}_{j,t+k}} \rho_{jk} \right] \right\} = E_t\left\{ (1 + r_{j,t+1}) \delta \sum_{k=0}^{M} \left[\delta^k \frac{\partial u(\bar{C}_{t+k+1})}{\partial \bar{C}_{j,t+k+1}} \rho_{jk} \right] \right\}$$

where $r_{j,t+1}$ is the real rate of interest on commodity j, i.e., $1+r_{j,t+1} = (1+R_t)p_{jt}/p_{j,t+1}$. The right hand side of this equation is the marginal cost of foregoing one unit of expenditures on the j-th commodity. This involves a summation from 0 to M because a change in current expenditures influences current and future consumption for M periods. The left hand side is the marginal benefit of increasing $1+r_{j,t+1}$ units of expenditures on commodity j in the next period. This also involves a summation from 0 to M for the same reason. In Appendix A it is shown that: Under (3.4),

$$(3.5) \qquad E_t\left\{ \left[(1+r_{j,t+1}) \delta \frac{\partial u(\bar{C}_{t+1})}{\partial \bar{C}_{j,t+1}} \right] / \left[\frac{\partial u(\bar{C}_t)}{\partial \bar{C}_{jt}} \right] \right\} = 1 \qquad (j=1,2,\ldots,n)$$

holds approximately if M (the length of the distributed lag) is small relative to T (the length of remaining life), and holds exactly if (as is usually the case for durables) ρ_{jk} is geometrically declining in k and $r_{j,t+1}$ is known in

t and $r_{j,t+1} = r_{j,t+2}$.

Equation (3.5) can be made tractable under two alternative assumptions. First, assume that the instantaneous utility function $u(\cdot)$ takes the following form:

$$(3.6) \qquad u(\bar{C}_t) = - g_1 \exp(- \mu_1 \bar{C}_{1t}) - \ldots - g_n \exp(- \mu_n \bar{C}_{nt}).$$

Rewrite (3.5) as

$$(3.7) \qquad (1+r_{j,t+1})\delta[\frac{\partial u(\bar{C}_{t+1})}{\partial \bar{C}_{j,t+1}}]/[\frac{\partial u(\bar{C}_t)}{\partial \bar{C}_{jt}}] = 1 - e_{j,t+1} ,$$

where $e_{j,t+1}$ is the difference between the right hand side of (3.5) and the right hand side of (3.7), that is, $e_{j,t+1}$ is the forecast error of the right hand side of (3.7). Take the log of both sides of (3.7) and use the approximation that $\ln(1+x) \simeq x$ to obtain

$$(3.8) \qquad \ln(1+r_{j,t+1}) + \ln(\delta) + \ln[\frac{\partial u(\bar{C}_{t+1})}{\partial \bar{C}_{j,t+1}}] - \ln[\frac{\partial u(\bar{C}_t)}{\partial \bar{C}_{jt}}] = - e_{j,t+1}.$$

Now use (3.6) on (3.8) to obtain

$$(3.9) \qquad \bar{C}_{j,t+1} - \bar{C}_{jt} = d_{jt} + e_{j,t+1} \qquad (j=1,2,\ldots,n)$$

where

$$(3.10) \qquad d_{jt} = \mu_j^{-1}[\ln(1+r_{j,t+1}) + \ln(\delta)].$$

Another way to make (3.5) tractable is to assume that the instantaneous

utility funciton u(·) is quadratic:

$$(3.11) \qquad u(\bar{C}_t) = a'\bar{C}_t - (1/2)\bar{C}_t'B\bar{C}_t$$

and that

$$(3.12) \qquad (1+r_{j,t+1})\delta = 1.$$

It then is easy to show that (3.5) reduces to (3.9) with $d_{jt} = 0$. This is a multi-commodity version of of Hall's (1978) martingale hypothesis. Under either assumption about the instantaneous utility function, consumption on commodity j is unrelated to lagged consumption on other commodities. Note that this result is obtained under the assumption which does not assume intra-temporal separability among commodities.[14]

The foregoing discussion has ignored two issues, namely family size and seasonality. I will incorporate them into the model in the following fashion. Let f_{jt} be the commodity-specific number of equivalent adults in period t. I will use lower case letters c_{jt} and $\bar{c}_{jt}$ to represent expenditure and consumption on commodity j in period t expressed in equivalent adult per capita, i.e.,

$$(3.13) \qquad c_{jt} = C_{jt}/f_{jt} \quad \text{and} \quad \bar{c}_{jt} = \bar{C}_{jt}/f_{jt}.$$

It is reasonable to suppose that current consumption per equivalent capita is a distributed lag function of expenditures per equivalent capita. So (3.3) is modified as

$$(3.3') \qquad \bar{c}_{jt} = \sum_{k=0}^{M} (\rho_{jk} c_{j,t-k}) \qquad (j=1,2,\ldots,n).$$

I incorporate the family size and seasonality effects into the first specification of the utility function (3.6) as

$$(3.6') \qquad u = -g_{1t}\exp(-\mu_1 \bar{c}_{1t}) - \ldots - g_{nt}\exp(-\mu_n \bar{c}_{nt}),$$

where g_{jt} $(j=1,2,\ldots,n)$ serves to represent both seasonal variations in the instantaneous utility function and the family size effects. The resulting equation that corresponds to (3.9) is

$$(3.9') \qquad \bar{c}_{j,t+1} - \bar{c}_{jt} = d_{jt} + e_{j,t+1} \qquad (j=1,2,\ldots,n),$$

with

$$(3.10') \qquad d_{jt} = \mu_j^{-1}[\ln(1+r_{j,t+1}) + \ln(\delta) + \ln(g_{j,t+1}/g_{jt})].$$

The family size and seasonality effects are incorporated into the second specification of the quadratic utility function as

$$(3.11') \qquad u = [a_t' \bar{c}_t - (1/2)\bar{c}_t' B \bar{c}_t]F_t,$$

where F_t is an overall index of family size and a_t is an n-dimensional vector of seasonality factors. The resulting equation is again (3.9') where $\bar{c}_{jt}$ is redefined as $\bar{c}_{jt}$ times F_t/f_{jt} and d_{jt} is a function of the change in the commodity-specific number of equivalent adults and of the seasonality factors in periods t and t+1. In short, the family size effect is incorporated in (3.9') in the family size-adjusted consumption $\bar{c}$ and in the intercept term d_{jt} and seasonality is incorporated in the intercept term.

Substituting (3.3') into (3.9') one obtains the equation stated in terms of expenditures:

(3.14) $\quad c_{j,t+1} - c_{jt} =$

$$d_{jt} - \rho_{j1}(c_{jt} - c_{j,t-1}) - \cdots - \rho_{jM}(c_{j,t-M+1} - c_{j,t-M}) + e_{j,t+1}$$

$$(j=1,2,\ldots,n)$$

where ρ_{j0} is normalized to be unity and it is understood that d_{jt} varies from season to season and depends on changes in family size. Appendix B shows that approximately the same equation can be derived from a continuous-time model where c's are unit averages over periods of an arbitrarily given length. If the household's expectation as of t of $c_{j,t+1}$ is denoted by $c^e_{j,t+1}$, equation (3.14) can be written as

(3.14') $\quad c^e_{j,t+1} - c_{jt} = d_{jt} - \rho_{j1}(c_{jt} - c_{j,t-1}) - \cdots - \rho_{jM}(c_{j,t-M+1} - c_{j,t-M}).$

It is clear from (3.10') that d_{jt} in (3.14) and (3.14') depends on the subjective rate of time preference δ and the (absolute) degree of risk aversion μ_j. Equation (3.14) has a strong implication that _nothing_ should Granger cause $c_{jt+1} - c_{jt}$ if expectations are rational [so that $E_t(e_{j,t+1}) = 0$]. So, for example, a fully anticipated tax cut should have no effect whatsoever when it is enacted; only unexpected policies can influence the behavior of expenditures. This can be easily tested on time-series data (provided that the real rate is constant), but to do the same thing on short panel data is difficult for two reasons.

First, at any given point in time the forecast error $e_{j,t+1}$ can be correlated with any variable dated t if the correlation is taken with respect to the distribution across households.[15] Since the present panel has a small time dimension and a large cross-section dimension, estimation of equations like (3.14) will have to exploit the cross-section dimension. But the rational expectations hypothesis does not necessarily preclude correlation in cross-section between the right hand side variables and the forecast error term $e_{j,t+1}$. It is precisely for this reason that equation (3.14') rather than equation (3.14) forms a basis for the equation to be estimated in section 5. The second difficulty is that the length of the panel data is too short to allow for a realistic lag length in (3.14). But this can be overcome by the use of instrumental variables, as we will see in the next section.

My prior expectation is that the theory just presented will fail empirically. Probably the most likely source of failure is liquidity constraints or borrowing constraints. Casual observations and my own experience show that expenditures by economics graduate students (in the U.S.) are largely determined by their current income and their ability to borrow. A most natural way to incorporate borrowing constraints is to let the interest rate be endogenous and depend on the household's income and asset position. But then the Euler equation (3.4) will become much more complicated, because the marginal benefit of foregoing one unit of expenditures consists not only of increased expenditures in the next period but also of improved credit conditions. Furthermore, the present data set has no information on assets and liabilities, so it is impossible to implement the idea of endogenous interest rates in a satisfactory fashion.

The view about borrowing constraints taken in this study is that part of the households in the population behaves according to the permanent income

hypothesis described above while the remaining part does not. Households which do not follow the permanent income hypothesis are subject to borrowing constraints, in the sense that the marginal propensity to spend out of current disposable income is unity. If a constant fraction α_j of additional disposable income of constrained households goes to expenditures on commodity j, the behavior of expenditures by constrained households is described by

$$(3.15) \qquad c_{j,t+1} - c_{jt} = \alpha_j \left(\frac{PYD_{t+1}}{P_{j,t+1} f_{j,t+1}} - \frac{PYD_t}{P_{jt} f_{jt}} \right) \qquad (j=1,2,\ldots,n)$$

$$\text{with} \qquad \sum_{j=1}^{n} \alpha_j = 1,$$

where PYD is nominal disposable income and f_{jt} is the number of equivalent adults specific to commodity group j. If the household's expectation as of t of $c_{j,t+1}$ and PYD_{t+1} are denoted by $c^e_{j,t+1}$ and PYD^e_{t+1}, respectively, and if $P_{j,t+1}$ and $f_{j,t+1}$ are perfectly foreseen in period t, then this equation can be rewritten as

$$(3.15') \qquad c^e_{j,t+1} - c_{jt} = \alpha_j EDY_{jt} \qquad (j=1,2,\ldots,n) \qquad \text{with} \qquad \sum_{j=0}^{n} \alpha_j = 1,$$

where

$$(3.16) \qquad EDY_{jt} = \frac{PYD^e_{t+1}}{P_{j,t+1} f_{j,t+1}} - \frac{PYD_t}{P_{jt} f_{jt}}$$

is family size-adjusted expected disposable income change. In section 5, a mixture of (3.14') — the equation for the households which follow the permanent income hypothesis — and (3.15') — the equation for constrained households — will be estimated. The next section discusses econometric

issues concerning the estimation of (3.14') and (3.15').

4. ECONOMETRIC ISSUES

The main objective in the remaining part of this paper is to estimate the parameters of the two equations (3.14') and (3.15') that describe the behavior of unconstrained and constrained households. This section discusses three issues that should be taken into account when one deals with cross-section or panel data. They are: (i) individual (or household-specific) effects, (ii) measurement error, and (iii) heteroskedasticity. Most of the discussion in this section will be technical and rather lengthy. Nontechnical readers can skip to the last paragraph of this section without losing continuity.

I think it is reasonable to assume that the lag coefficients ρ_{jk} in (3.14') are the same across households. Those are just a description of the mechanical relationship between expenditures and consumption; the shape of the lag distribution will be largely determined by the nature of the commodity, not by (observable and unobservable) characteristics of the household. It is, however, probably unrealistic to assume that the rate of time preference δ and the degree of risk aversion μ_j $(j=1,2,\ldots,n)$ are constant across households. They will most likely depend on the age of the household head and some other unobservable household characteristics. This means that the intercept term d_{jt} in (3.14') depends not only on observable household characteristics such as age and change in family size but also on unobservable characteristics (individual effects).[16] One can always write d_{jt} as:

(4.1) d_{jt} = linear function of AGE and AGE^2 + ε_{jt} $(j=1,2,\ldots,n)$

where AGE is the age of the household head and where the linear function of AGE and AGE^2 is the least squares projection of d_{jt} on AGE, AGE^2. So ε_{jt} represents unobservable household characteristics that are uncorrelated with AGE and AGE^2. The theoretical discussion in section 3 implies that d_{jt} also depends on change in family size and seasonality. Since estimation will be performed <u>in the cross-section dimension</u> for a fixed t (t=4), there is no need to explicitly incorporate seasonality in (4.1). Family size in period 5 is not in the data set; I assume there is no change in family size from period 4 to period 5. This is why change in family size does not appear in (4.1). The unobservable individual effect (i.e., unobservable household characteristics) ε_{jt} will be a part of the error term in the estimation equation.

Another source of the error term is the truncation remainder. As the panel is only four quarters long, only three lags, namely $-\rho_{j1}(c_{j4} - c_{j3}) - \rho_{j2}(c_{j3} - c_{j2}) - \rho_{j3}(c_{j2} - c_{j1})$, can be included in the equation, and a part of the remaining lags, $\sum_{k=4}^{M} \rho_{jk}(c_{j,5-k} - c_{j,4-k})$, has to be included in the error term. It is easy to see from (3.14) and (4.1) that the remaining lags can be written as the sum of three parts: (i) the part that can be linearly predicted by AGE and AGE^2; (ii) the individual effect that are uncorrelated with AGE and AGE^2; and (iii) a weighted sum of past forecast errors $e_{j,5-k}$ $(k \geq 4)$. The deviation of the sum of (ii) and (iii) from its population mean will be called the <u>truncation remainder</u> and denoted by TR_j. It is reasonable to assume that AGE and AGE^2 are uncorrelated with (iii) above because the household can predict its future AGE perfectly. Thus the truncation remainder TR_j for commodity j is the part of the remaining lags that are uncorrelated with AGE and AGE^2. This is the second component of the error term.

If, in addition, there is measurement error in expenditures, the error

term will have measurement error as the third component.[17] Thus the estimation equation becomes

(4.2) $\qquad c_{j5}^{e} - c_{j4} =$ linear function of AGE and AGE^2

$$- \rho_{j1}(c_{j4} - c_{j3}) - \rho_{j2}(c_{j3} - c_{j2}) - \rho_{j3}(c_{j2} - c_{j1}) + v_j,$$

where

(4.3) $\qquad v_j = \varepsilon_{j4} - TR_j +$ measurement error in c_{j1}, c_{j2}, c_{j3}, c_{j4} and c_{j5}^{e}.

The equation (3.15') that describes the behavior of constrained households becomes, in the presence of measurement error,

(4.4) $\qquad c_{j5}^{e} - c_{j4} = \alpha_j EYD_{j4} + w_j \qquad (j=1,2,\ldots,n)$

where w_j is measurement error in $c_{j5}^{e} - c_{j4}$ and in EYD_{j4}.

There is no shortage of reasons why the error terms v_j and w_j in two equations (4.2) and (4.4) are correlated with the right hand side variables. Since the error term contains measurement error, there is the classical errors-in-variables problem. The truncation remainder, TR_j, is obviously correlated with the first three lags, $c_{j4} - c_{j3}$, $c_{j3} - c_{j2}$, and $c_{j2} - c_{j1}$. Since individual differences in the rate of time preference and in the degree of risk aversion affects the behavior of expenditures, the individual effect ε_{j4} is also correlated with the first three lags. But suppose there are available a set of instruments, x_j, for which

(4.5) $\qquad E(v_j x_j) = 0 \quad$ and $\quad E(w_j x_j) = 0 \qquad (j=1,2,\ldots,n).$

This assumption means that neither the individual effect, nor the truncation remainder, nor measurement error is correlated with x_j. The two variables AGE and AGE^2 are valid instruments as it can be reasonably assumed that they are uncorrelated with measurement errors.

Let λ be the fraction of constrained households in the population (from which the sample was drawn). Then (4.2) holds with probability $1 - \lambda$ and (4.4) holds with probability λ. The following equation can be derived (see Appendix C):

$$(4.6) \qquad c_{j5}^e - c_{j4} = \text{linear function of AGE and } AGE^2$$

$$- (1-\lambda)\rho_{j1}(c_{j4} - c_{j3}) - (1-\lambda)\rho_{j2}(c_{j3} - c_{j2}) - (1 - \lambda)\rho_{j3}(c_{j2} - c_{j1})$$

$$+ \lambda\alpha_j EDY_{j4} + \eta_j, \quad \text{with } E(\eta_j x_j) = 0 \qquad (j = 1,2,\ldots,n),$$

where EDY_{j4}, family size-adjusted expected change in disposable income, is defined in (3.16), and the error term η_j is composed of the three components, namely the individual effect, the truncation remainder, and measurement errors. To derive (4.6) it is necessary to assume that the fraction λ is constant, independent of the right hand side variables and instruments. If this assumption sounds too strong, one can think of (4.6) as a device to test the permanent incoe hypothesis; testing for $\lambda = 0$ amounts to a test of the hypothesis. Equation (4.6) can be estimated by two- or three-stage least squares with x_j as instruments. This is the equation to be estimated in the next section.

The final econometric issue is heteroskedasticity. Since the present data set is a random sample, the variables in (4.6) are i.i.d. (independently

and identically distributed) across households. So the _unconditional_ variance

of η_j is constant. However, the _conditional_ variance of η_j conditional on x_j

is a function of x_j, in general. In order to carry out valid statistical

inference the standard theory of two- and three-stage least squares is

inadequate. Fortunately, however, the theory has recently been generalized to

encompass heteroskedasticity (see, e.g. Chamberlain [1982]). I now briefly

summarize it.

There are n equations to be estimated:

$$(4.7) \qquad y_{ij} = \delta_j' z_{ij} + \eta_{ij} \qquad (j=1,2,\ldots,n; \quad i=1,2,\ldots,N)$$

where δ_j is a vector of coefficients, n is the number of commodity groups, i

is the household index, and N is the sample size (the number of households).

The dependent variable y_{ij} corresponds to $c_{j5}^e - c_{j4}$ of household i and the

vector of right hand side variables z_{ij} corresponds to $(1, AGE, AGE^2, c_{j4} -$

$c_{j3}, c_{j3} - c_{j2}, c_{j2} - c_{j1}, EDY_{j4})$ pertaining to household i. The column

vector of instruments x_{ij} are orthogonal to η_{ij}: $E(\eta_{ij} x_{ij}) = 0$. The

generalized two-stage least squares estimator of δ_j is given by

$$(4.8) \qquad \hat{\delta}_j = (Z_j' X_j \hat{\Psi}_{jj}^{-1} X_j' Z_j)^{-1} (Z_j' X_j \hat{\Psi}_{jj}^{-1} X_j' y_j) \qquad (j=1,2,\ldots,n),$$

where Z_j and X_j are matrices whose rows are z_{ij}' and x_{ij}', respectively, and y_j

is the N-dimensional vector whose elements are y_{ij}'s. The matrix $\hat{\Psi}_{jj}$ in this

experession is given by

$$(4.9) \qquad \hat{\Psi}_{jj} = \frac{1}{N} \sum_{i=1}^{N} \{(y_{ij} - \tilde{\delta}_j z_{ij})^2 x_{ij} x_{ij}'\} \qquad (j=1,2,\ldots,n),$$

where $\tilde{\delta}_j$ is a consistent estimator of δ_j. It can be shown (under a set of appropriate regularity conditions) that $(\hat{\delta}_1, \hat{\delta}_2, \ldots, \hat{\delta}_n)$ is asymptotically normal in the presence of conditional heteroskedasticity. The theory of three-stage least squares can be generalized to incorporate conditional heteroskedasticity in a similr fashion.

If the number of instruments x_{ij} is equal to the number of the right hand side variables z_{ij}, then the above generalized two-stage least squares estimator reduces to the usual instrumental variables estimator

$$(4.10) \qquad \hat{\delta}_j = (X_j'Z_j)^{-1}X_j'y_j \qquad (j=1,2,\ldots,n),$$

and the generalized three-stage least squares estimator also reduces to this estimator. It can be shown that the asymptotic variance-covariance matrix of $\hat{\delta}_j$ is consistently estimated by

$$(4.11) \qquad S'^{-1}_{z_jx_j} \hat{\psi}_{jj} S^{-1}_{z_jx_j} \qquad (j=1,2,\ldots,n),$$

where $S_{z_jx_j} = \frac{1}{N} \sum_{i=1}^{N} z_{ij}x_{ij}'$ and $\hat{\delta}_j$ is used in place of $\tilde{\delta}_j$ in calculating $\hat{\psi}_{jj}$, and that the asymptotic covariance matrix between $\hat{\delta}_j$ and $\hat{\delta}_\ell$ is consistently estimated by

$$(4.12) \qquad S'^{-1}_{z_jx_j} \hat{\psi}_{j\ell} S^{-1}_{z_\ell x_\ell} \qquad (j,\ell=1,2,\ldots,n),$$

where

$$(4.13) \qquad \hat{\psi}_{j\ell} = \frac{1}{N} \sum_{i=1}^{N} \{(y_{ij} - \hat{\delta}_j z_{ij})(y_{i\ell} - \hat{\delta}_{i\ell})x_{ij}x'_{i\ell})\}.$$

If $z_{ij} = x_{ij}$, the estimator (4.10) is the usual OLS estimator. Its heteroskedasticity-robust asymptotic variance is given by (4.11) with $z_{ij} = x_{ij}$. This is the formula I used in calculating the standard errors in Table 5 for the VAR model. Formulas (4.10)-(4.13) are the ones I will use in calculating the point estimates and their associated standard errors for equation (4.6) in the next section.

To summarize: The equation to be estimated is (4.6) which explicitly recognizes that a certain fraction λ of the population is liquidity constrained. This equation will be estimated in the cross-section dimension. Since the panel is only four quarters long, only three lagged expenditure changes can be included on the right hand side, and the remaining lags (the truncation remainder) are relegated to the error term. Also included in the error term are the individual effect (i.e., individual differences in the rate of time preference and the degree of risk aversion) and measurement error. This provides a reason for correlation between the error term and the right hand side variables. The equation will be estimated by instrumental variables in a way that is robust to heteroskedasticity.

5. RESULTS

To anticipate the results, identification of λ (the fraction of liquidity constrained households in the population) turned out to be rather tenuous. So I first present the parameter estimates of the pure permanent income hypothesis represented by equation (4.6) with $\lambda = 0$, and then turn to the estimation of λ.

The critical issue in estimating equation (4.6) with $\lambda = 0$ by the generalized two-stage least squares is the choice of instruments. Valid

instruments must be uncorrelated with the three components of the error

term n_j, namely the individual effect, the truncation remainder, and measurement error. I include AGE and AGE^2 in the set of instruments. As for the

instruments for lagged expenditure changes $c_{jt} - c_{j,t-1}$ (t=2,3,4), I use the

associated <u>unexpected</u> changes $c_{jt} - c^e_{jt}$ (t=2,3,4). It is reasonable to assume

that unexpected changes are uncorrelated with the individual effect which is

known to the household. As is shown in Table 6, there is some evidence of

statistically significant correlation between unexpected expenditure changes

and lagged actual expenditure changes, implying that unexpected changes can be

correlated with the truncation remainder. But what Table 6 also tells us is

that the correlation is small in size — much smaller than the correlation of

actual change with its own lagged changes. So the bias due to correlation of

instruments with the truncation remainder will be small, if any. There is no

a priori reason to preclude correlation between unexpected change and measurement error. I use unexpected changes as instruments because I think there is

no other valid choice of instruments. But at least there is one case in which

measurement error causes no problem. It is the case where actual expenditures

c_{jt} and its expectation c^e_{jt} are subject to the same measurement error. In

this case measured unexpected change $c_{jt} - c^e_{jt}$ is free from measurement error.

If unexpected change contained a large measurement error, it would be serially

correlated. But Table 6 shows no particularly strong autocorrelation in

unexpected changes. Thus, the set of instruments for estimating equation

(4.6) with $\lambda = 0$ for commodity group j is: $(1, AGE, AGE^2, c_{j4} - c^e_{j4}, c_{j3} - c^e_{j3},$

$c_{j2} - c^e_{j2})$. The number of instruments is equal to the number of the right

hand side variables.[18]

The results of the estimation of (4.6) with $\lambda = 0$ by the generalized two-

stage least squares [which uses formulas (4.10) and (4.11)] are given in Panel

A of Table 7 for the ten commodity groups. The intercept, the AGE and AGE^2 coefficients are not reported because none of them are significant at 5 percent. All but one lag coefficients are highly significant. The estimated first three lag coefficients ρ_{j1}, ρ_{j2}, ρ_{j3} are small (but significant) for food (C1) and very close to unity for durables (C4) and clothes (C3). This is very reasonable. What is (probably not really surprising but) revealing is the large lag coefficients for commodity groups (C5-C9) that are usually labeled as "services." Even though services are physically perishable, their psychological effect on households' preference is long-lasting. The lag coefficents for C5 seems unduly large because, if taken seriously, they mean that people derive more utility from the memory of a trip than from the trip itself. This is probably due to sampling error, as the standard errors for C5 is very high.

For later reference I report the parameter estimates by the ordinary least squares in Panel B of Table 7. The estimated lag coefficients are smaller than the estimates by the two-stage least squares, because of measurement errors and because the first three lagged changes are negatively correlated with the truncation remainder (as is predicted by the permanent income hypothesis).

The estimated model allows for no feedback from lagged expenditure changes on other commodity groups. It might be that the surprisingly high durability of services is due to the influence of lagged expenditures on, say, consumer durables. To check this, I expanded equation (4.6) with $\lambda = 0$ to include lagged expenditure changes on other commodity groups. So the equation now has $c_{j5}^e - c_{j4}$ as the dependent variable, and AGE, AGE^2, $c_{jt} - c_{j,t-1}$ ($t = 2,3,4$) and $c_{\ell t} - c_{\ell,t-1}$ ($\ell \neq j$, $t = 2,3,4$) on the right hand side. This equation was estimated by the generalized two-stage least squares for the ten

commodity groups (j = 1,2,...,10) with AGE, AGE^2, and the associated unexpected changes $c_{\ell t} - c^e_{\ell t}$ (ℓ =1,2,...,10) as instruments. Table 8 reports pertinent Wald-type statistics for the hypothesis that lagged expenditure changes on other commodity groups have all zero coefficients. Except for C4 (consumer durables) and possibly C2 (rent, fuel and utilities), lagged expenditure changes on other commodities are totally insignificant. One possible reason for the rejection of the hypothesis for durables is that the equation for durables is misspecified. The equation was derived from the Euler equation (3.4) under the assumption of interior solution. But in any given quarter over forty percent of the households in the sample reported no expenditures on consumer durables. Since those households are at the corner solution, the Euler equation does not hold for durables. Some other estimation technique such as Tobit and Probit would be required in order to correctly treat the durables equation. The possible misspecification of the durables equation was, in fact, the main reason for not using the generalized three-stage least squares; by sticking to the (generalized) two-stage least squares I can avoid biases due to the transmission of misspecification in one equation to another.

I now turn to the estimation of equation (4.6) without the λ = 0 restriction. I tried two alternative instruments for instrumenting EDY_{j4}, family size-adjusted expected disposable income change. One is family size-adjusted expected normal income change, which is obtained by substituting YN in place of YD in the definition (3.16) of EDY_{j4}. As is seen from Table 5, there is no significant feedback from lagged expenditures to normal income. So it is reasonable to assume that this instrument is uncorrelated with the truncation remainder. It is also plausible that the individual effect is uncorrelated with this instrument. If normal income is measured without

error, there is no correlation between this instrument and measurement error

in EDY_{j4}. The generalized two-stage least squares estimate of λ turned out to

be .374 with a standard error of .131. However, estimates of the lag

coefficients ρ_{jk} (k = 1,2,3) became unduly high; for example, estimate of

ρ_{j1} for j = 5 (recreatinal expenses) is 1.93 with a standard error of .69.

This is because the coefficients of lagged expenditures changes, which are

$-(1-\lambda)\rho_{jk}$'s, have changed very little compared with the case with $\lambda = 0$. The

second alternative instrument is (lagged) unexpected disposable income change,

$YD_4 - YD_4^e$. This produced an estimate of -.12!

The reason for such unreliable estimates is that expected disposable

income change is hard to explain. A regression of EDY_{j4} on (family size-

adjusted) expected normal income change yields an R^2 of only about .08. (The

second instrument has even less explanatory power). Change in disposable

income is dominated by temporary income.

After going through all this, I decided to treat EDY_{j4} as predeter-

mined. That is, the instrument for EDY_{j4} is EDY_{j4} itself. The parameter

estimates for equation (4.6) with EDY_{j4} predetermined are given in Table 9.

The estimates are rather implausible for a couple of reasons. For one thing,

the estimate of α_j's says that liquidity constrained households spends about

fouty-four percent of their additional income on durables. This is a bit

unrealistic. Probably this high estimate reflects the lumpiness of durables,

an element that is not incorproated in the permanent income hypothesis. If

durables are lumpy and if there are transaction costs in trading durables, it

seems plausible that optimizing households try to synchronize the timing of

durable purchases with income fluctuations. Another implausible fact about

Table 9 is that the estimates of the lag coefficients are too high, parti-

cularly for durables (C4) and recreational expenses (C5). Again, estimates of

- $(1-\lambda)\rho_{jk}$ ($k = 1,2,3$) have changed very little; the estimates of the lag coefficients ρ_{jk} in Table 9 are uniformly higher than those in Table 9A by about fifteen percent. If reasonable estimates of the lag coefficients for durables are around unity, the estimate of λ of .12 seems to be biased upwards.

To examine the source of the bias, I calculated the sample correlation between EDY_{j4} and lagged expenditure changes. This is reported in Table 10. Although correlation is not very strong, there is a tendency that correlation becomes significantly negative as expenditure changes go back into the past. This suggests that EDY_{j4} is negatively correlated with the truncation remainder and hence is _positively_ correlated with the error term η_j which depends negatively on the truncation remainder. This provides an upward bias on the estimate of λ. On the other hand, measurement error in EDY_{j4} implies a downward bias. Although the direction of the bias can go either way in general, an upward bias seems more likely because measurement error in disposable income is likely to be small for the present sample of workers' households.

On the whole, then, the empirical evidence has brought up quite clearly the surprisingly high durability of consumption expenditures while the evidence for liquidity constraints is weak. But is this consistent with time-series data? This is an important question to ask because on the U.S. aggregate time-series data change in expenditures on nondurables and services as a whole is very much like white noise (Hall [1978]). The Japanese National Income Accounts have two different classifications of personal consumption expenditures. The first has four commodity groups by durability (nondurables, semidurables, durables, and services). Durable expenditures in this classificaiton seem to correspond to C4 (durables) in the present survey data. The

second classification of expenditures is more in line with the one in the present survey data and has eight commodity groups: (i) food, beverages and tobacco, (ii) rents (including imputed rents), fuel, and utilities, (iii) clothes and footwears, (iv) furniture, household appliances, and housewares, (v) recreation and education, (vi) medical care, (vii) transportation and communication, and (viii) other. Roughly speaking, items (i), (ii) and (iii) correspond to C1, C2 and C3, respectively, and item (v) corresponds to the sum of C5, C6 and C7 in the present survey data. For those commodity groups, third-order univariate autoregressions in changes are estimated by the ordinary least squares on the Japanese National Income Accounts data. The results are reported in Table 11. Except for durables, the estimated lag coefficients point to a substantial degree of durability. The time-series estimates in Table 11 are to be compared with the ordinary least squares estimates of equation (4.6) with $\lambda = 0$ in Panel B of Table 7 which also truncates the lag distribution at the third lag.[19] The two sets of point estimates are fairly close to each other with the exception of the durable goods equation. The standard errors, however, are much larger for time-series estimates, reflecting a relatively small amount of information contained in aggregate time-series data. It thus seems fair to conclude that the panel evidence in this paper is consistent with the time-series evidence and that time-series data do not have enough power to detect consumption durability.

The evidence presented so far is favorable to the permanent income hypothesis with consumption durability. However, the evidence is also consistent with the habit persistence hypothesis which posits that current expenditures are determined by lagged expenditures and current disposable income.[20] If this hypothesis is right, expenditure change on commodity j from period 3 (1981:Q4) to period 4 (1982:Q1) may be written as[21]

(5.1) $C_{j4} - c_{j3}$ = linear function of AGE, AGE^2, $FSZ_4 - FSZ_3$, $(FSZ_4 - FSZ_3)^2$

$$+ \beta_{j1}(c_{j3} - c_{j2}) + \beta_{j2}(c_{j2} - c_{j1}) + \gamma ADY_{j3} + error,$$

where the error term includes the truncation remainder. In this equation ADY_{j3} represents family size-adjusted <u>actual</u> change in disposable income and is defined by

(5.2) $$ADY_{j3} = \frac{PYD_4}{P_{j4}f_{j4}} - \frac{PYD_3}{P_{j3}f_{j3}},$$

where, as before, PYD_t is nominal disposable income, p_{jt} is the price of commodity j, and f_{jt} is the number of equivalent adults specific to commodity j in period t. In contrast, the permanent income hypothesis that was developed in section 3 implies that actual expenditure change $c_{j4} - c_{j2}$ on commodity j reacts to <u>unexpected</u>, not actual, disposable income change. To determine which hypothesis is more consistent with the data, I estimated the following equation which has both actual and unexpected disposable income changes:

(5.3) $c_{j4}, - c_{j3}$ = linear function of AGE, AGE^2, $FSZ_4 - FSZ_3$, $(FSZ_4 - FSZ_3)^2$

$$+ \beta_{j1}(c_{j3} - c_{j2}) + \beta_{j2}(c_{j2} - c_{j1}) + \gamma_{j1} ADY_{j3} + \gamma_{j2} UDY_{j3} + error,$$

where family size-adjusted unexpected disposable income change UDY_{j3} is defined by

(5.4) $$UDY_{j3} = \frac{PYD_4}{P_{j4}f_{j4}} - \frac{PYD_4^e}{P_{j4}f_{j4}} \qquad (j = 1,2,\ldots,10).$$

The parameter estimates for equation (5.3), with unexpected expenditure change $c_{j3} - c_{j3}^e$ and $c_{j2} - c_{j2}^e$ as instruments for actual expenditure changes $c_{j3} - c_{j2}$ and $c_{j2} - c_{j1}$, are given in Table 12. The results are again favorable to the permanent income hypothesis. First, the estimated coefficients of lagged expenditure changes are roughly in line with those in Table 7 and Table 9.[22] The habit persistence hypothesis has no theory of why the lag coefficients take the kind of pattern in terms of signs and magnitudes reported in the Table. Second, the estimate of the coefficient of _unexpected_ disposable income change of .29 is much higher than the estimate of _actual_ disposable income change coefficient of .08.[23] Households respond to unexpected rather than actual income changes. This strongly suggests that households are forward-looking as is assumed in the permanent income hypothesis. The evidence in Table 12, however, does reject the permanent income hypothesis, because if the hypothesis is literally correct actual income change ADY_{j3} should have no role in equation (5.3). One interpretation of the coefficient of actual income change of about eight percent is that it is the fraction of liquidity constrained households in the population. This number is fairly close to the estimate of λ of about twelve percent.

Throughout this section I have ignored taste shocks which, if present, should form the fourth component of the error term. The instruments I have used for lagged expenditure changes — unexpected expenditure changes — are positively correlated with unforecastable taste shocks. If so, the lag coefficents ρ_{jk} estimated in this section are biased upwards while the income coefficients remain unbiased. This may explain the significantly positive lag coefficients for food expenditures, if food is a priori believed to be perfectly perishable. However, as I argued toward the end of section 2, there seems to be no strong reason to believe that taste shocks are important

in explaining the behavior of expenditure changes.

6. CONCLUDING REMARKS

The initial aim of the research reported here was to obtain a sharp estimate of the fraction of liquidity constrained households in the population by exploiting the large cross-section dimension of the data. This paper was not very successful on this account. The paper, however, was successful in highlighting the long-lasting effect of consumption expendtures for services and nondurables. Another useful by-product is the paper's demonstration of the strong response of expenditures to unexpected income changes without an explicit modelling of the income process, which leaves little doubt about the forward-looking nature of consumers.

The surprisingly high durablity of commodities has important implications for the econometrics of consumer demand and for macroeconomic stabilization policies. The usual specification in the econometrics of consumer demand is that the demand for nondurables and for services is a function of their current prices and total current expenditures. This is appropriate if the effect on preferences of nondurables and services is instantaneous. Otherwise the relevant variable is the user costs of capital, not current prices.[24] Expenditures and consumption should be treated like investment and capital, respectively.

Since the existing literature has ignored the durability of nondurables and services, its consensus estimate of the fraction of constrained households is likely to be biased upwards; what appears to be the excess sensitivity of expenditures to income may be merely due to the exclusion of lagged expenditures. Thus the effectiveness of countercyclical tax policy to control

aggregate demand by changing disposable income may not be as great as is generally supposed. A potentially more important factor suggested by the durability of commodities is the real interest rate as a determinant of (the optimal stock of) consumption. If the real interest rate is controllable and if consumption is sensitive to the real rate, then policymakers can manipulate expenditures by the households that follow the permanent income hypothesis. The present paper was silent on the issue of the interest elasticity of consumption because of the small time-series dimension of the data.

Although the paper was able to reject the permanent income hypothesis, about a half of the excess sensitivity comes from durable purchases, as the results in Tables 9 and 12 show. It seems plausible that the apparent sensitivity of lumpy durable purchases can be generated by a model that allows for a small wedge between the borrowing and lending rates without significantly altering the behavior of nondurables and services expenditures. If so, the permanent income hypothesis with this minor modification applies to virtually all households. Furthermore, whether policymakers can exploit the short-run sensitivity of durables purchases in order to control aggregate consumer expenditures over a medium-run such as the length of a business cycle is another question.

More fundamentally, the empirical validity of the permanent income hypothesis casts serious doubts about the wisdom of countercyclical policies. The fact that expenditure changes follow univariate autoregressions with order higher than one implies that cyclical fluctuations in expenditures are a result of optimization on the part of forward-looking consumers. What, then, is the point in disturbing the optimally chosen time path of expenditures?

Appendix A: Proof of (3.5)

This appendix proves (3.5) under two alternative assumptions.

Case 1: M is small relative to T.

Define

$$_t y_{t+k} = E_t[(1 + r_{j,t+1}) \delta \frac{\partial u(\bar{C}_{t+k+1})}{\partial \bar{C}_{j,t+k+1}} - \frac{\partial u(\bar{C}_{t+k})}{\partial \bar{C}_{j,t+k}}].$$

Then (3.4) becomes

$$\sum_{k=0}^{M} (_t y_{t+k} \delta^k \rho_{jk}) = 0.$$

This must be true at any future point in the remaining lifetime, so

$$\sum_{k=0}^{L} (_s y_{s+k} \delta^k \rho_{jk}) = 0, \quad s = t, \ t+1,\ldots,t+T-1,$$

where $L = \min (t+T-s, M)$ and $_s y_{t+T} = - E_s[\partial u(\bar{C}_{t+T})/\partial \bar{C}_{j,t+T}]$. Apply the
conditional expectations operator E_t on both sides of this equation to obtain

$$(A.1) \qquad \sum_{k=0}^{L} (x_{s+k-t} \delta^k \rho_{jk}) = 0, \quad s = t, \ t+1,\ldots, \ t+T-1,$$

where $x_\tau = {_t y_{t+\tau}}$. This is an m-th order difference equation in x_τ. If the
terminal value x_T is given, (A.1) can determine the remaining value of
x_T, namely $x_0, x_1,\ldots,x_{T-1}$. [The lifetime budget constraint (3.2) is
necessary to determine the level of x_T.] Since $\delta^k \rho_{jk}$ (k = 1,2,...M) is
declining in k, the difference equation is unstable. Since the terminal value
x_T is finite, the initial value x_0 must be small. In fact, if T is infinity,
then $x_0 = 0$.

Case 2: ρ_{jk} is declining geometrically in k, $P_{j,t+1}$ is known in t, and
$r_{j,t+1} = r_{j,t+2}$.

Since $\rho_{jk} = (\rho_j)^k$, (3.3) implies

$$\bar{C}_{jt} = C_{jt} + \rho_j \bar{C}_{j,t-1}.$$

Consider the following small deviation from the optimal decision rule: Reduce current expenditures on commodity j by one unit and increase the next period's expenditure on commodity j by ρ_j units. Since this deviation means an additional saving of $\$p_{jt}$ in period t, the additional income in period t+1 is $(1 + R_t)p_{jt} - \rho_j p_{j,t+1}$ dollars. Note that this deviation leaves $\bar{C}_{j,t+1}$ unchanged from its level implied by the optimal decision rule. This small deviation should neither decrease nor increase the objective function, so that

(A.2) $u_{jt} = \delta E_t[v_{t+1}((1 + R_t)p_{jt} - \rho_j p_{j,t+1})],$

where $u_{jt} = \partial u(\bar{C}_t)/\partial \bar{C}_{jt}$ and v_{t+1} is the marginal utility of income in period t+1. The marginal utility of income satisfies the equation

(A.3) $e_t = (1 + R_t) E_t(v_{t+1}).$

If $p_{j,t+1}$ is known at t, (A.2) can be rewritten as

(A.4) $u_{jt} = (1 + r_{j,t+1} - \rho_j)p_{j,t+1} \delta E_t(v_{t+1}).$

The right hand side of (A.4) has the interpretation of the "cost of capital" adjusted for the marginal utility of income. Now

$$E_t[(1 + r_{j,t+1})\delta u_{j,t+1}]$$

$$= E_t[(1 + r_{j,t+1})\delta(1 + r_{j,t+2} - \rho_j)p_{j,t+2} \delta E_{t+1}(v_{t+2})] \quad \text{[from (A.4)]}$$

$$= E_t[(1 + r_{j,t+1})(1 + r_{j,t+2} - \rho_j)(1 + r_{j,t+2})^{-1}p_{j,t+1} \delta v_{t+1}]$$

[from (A.3)]

If $r_{j,t+1} = r_{j,t+2}$, this is equal to u_{jt} by (A.4).

Appendix B: Time Aggregation

There is no reason that the length of a unit period for the household's optimization problem is exactly one quarter. The purpose of this appendix is to show that the quarterly model -- equation (3.14) in the text -- can be derived as an approximation to the continuous-time model.

The continuous-time versions of (3.9) is

$$(B.1) \qquad \bar{C}(\tau') - \bar{C}(\tau) = e(\tau,\tau'), \quad E_\tau e(\tau,\tau') = 0 \text{ for } \tau' > \tau,$$

where the subscript j is dropped for notational simplicity and the intercept term d_{jt} is ignored for simplicity. Let $t = 0,1,2,\ldots$ be points in the continuous-time axis that mark the end of each quarter. Set $\tau = t$ and $\tau' = t+1$ to obtain

$$(B.2) \qquad \bar{C}(t+1) - \bar{C}(t) = e(t,t+1), \quad E_t e(t,t+1) = 0.$$

In the continuous-time model, $\bar{C}$ is related to C by

$$(B.3) \qquad \bar{C}(\tau) = \int_0^\infty \rho(v)C(\tau-v)dv.$$

Combine (B.2) and (B.3) to get

$$(B.4) \qquad e(t,t+1) = \int_0^\infty \rho(v)C(t+1-v)dv - \int_0^\infty \rho(v)C(t-v)dv.$$

Now, consider the following step function as an approximation to $\rho(v)$:

$$(B.5) \qquad \bar{\rho}(v) = \rho(0) \text{ if } 0 \leqslant v < 1, \ \bar{\rho}(v) = \rho(1) \text{ if } 1 \leqslant v < 2, \text{ etc.}$$

Then one obtains

$$(B.6) \qquad e(t,t+1) \approx \int_0^\infty \bar{\rho}(v)C(t+1-v)dv - \int_0^\infty \bar{\rho}(v)C(t-v)dv$$

$$= \rho(0)(C_{t+1} - C_t) + \rho(1)(C_t - C_{t-1}) + \ldots,$$

where C_t's are unit-averages, namely

(B.7) $C_{t+1} = \int_t^{t+1} C(\tau)d\tau.$

Normalizing $\rho(0)$ to be unity, one obtains from (B.6) that

(B.8) $C_{t+1} - C_t = - \rho(1)(C_t - C_{t-1}) - \rho(2)(C_{t-1} - C_{t-2}) - \ldots,$

$$+ e(t,t+1).$$

If period t is the time interval between t-1 and t, the left hand side of (B.8) is the change in unit-averaged expenditures from period t to period t+1. Note that $e(t,t+1)$ is orthogonal to information available at the <u>end</u> of period t, since $E_t e(t,t+1) = 0$.

APPENDIX C: Derviation of (4.6)

This appendix derives (4.6) under the assumption that λ, the fraction of constrained households in the sample, is an exogenously given constant. Write the two equations (4.2) and (4.4) compactly as

$$(C.1) \qquad y = \delta_1 z_1 + v \qquad \text{for (4.2)}$$

$$(C.2) \qquad y = \delta_2 z_2 + w, \qquad \text{for (4.4)}$$

where the subscript j is dropped for notational simplicity. Let a dummy variable D take the value of unity if the household is constrained and zero if the household follows the permanent income hypothesis. The expected value of D is λ. The two equations can be combined into one equation

$$(C.3) \qquad y = (1 - D)\delta_1 z_1 + D\delta_2 Z_2 + (1-D)v + Dw.$$

If D is independent of z_1, z_2, x, v, w, then the least squares projection of y on x, $E^*(y|x)$, can be written from (C.3) as

$$(C.4) \qquad E^*(y|x) = (1 - \lambda)\delta_1 E^*(z_1|x) + \lambda\delta_2 E^*(z_2|x).$$

Combining (C.3) and (C.4) one obtains

$$(C.5) \qquad y = (1 - \lambda)\delta_1 z_1 + \lambda\delta_2 z_2 + \eta,$$

where

$$(C.6) \qquad \eta = y - E^*(y|x) - (1 - \lambda)\delta_1 [z_1 - E^*(z_1|x)] - \lambda\delta_2 [z_2 - E^*(z_2|x)].$$

By construction, $E^*(\eta|x) = 0$, i.e., $E(\eta x) = 0$ as required. Note that the conditional variance of η conditional on x is a function of x by construction, even if the initial error terms v and w are conditionally homoskedastic.

FOOTNOTES

1. In this paper the permanent income hypothesis is taken to mean that households optimize their intertemporal utility function subject to the lifetime budget constraint.

2. See King (1983) for a survey of recent contributions.

3. This example is due to Larry Summers.

4. The survey also has data on the amount of money that is given to members of the family other than the head. This is not considered in the analysis of this paper. The expenditure data refer to the full cost of purchases even though full payment may not have been made at the date of purchase.

5. No data on education are available. This is characteristic of most surveys in Japan.

6. The reason for doing this is to treat homeowners and nonhomeowners symmetrically. This paper will work with changes in expenditures. Although the survey does not report imputed rents for homeowners, this will disappear when expenditure changes are taken.

7. One case reported about 3.8 million yen for "other expenses" in period 1. This was a clear outlier. (The next highest value was about 1.2 million yen.) Four cases reported temporary income for period 1 in excess of 10 million yen. If these four cases are included, the sample standard deviation of temporary income in period 1 nearly quadruples, although the results to be reported in this paper are not changed in any important way (except for the results on temporary income). Another case reported temporary income in excess of 10 million yen in period 2. The remaining seventh case reported expected normal income for period 5 of 19,890 thousand yen. Since its actual normal income in periods 1,2,3 and 4 is 1,980 thousand yen, I concluded that the number was wrong by one decimal point.

8. For the commodity-specific number of equivalent adults, see Deaton and Muelbauer (1980).

9. The Annual Report on the Survey of Family Consumption (The Economic Planning Agency) reports quarterly time-series data from 1977:Q2 on average expenditures on the ten commodity groups. I estimated the multiplicative model of seasonality using this time-series data and then used the resulting seasonality factor to perform seasonal adjustment on the present data set.

10. If the real interest rate is equal to the subjective discount rate and if the instantaneous utility function is quadratic, then change in consumption is white noise, as Hall (1978) has shown. If, in addition, the first-order coefficients in the quadratic utility function is subject to taste shocks, then change in consumption is a white noise process plus a moving average of taste shocks. This was pointed out to me by Robert Flood.

11. The Family Income and Expenditure Survey, compiled by the Prime Minister's Office of Japan, is a diary survey on monthly expenditures on over several hundred commodity groups. Since one-sixth of the sample is replaced by new households every month, it is possible to create a six-month panel of monthly expenditures. A forthcoming study done at the Economic Planning Agency contains calculation of the autocorrelation coefficients for monthly expenditure changes. The first order auto-correlation coefficient for food is close to -0.4 on average.

12. This VAR model is estimated on family size-unadjusted data because I thought the interpretation of the VAR coefficients became more straightforward. The coefficients estimated on family size-adjusted data are virtually identical. The significance of the lag coefficients is determined by heteroskedasticity-robust standard errors. See section 4 for more details on how to calculate them. Four additional variables -- AGE, AGE^2, $FSZ_4 - FSZ_3$ and $(FSZ_4 - FSZ_3)^2$ -- are also included on the right-hand side of the equations, but their estimated coefficients are not reported in Table 5. The lagged expenditure coefficients in the YT

("temporary" income) equation are large in absolute value. This is due to
seasonality in YT. If seasonally adjusted data on expenditures and income
are used, the coefficients become must smaller in absolute value.

13. To economize notation, bequests are not considered, although it is
straightforward to do so.

14. So the omission of leisure in our model does not seem to cause any
serious problem. Anyway, there are no data on labor supply in the present
data set.

15. This is pointed out in Chamberlain (1982). Suppose, for example, there
is a totally unexpected income tax reform in period t that slashes the
marginal tax rates for the rich. The forecast error $YD_t - YD_t^e$ will be
positive for the rich and negative for the poor. So the correlation
between $YD_t - YD_t^e$ and YD_{t-1} across households, which equals

$$\plim_{N \to \infty} N^{-1} \sum_{i=1}^{N} (YD_{it} - YD_{it}^e) YD_{i,t-1}$$

(where N is the sample size and i indexes households), is positive. The
mean of forecast errors can also differ from zero, because everyone can be
wrong in the same direction at any given point in time. The household
subscript i has been dropped in the text.

16. The intercept term also depends on the after-tax real rate $r_{j,t+1}$. Since
interest income is virtually tax-free in Japan, it is reasonable to assume
that $r_{j,t+1}$ is the same across households.

17. In what follows, I will ignore taste shocks. The implication of taste
shocks for parameter estimtes will be discussed in the last paragraph of
section 5.

18. Unexpected expenditure changes in other commodities, $c_{\ell t} - c_{\ell t}^e (\ell \neq j)$,
could also be used as instruments in estimating the equation for commodity
j, but they are almost uncrorrelated with actual expenditure changes on
commodity j and so no significant efficiency gain will be accomplished.

19. The time-series estimates in Table 11 assume that the real rates are constant over time.

20. Brown (1952)'s statement of the habit persistence hypothesis is as follows: "...the lag effect in consumer demand was produced by the consumption habits which people formed as a result of past consumption. The habits, customs, standards, and levels associated with real consumption previously enjoyed become 'impressed' on the human physcological and psychological systems and this produces an inertia or 'hysteresis' in consumer behavior." Brown summarizes his hypothesis in his equation 4: $C = a_o + a_1Y + a_2C_{-1} + u$, where Y is current income and C_{-1} is lagged consumption.

21. Changes from period 3 to period 4 are considered because actual changes from period 4 to period 5 are unobservable.

22. The lag coefficients for food expenditures in Table 12 are considerably larger than those in Tables 7 and 9. This is probably due to multiplicative seasonality. The dependent variable in Table 12 is expenditure change from the fourth quarter to the first quarter of the following year. The first lag is expenditure change from the third to the fourth quarter, which is strongly negatively correlated with the dependent variable because of the high level of expenditures in the fourth quarter. The use of the data that are adjusted for multiplicative seasonality did produce smaller point estimates for the lag coefficients for food. There are, however, costs associated with the use of seasonally adjusted data. The formula (3.3) that links expenditures to cnsumption should be in non-seasonally adjusted data. It does not seem sensible to suppose the equation (3.15) for liquidity constrained households holds on seasonally adjusted data. Anyway, since there is not much seasonality in expenditures in the first and second quarters of the year, the results in Tables 7-9 are robust to multiplicative seasonality.

23. If expected and unexpected income changes rather than actual and unexpected income changes are used, then the expected income change coefficient will be .08 and the unexpected income change coefficient will

be .37.

24. See (A.4) in Appendix A for a derivation.

REFERENCES

BROWN, T. M. "Habit Persistence and Lags in Consumer Behaviour." Econometrica 20 (July 1952): 355-371.

CHAMBERLAIN, GARY, "Panel Data." in: The Handbook of Econometrics, M. Intrilligator and Z. Grillichs ed.

DEATON, ANGUS, and MUELLBAUER, JOHN. Economics and Consumer Behavior, Cambridge University Press, 1980.

HALL, ROBERT E. "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence." Journal of Political Economy 86 (December 1978): 971-987.

HALL, ROBERT E., and MISHIKIN, FREDERIC S. "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data On Households." Econometrica 50 (March 1982): 461-481.

KING, MERVIN. "The Economics of Saving: A Survey of Recent Contributions." National Bureau of Economic Research Working Paper No. 1247, December 1983.

TABLE 1

MEANS AND STANDARD DEVIATIONS OF LEVELS

A. Family Size-Unadjusted

Variable	1981:Q2	1981:Q3	1981:Q4	1982:Q1
C1	212.6 (83.7)	217.5 (84.2)	240.7 (96.6)	215.7 (86.6)
C2	65.9 (44.2)	64.7 (43.0)	74.3 (47.6)	74.3 (44.0)
C3	52.1 (73.5)	50.7 (78.5)	70.8 (73.5)	53.0 (61.1)
C4	58.9 (165.9)	59.6 (179.1)	64.1 (139.8)	41.5 (119.4)
C5	33.5 (50.6)	52.6 (66.4)	41.2 (52.9)	34.1 (51.7)
C6	26.6 (31.3)	26.8 (38.4)	28.3 (33.1)	25.6 (24.4)
C7	60.8 (110.0)	48.4 (77.2)	51.8 (83.0)	64.9 (132.1)
C8	21.0 (38.7)	21.9 (31.9)	24.2 (40.0)	22.2 (39.3)
C9	52.8 (114.5)	55.9 (80.3)	74.6 (98.5)	57.2 (72.2)
C10	76.9 (73.5)	78.9 (76.7)	88.3 (81.3)	70.3 (60.8)
YN	681.5 (276.6)	688.4 (291.2)	693.8 (292.9)	686.9 (282.9)
YT	202.7 (337.3)	214.1 (244.6)	446.8 (366.4)	63.1 (121.8)

NOTE. -- Standard deviations are in parentheses. The numbers for expenditures and income are stated in thousands of 1980 yen.

TABLE 1 (Continued)

B. FAMILY SIZE-ADJUSTED

Variable	1981:Q2	1981:Q3	1981:Q4	1982:Q1
C1	157.5 (58.1)	160.7 (56.6)	177.6 (64.8)	159.2 (59.7)
C2	56.1 (37.6)	55.1 (36.2)	63.2 (39.9)	63.3 (37.2)
C3	42.6 (60.2)	41.3 (63.8)	57.8 (60.9)	43.0 (49.5)
C4	51.5 (142.1)	51.8 (151.0)	56.4 (123.4)	36.3 (102.2)
C5	30.0 (46.2)	47.0 (59.7)	36.8 (47.7)	30.5 (47.2)
C6	21.1 (23.9)	21.3 (31.3)	22.4 (26.4)	20.3 (19.0)
C7	41.6 (78.0)	33.0 (57.2)	35.0 (58.5)	43.6 (88.4)
C8	19.7 (37.1)	20.5 (30.3)	22.7 (38.6)	20.6 (36.1)
C9	52.9 (104.1)	56.0 (80.6)	74.8 (98.3)	57.3 (72.5)
C10	69.7 (65.9)	71.7 (70.5)	80.0 (72.7)	63.8 (55.1)

NOTE. -- Standard deviations are in parentheses. The numbers for expenditures are stated in thousands of 1980 yen and are per two equivalent adults.

TABLE 2

ESTIMATES OF THE MULTIPLICATIVE MODEL OF FAMILY SIZE

| Independent Variable, Log of: | Family Size Dummies | | | | | | R^2 | Sample Size |
	F3	F4	F5	F6	F7	F8+		
C1	.232	.326	.423	.530	.644	.659	.146	8,040
C2	.112	.221	.169	.225	.264	.454	.018	8,027
C3	.125	.230	.328	.385	.392	.512	.017	7,841
C4	.133	.092	.241	.215	.251	.434	.004	4,849
C5	.097	.081	.218	.255	.258	.233	.006	7,163
C6	.150	.286	.326	.392	.315	.189	.024	7,993
C7	.190	.443	.533	.553	.481	.245	.021	5,830
C8	−.001	−.029	.171	.348	.173	.355	.009	7,353
C9	−.009	−.062	.005	.205	.254	.444	.007	7,918
C10	.109	.069	.175	.168	.224	.418	.005	8,019

NOTE. -- Cases with the zero for the dependent variable are deleted in calculating regression coefficients. Intercept terms are not reported. F8+ is the dummy variable for family of size 8 or more.

TABLE 3

MEANS AND STANDARD DEVIATIONS OF CHANGES

Variable (X)	X_2-X_1	X_3-X_2	X_4-X_3
C1	3.20 (35.3)	16.91 (35.5)	-18.45 (40.7)
C2	-1.05 (27.7)	8.15 (27.5)	.06 (27.1)
C3	-1.29 (64.4)	16.44 (62.2)	-14.81 (57.8)
C4	.29 (191.5)	4.58 (178.5)	-20.01 (152.7)
C5	17.00 (63.7)	-10.24 (58.7)	-6.27 (56.5)
C6	.21 (32.6)	1.08 (33.9)	-2.10 (23.4)
C7	-8.59 (50.9)	2.00 (43.8)	8.53 (74.4)
C8	.77 (40.7)	2.18 (40.8)	-2.04 (46.5)
C9	3.05 (118.0)	18.84 (103.0)	-17.47 (101.2)
C10	2.04 (65.9)	8.27 (70.6)	-16.16 (61.9)
YN	6.85 (117.1)	5.41 (104.0)	-6.82 (102.6)
YT	11.35 (421.0)	232.69 (362.5)	-383.69 (350.5)

NOTE. -- Standard deviations are in parentheses. Expenditures are family size-adjusted. Income is not family size-adjusted.

TABLE 4

SAMPLE AUTOCORRELATION OF CHANGES

Variable	Seasonally Unadjusted		Seasonally Adjusted	
	autocorrelation		autocorrelation	
	first order	second order	first order	second order
C1	-.264*** -.472***	-.131***	-.291*** -.401***	-.122***
C2	-.289*** -.539***	-.034	-.326*** -.504***	-.034
C3	-.425*** -.435***	-.130***	-.515*** -.267***	-.104***
C4	-.541*** -.484***	.002	-.576*** -.368***	.021
C5	-.593*** -.318***	-.187***	-.405*** -.381***	-.171***
C6	-.653*** -.493***	.010	-.675*** -.462***	.010
C7	-.432*** -.297***	.085***	-.519*** -.335***	.130***
C8	-.357*** -.524***	-.010	-.353*** -.474***	-.005
C9	-.345*** -.634***	-.038*	-.400*** -.493***	-.032
C10	-.468*** -.534***	.057	-.501*** -.465***	-.050*
YN	-.333*** -.333***	-.065**	-.335*** -.328***	-.060**
YT	-.580*** -.732***	.112***	-.736*** -.087***	-.073**

NOTE TO TABLE 4. -- Two first-order autocorrelation coefficients
are calculated. The numbers that first appear in the column for
first-order autocorrelation are the correlation coefficient beteen
$X_3 - X_2$ and $X_2 - X_1$, and the numbers that appear below them are the
correlation coefficient of $X_4 - X_3$ and $X_3 - X_2$ (X = C1,C2,...,YN,YT).
Expenditures are family size-adjusted.

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

TABLE 5

TWELVE-VARIABLE VECTOR AUTOREGRESSION MODEL

A. PARAMETER ESTIMATES AND SUMMARY STATISTICS

Dependent Variable	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	YN	YT	R^2	S.E.R.
$C1_4 - C1_3$	-.603**	-.018	.000	.011	.007	.024	.012	-.033*	.010	-.010	.002	-.007	.32	44.0
	-.281	.023	-.025	-.000	-.010	.039	.019	.041	-.005	.015	.020	-.007		
$C2_4 - C2_3$	-.002	-.599**	-.039	-.002	-.007	.002	-.005	.032*	.001	-.023	.010	.009*	.36	25.6
	-.009	-.209	.002	-.003	.011	.004	-.002	.041	.008	-.017	.007	.001		
$C3_4 - C3_3$	-.029	.003	-.553**	-.002	-.008	.031*	.120*	.065	-.018	-.027	.046*	-.020*	.35	56.4
	.010	-.038	-.343	.005	.024	-.112	.085	-.060	-.038	.018	.080	-.010		
$C4_4 - C4_3$	-.122	-.086	-.045	-.573**	-.054	.281	.103	-.116	.051	.023	-.018	-.028	.33	143.2
	-.047	-.095	-.020	-.295	-.124	.333	-.038	-.081	.091	.010	.016	-.016		
$C5_4 - C5_3$	.036	-.050	-.004	.004	-.631**	.022	.025	-.011	-.014	-.020	.003	-.005	.32	51.0
	.025	-.038	-.036	-.003	-.499	.020	.038	-.002	-.002	.004	.015	-.005		
$C6_4 - C6_3$	.000	-.001	.006	.003	.024	-.570**	.008	-.011	.000	-.002	.002	-.003	.39	22.5
	.011	-.022	.009	.002	.014	-.355	.013	-.010	-.003	.003	.001	-.001		
$C7_4 - C7_3$	.065	.141	-.115*	-.007	-.085	.026	-.587**	-.010	.003	.016	.008	.036	.13	104.3
	.073	.114	-.102	.015	-.011	-.002	-.044	-.021	.008	.059	.011	.002		
$C8_4 - C8_3$	-.006	.002	.030	.003	.011	.028	-.003	-.677**	-.019	-.005	-.006	.005	.32	40.3
	-.026	.038	.026	.006	.006	.022	-.019	-.289	-.004	-.001	-.044	.002		
$C9_4 - C9_3$	.005	.087	.042	.032	-.041	.008	-.125	.033	-.723**	.015	-.036	-.013**	.49	72.1
	.031	.061	.036	.013	-.015	.030	-.010	.021	-.245	-.010	.011	-.019		
$C10_4 - C10_3$	.040	-.094**	.034*	.000	-.047	-.067*	.006	-.019	-.005	-.643**	-.006	-.006	.43	51.8
	-.014	.071	-.007	-.010	.010	.009	-.020	.020	.008	-.368	.017	.003		
$YN_4 - YN_3$	.064	.075	.035	-.011	.090	-.053	.001	-.206*	.058	-.020	-.390**	.017**	.18	93.0
	.010	.115	-.026	-.009	.089	-.049	.013	-.078	.023	-.025	-.172	-.010		
$YT_4 - YT_3$	-.179	-.403*	-.151	.104**	.113*	-.045	.488**	.040	-.095	-.129	.004	-.955**	.71	189.9
	-.128	-.179	-.267	.009	-.133	.030	.228	.030	-.079	-.129	-.013	-.359		

NOTE. — For each dependent variable, the upper line contains the coefficients of first lags and the lower line contains the coefficients of second lags. For example, the coefficient of YN_2-YN_1 in the equation for $C1_4-C1_3$ is .020. The last column under the label "S.E.R." reports the standard error of the regression, namely the sample standard deviation of the residuals.

* Two lags as a whole significant at the 5 percent level.
** Two lags as a whole significant at the 1 percent level.

TABLE 5 (Continued)

B. CONTEMPORANEOUS CORRELATION OF THE RESIDUALS OF THE VECTOR AUTOREGRESSION MODEL

	C2	C3	C4	C5	C6	C7	C8	C9	C10	YN	YT
C1	.005	-.005	.034	.045*	.023	-.056*	.055	.031	.035	.165**	.077**
C2		-.118**	-.049*	.002	-.028	.033	.006	.015	.031	-.019	.006
C3			.074**	.044*	.059**	.062**	-.047*	.131**	-.015	.061**	.077**
C4				-.000	-.001	.065**	.014	.081**	-.021	.035	.131**
C5					-.026	-.020	-.013	-.002	.055*	.056*	.050*
C6						.020	.028	.025	.018	.058**	.042
C7							-.022	-.011	.031	.034	.029
C8								.103**	.031	-.008	.103**
C9									.017	.046*	.131**
C10										.051*	.122**
YN											-.016

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

TABLE 6

CORRELATION COEFFICIENTS OF UNEXPECTED CHANGES WITH
LAGGED UNEXPECTED AND ACTUAL CHANGES

Variable (X)	Correlation Coefficient of $X_4 - X_4^e$ with:			
	$X_3 - X_3^e$	$X_2 - X_2^e$	$X_3 - X_2$	$X_2 - X_1$
C1	-.090***	-.126***	-.117***	-.129***
C2	-.019	-.201***	-.030	-.152***
C3	-.038	.004	.007	-.049*
C4	.092***	.004	.043	-.101***
C5	-.010	.000	-.145***	.005
C6	-.050*	-.068**	.026	-.030
C7	-.019	-.027	.050*	-.066*
C8	-.110***	-.002	-.094***	-.013
C9	.132***	.062**	.034	-.028
C10	-.010	-.005	-.050*	-.016
YN	-.056*	-.229***	-.087***	-.134***
YT	-.069**	.095***	-.043	.095***

NOTE. -- Expenditures are family size-adjusted.

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

TABLE 7

PARAMETR ESTIMATES FOR EQUATION (5.7) WITH $\lambda = 0$

A. Generalized Two-Stage Least Squares Estimates

Commodity Group (j)	ρ_{j1}	ρ_{j2}	ρ_{j3}	R^2
C1	.275 (.035)	.249 (.037)	.099 (.024)	.16
C2	.506 (.062)	.303 (.049)	.174 (.035)	.28
C3	.963 (.118)	.944 (.192)	1.252 (.328)	.16
C4	1.056 (.055)	1.085 (.097)	1.149 (.108)	.18
C5	1.224 (.374)	1.257 (.388)	1.133 (.356)	.20
C6	.617 (.134)	.613 (.136)	.530 (.135)	.11
C7	.867 (.107)	.632 (.151)	.361 (.207)	.33
C8	.866 (.111)	.974 (.212)	.883 (.224)	.15
C9	1.041 (.127)	.911 (.152)	.962 (.134)	.10
C10	.561 (.080)	.426 (.086)	.408 (.077)	.16

NOTE. -- The instruments for lagged changes in expenditures are the associated unexpected changes. Heteroskedasticity-rubust standard errors are in parentheses. The R^2 is calculated from the second-stage regression.

TABLE 7 (Continued)

B. Ordinary Least Squares Estimates

Commodity Group (j)	ρ_{j1}	ρ_{j2}	ρ_{j3}	R^2
C1	.207 (.029)	.187 (.031)	.069 (.020)	.15
C2	.410 (.049)	.263 (.035)	.121 (.029)	.34
C3	.452 (.108)	.257 (.135)	.216 (.070)	.29
C4	.612 (.067)	.316 (.057)	.194 (.039)	.33
C5	.670 (.144)	.374 (.106)	.231 (.106)	.43
C6	.259 (.064)	.178 (.050)	.125 (.034)	.10
C7	.780 (.054)	.295 (.096)	.132 (.061)	.65
C8	.549 (.059)	.396 (.055)	.125 (.051)	.34
C9	.565 (.103)	.356 (.097)	.200 (.070)	.26
C10	.385 (.072)	.244 (.052)	.188 (.033)	.26

NOTE. -- Heteroskedasticity-robust standard errors are in parentheses.

TABLE 8

WALD STATISTICS

Commodity Group	Wald Statistic	P Value[†]
C1 (food)	36.3	.109
C2 (rents, fuel and utilities)	40.3	.048
C3 (cloths and household textiles)	17.6	.915
C4 (durables)	48.5	.007
C5 (recreation)	12.5	.992
C6 (cultural expenses)	24.6	.599
C7 (education)	27.0	.466
C8 (medical expenses)	22.7	.702
C9 (social expenses)	26.2	.508
C10 (other)	34.4	.157

[†]The degreees of freedom is 27.

TABLE 9

PARAMETR ESTIMATES FOR EQUATION (5.7)
BY GENERALIZED TWO-SRAGE LEAST SQUARES

Comodity Group (j)	ρ_{j1}	ρ_{j2}	ρ_{j3}	α_j
C1	.310 (.042)	.277 (.041)	.106 (.026)	.110 (.039)
C2	.572 (.076)	.343 (.058)	.196 (.041)	.012 (.015)
C3	1.084 (.145)	1.064 (.226)	1.415 (.385)	-.158 (.136)
C4	1.190 (.085)	1.224 (.122)	1.297 (.141)	.440 (.248)
C5	1.370 (.417)	1.376 (.431)	1.297 (.395)	.228 (.149)
C6	.697 (.157)	.693 (.160)	.599 (.157)	.004 (.018)
C7	.981 (.134)	.713 (.178)	.410 (.235)	.087 (.071)
C8	.968 (.133)	1.087 (.241)	.997 (.254)	.079 (.061)
C9	1.177 (.159)	1.035 (.183)	1.094 (.164)	.133 (.104)
C10	.633 (.095)	.481 (.100)	.460 (.090)	.067 (.065)

$\hat{\lambda}$ = sum of EDY_{j4} coefficients over j = .116 (.045)

NOTE. -- Heteroskedasticity-robust standard errors are in parentheses.

TABLE 10

CORRELATION OF FAMILY SIZE-ADJUSTED EXPECTED CHANGE IN
DISPOSABLE INCOME WITH LAGGED EXPENDITURES CHAGES

Commodity Group (j)	Correlation Coefficient of $EDYD_{j4}$ with:		
	$X_{j2}-X_{j1}$	$X_{j3}-X_{j2}$	$X_{j4}-X_{j3}$
C1	−.062**	.021	−.025
C2	−.044*	.102***	−.027
C3	−.126***	.056*	.016
C4	−.066**	.024	−.016
C5	−.000	−.029	.028
C6	−.005	−.023	.036
C7	−.067**	.011	−.013
C8	.052*	−.025	.053*
C9	−.016	.035	−.043
C10	−.081***	.054*	−.079***

NOTE. -- EDY_{j4} ($j=1,2,..,10$) is family size-adjusted expected
disposable income change and is defined formally in (3.16).

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

TABLE 11

AGGREGATE TIME-SERIES ESTIMATE OF THIRD-ORDER AUTOREGRESSIONS
ON EXPENDITURES CHANGES

Commodity Group in the National Income Acounts	ρ_1	ρ_2	ρ_3
Food, beverages and tobacco	.245 (.161)	.210 (.164)	.032 (.160)
Rents, fuel and utilities[†]	.313 (.151)	.443 (.140)	.377 (.146)
Clothes and footwares	.390 (.169)	.306 (.177)	.054 (.171)
Durables	-.033 (.161)	.171 (.158)	.030 (.163)
Recreation and education	.177 (.146)	.396 (.140)	.061 (.149)
Medical care	.438 (.155)	.246 (.166)	.161 (.157)

NOTE. -- Standard errors are in parentheses. The estimated model is x_t = seasonal dummies $- \rho_1 x_{t-1} - \rho_2 x_{t-2} - \rho_3 x_{t-3}$, where x_t is expenditures change from quarter t-1 to quarter t. The data on expenditures are in real and per capita terms. The sample period is 1971:Q1 - 1982:Q2.

[†]Rents here include imputed rents.

TABLE 12

PARAMETR ESTIMATES FOR EQUATION (6.3)

BY GENERALIZED TWO-SRAGE LEAST SQUARES

Commodity Group (j)	Coefficient of:			
	$c_{j3} - c_{j2}$	$c_{j2} - c_{j1}$	ADY_{j3}	UDY_{j3}
C1	-.636	-.315	.0090	.0166
	(.048)	(.071)	(.0036)	(.0135)
C2	-.680	-.280	-.0069	.0130
	(.076)	(.054)	(.0023)	(.0060)
C3	-.824	-1.027	.0209	.0053
	(.125)	(.228)	(.0093)	(.0177)
C4	-1.027	-1.044	.0399	.0565
	(.078)	(.107)	(.0198)	(.0455)
C5	-.927	-.836	.0081	.0048
	(.064)	(.062)	(.0045)	(.0114)
C6	-.880	-.746	.0031	.0031
	(.081)	(.123)	(.0022)	(.0057)
C7	-.762	-.368	-.0075	.0770
	(.197)	(.250)	(.0068)	(.0306)
C8	-1.042	-.954	-.0022	.0256
	(.187)	(.213)	(.0032)	(.0164)
C9	-.912	-.844	-.0020	.0798
	(.051)	(.082)	(.0069)	(.0296)
C10	-.751	-.614	.0129	.0101
	(.082)	(.073)	(.0054)	(.0146)

sum of ADY_{j3} coefficients over j = .0753
                                       (.0255)

sum of UDY_{j3} coefficients over j =   .2916
                                                  (.0855)

NOTE. -- Heteroskedasticity-robust standard errors are in parentheses. The instruments for lagged expenditures changes are their associated unexpected changes. See equations (6.2) and (6.4) in the text for the definition of ADY_{j3} and UDY_{j3}.