ECONOMIC GROWTH CENTER

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CENTER DISCUSSION PAPER NO. 340

A NEW TEST OF THE PERMANENT INCOME HYPOTHESIS: THE IMPACT OF WEATHER ON THE INCOME AND CONSUMPTION OF FARM HOUSEHOLDS IN INDIA

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March 1980

The permanent income hypothesis has sustained the interest of economic researchers since it was originally advanced by Friedman (1952). Yet, even with an abundance of empirical tests of the proposition, no real consensus has emerged.[1] The reason, I believe, is that there has been no instance in which the data have conformed well to the hypothetical experiment required to simulate the structural ingredients of the theory. The theory is, after all, based upon what is unobservable to the researcher, although presumably known to the economic actor, namely permanent income. Tests of the theory necessitate some further maintained assumption about the manner in which the consuming unit forms its *ex ante* notion of permanent income relevant to its lifetime consumption decision.[2]

The principal technique employed to directly estimate the permanent income elasticity of consumption has been based upon an instrumental variables approach. The most common instruments have been either lagged (or future) income (or some composite of higher order lags) or lagged (or future) consumption (Liviatan, 1963). Under the stringent assumptions that the serial correlation of the transitory components of income and consumption are zero and likewise that the contemporaneous and intertemporal covariances of measurement errors of and between income and consumption are also zero, consistent estimates of the relevant parameter can be obtained.[3] Since plausible scenarios exist for non-zero correlations, these instruments provide only weak tests of the theory.[4] Moreover, in the presence of serial correlation, these instrumental variable estimates of the permanent elasticity require the maintained assumption that the transitory income elasticity of consumption is zero. But, those researchers who have attempted to jointly test both propositions of the permanent income hypothesis, that the permanent elasticity is unity and the transitory income elasticity is zero, have used a residual concept of transitory income which is not likely to be free of all permanent elements.

The purpose of this paper is to present a strong test of both propositions of the permanent income hypothesis based on survey data extracted from an environment which closely approximates the appropriate laboratory experiment. In particular, I look at the impact of permanent and transitory weather on the income and consumption of rural Indian farm households using a three year panel survey. The crucial features of the environment are, first, the technological stability of Indian agriculture (except for certain districts with green revolution governmental programs which are excluded from the analysis) and, second, the intergenerational geographic stability of landed households in India. Together they imply almost perfect knowledge about "permanent" weather conditions and the relationship of weather to agricultural production. The results are supportive of the permanent income view.

The plan of the paper is as follows. In the next section, I briefly review the structure of the permanent income theory and discuss the instrumental variable estimators previously used by other researchers. The following section sets out the parallel estimators based on weather variation. The data is then discussed and the estimates presented. The final section summarizes.

I. A Brief Review

The essential aspect of the permanent income hypothesis is the notion that households tailor current consumption to a long-run income concept and ignore income fluctuations about long-run income. The structure of a general model of consumption within which the permanent income hypothesis is embedded can be summarized in the following two equations (a multiplicative version is assumed with all variables measured in logarithmic scale to facilitate discussion in terms of elasticities):

$$(1) \qquad y_t = y^P + \varepsilon_t + m_{1t}$$

$$(2) \qquad c_t = \alpha y^P + \beta\varepsilon_t + \eta_t + m_{2t}$$

where y_t and c_t are current (period t) income and consumption, y^P is permanent income, ε_t is transitory income, η_t is transitory consumption, and m_{1t} and m_{2t} are pure measurement error terms that result only from imperfections in data gathering. Transitory elements are assumed to have zero means, $E(\varepsilon_t) = E(\eta_t) = 0$, and permanent components are assumed uncorrelated with transitory components, $E(\varepsilon_t y^P) = E(\eta_t y^P) = 0$.[5] Given these restrictions, the permanent income hypothesis asserts that $\alpha = 1$, the permanent income elasticity of consumption is unity, and that $\beta = 0$, the transitory income elasiticy of consumption is zero.

In a world of perfect certainty, i.e. where income fluctuates, but is known period by period, permanent income does not vary over the life-cycle. In that case, α and β can be consistently estimated with two years of data under certain conditions. Let us maintain throughout the rest of the discussion the assumptions above as well as the further assumption that reporting errors are uncorrelated with permanent or transitory income and consumption, i.e., $E(m_{jt} y_p) = E(m_{jt} \varepsilon_t) = E(m_{jt} \eta_t) = 0$ for $j = 1,2$. These latter assumptions are made not due to a belief in their validity, but because the basic points are unaffected while the expressions that follow are greatly simplified.

Denoting Δx as the difference between period t and period t-1 values of x, $\Delta x = x_t - x_{t-1}$, it is easily seen that

$$(3) \quad \frac{\text{cov } (c_t \cdot \Delta y)}{\text{cov } (y_t \cdot \Delta y)} = \frac{\beta \text{ cov } (\varepsilon_t \cdot \Delta\varepsilon) + \text{cov } (m_{2t} \cdot \Delta m_1)}{\text{cov } (\varepsilon_t \cdot \Delta\varepsilon) + \text{cov } (m_{1t} \cdot \Delta m_1)}$$

First-differencing income, in effect, differences out permanent income in a world of perfect certainty about income flows, so that if there is no measurement error or if the measurement error is time invariant, i.e., $m_{jt} = m_j$, equation (3) yields an unbiased estimate of the transitory income elasticity, β.[6] In general, the existence of measurement error will lead to bias. In addition, if future income flows are not known with certainty and permanent income is updated each period given new income realizations, first-differenced income will contain a permanent income component which will lead to an instrumental variables estimate which confounds permanent and transitory effects.[7]

Consider next the following two relationships which make use of lagged income and lagged consumption respectively as instrumental variables for permanent income.[8,9]

$$(4) \quad \frac{\text{cov } (c_t y_{t-1})}{\text{cov } (y_t y_{t-1})} = \frac{\alpha \text{ var } y^P + \beta \text{ cov } (\varepsilon_t \varepsilon_{t-1}) + \text{cov } (m_{1t-1}\, m_{2t})}{\text{var } y^P + \text{cov } (\varepsilon_t \varepsilon_{t-1}) + \text{cov } (m_{1t}\, m_{1t-1})}$$

$$(5) \quad \frac{\text{cov } (c_t c_{t-1})}{\text{cov } (y_t c_{t-1})} = \frac{\alpha^2 \text{ var } y^P + \beta^2 \text{ cov } (\varepsilon_t \varepsilon_{t-1}) + \text{cov } (\eta_t \eta_{t-1}) + \text{cov } (m_{2t} m_{2t-1})}{\alpha \text{ var } y^P + \beta \text{ cov } (\varepsilon_t \varepsilon_{t-1}) + \text{cov } (m_{1t}\, m_{2t-1})}$$

As has been previously recognized, serial correlation of transitory income and consumption components leads to biased estimates of α, given $\beta = 0$. Indeed, with the anticipated correlation being positive, the estimates are downward and upward biased respectively thus yielding bounds for the true value. Positive serial correlation in measurement errors widen those bounds, while a positive cross correlation in the measurement errors of income and consumption or a positive transitory income elasticity ($\beta > 0$) narrows or even reverses the biases. Non-zero correlations between reporting errors and y^p, ε_t, or η_t increases ambiguity. In general, therefore, only with rather strong restrictions can longitudinal data on income and consumption alone be used to test the permanent income hypothesis.

II. A Test Based on Weather

In this section, I explore a methodology which makes use of the fact that in a traditional agricultural setting with stable technology, there is a component of income that permanently differs across households in a known way, namely that which is related to "permanent" weather conditions. There is, in addition, a transitory component of weather, the distribution of which around the permanent level can be assumed known with certainty given a long history of experience passed down from generation to generation.

More formally, let w_t be a country-wide index of weather, where $\bar{w}$ is the mean value denoted as "normal" weather and where increasing values of w imply weather of a more adverse variety. Thus, a value of w greater than $\bar{w}$ indicates a crop yield less than normal and a value less than $\bar{w}$, a crop yield more than normal. Let y_t be farm profits, i.e., revenues from crops (including family consumption) minus hired input costs.[10] Since $\bar{w}$ reflects normal or expected weather, it is by definition related only to permanent income while the year to year fluctuation around the permanent level, $w_t - \bar{w}$, is related only to transitory income. Thus, for the representative household,

$$(6) \qquad y_t = \alpha_1 \bar{w} + \alpha_2 (w_t - \bar{w}) + v_{1t}$$

where $\alpha_1 \bar{w}$ is the weather component of permanent income, $\alpha_2(w_t - \bar{w})$ is the weather component of transitory income, and v_{1t} is a random component of income of both a permanent and transitory nature that is uncorrelated with either $\bar{w}$ or $w_t - \bar{w}$. Notice that v_{1t} includes measurement errors.

In a similar fashion, consumption can be expressed as

$$(7) \qquad c_t = \beta_1 \bar{w} + \beta_2 (w_t - \bar{w}) + v_{2t}$$

where the effect of weather on consumption is only indirect through its effect on income. A test of the permanent income hypothesis amounts to testing the joint hypothesis that $\alpha_1 = \beta_1$ and that $\beta_2 = 0$, given $\alpha_2 \neq 0$. The former is a test of whether the permanent income elasticity of consumption is unity and the latter of whether the transitory income elasticity of consumption is zero. Of course, the two equations need not be estimated separately in order to obtain elasticity estimates since

$$\frac{\beta_1}{\alpha_1} = \frac{\text{cov}\ (c_t \bar{w})}{\text{cov}\ (y_t \bar{w})} \text{ and } \frac{\beta_2}{\alpha_2} = \frac{\text{cov}\ (c_t (w_t - \bar{w}))}{\text{cov}\ (y_t (w_t - \bar{w}))},$$ although it must be shown that $\alpha_2 \neq 0$.

Although the farm household presumably knows its own weather distribution it is unlikely to be known to the researcher. Suppose that T years of data are available on self-reported weather outcomes (w_t) for N x M farm households, where M is the number of geographically distinct areas with different weather distributions and N is the number of households per area.[11] Each household is, for the present, assumed to use the same "normal" weathe base, that is, a country-wide base. The case where weather is reported relative to "own" normal weather is dealt with below. Using previous notation

(8) $w_{t\ell j} = \bar{w}_j + \xi_{tj}$, $t = 1,\ldots, T$; $j = 1,\ldots, M$; $\ell = 1,\ldots N$,

where $E\xi_{tj} = 0$, $E\xi_{tj}\bar{w}_j = 0$ for all j given t, and for all t given j. Thus, each household in a given area draws from the same frequency distribution of weather outcomes but the distribution function may vary across areas. However, there is a global weather distribution that applies to all regions from which the $\bar{w}_j$ is drawn for each region along with the corresponding distribution for the ξ_{tj}. In other words, there is a distribution of $\bar{w}_j$'s (assumed to have zero mean and finite variance $\sigma^2_{\bar{w}_j}$) and a distribution for each moment of ξ_{tj} from which each region draws the moments of its own weather distribution. Thus, each region draws a $\bar{w}_j$, a $\sigma^2_{\xi_t}$, a set of $\sigma_{\xi_t\xi_{t'}}$'s (for all t, t'), and so on, from global distributions of these moments, themselves assumed to have finite moments of at least second-order.

Denoting by $\bar{x}_j$ the sample mean of w_{tj} for the j^{th} household over the T years, it is clear that $\bar{x}_j$ also measures $\bar{w}_j$ with error

(9) $\bar{x}_j = \bar{w}_j + u_j$

where $\bar{x}_j = \frac{\Sigma w_{tj}}{T}$ and $u_j = \frac{\Sigma \xi_{tj}}{T}$. Assume for notational simplicity that only a single year of data is available for income and consumption, say year t. Using $\bar{x}_j$ as an instrument for permanent weather yields estimates for $\hat{\alpha}_1$ and $\hat{\beta}_1$ with limiting values given by

$$(10)\quad \underset{M\to\infty}{\text{plim}}\ \hat{\alpha}_1 = \alpha_1 \frac{\sigma^2_{\bar{w}_j}}{\sigma^2_{\bar{x}_j}} + \alpha_2 \left[\frac{\sigma^2_{\xi_{tj}}}{T\sigma^2_{\bar{x}_j}} + \frac{\sum_{t'=t-T+1}^{t-1} \text{cov}\ \xi_{tj}\xi_{t'j}}{T\sigma^2_{\bar{x}_j}} \right]$$

$$(11)\quad \underset{M\to\infty}{\text{plim}}\ \hat{\beta}_1 = \beta_1 \frac{\sigma^2_{\bar{w}_j}}{\sigma^2_{\bar{x}_j}} + \beta_2 \left[\frac{\sigma^2_{\xi_{tj}}}{T\sigma^2_{\bar{x}_j}} + \frac{\sum_{t'=t-T+1}^{t-1} \text{cov}\ \xi_{tj}\xi_{t'j}}{T\sigma^2_{\bar{x}_j}} \right] . \text{[12]}$$

where $\hat{\alpha}_1 = \frac{\sum_j y_{tj}\bar{x}_j}{\sum_j \bar{x}_j^2}$ and $\hat{\beta}_1 = \frac{\sum_j c_{tj}\bar{x}_j}{\sum_j \bar{x}_j^2}$; y_{tj} and c_{tj} are the mean values of $y_{t\ell j}$ and $c_{t\ell j}$ over the N households in the region. Since as T becomes large plim u_j approaches zero, the second bracketed term in each equation also approaches zero as $\sigma^2_{\bar{x}_j}$ approaches $\sigma^2_{\bar{w}_j}$, a constant.

Therefore, $\sigma^2_{\bar{w}_j}/\sigma^2_{\bar{x}_j}$ approaches unity as T becomes large. These are as expected since with enough time series observations on w_{tj}, $\bar{x}_j$ will measure $\bar{w}_j$ without error and $\hat{\alpha}_1$ and $\hat{\beta}_1$ are estimated without bias. In the case where the ξ_t's are independently distributed, and where transitory weather effects are smaller in absolute value than permanent weather effects, both $\hat{\alpha}_1$ and $\hat{\beta}_1$ are biased towards zero with fixed T. In addition, if the permanent income hypothesis is correct, that is if $\alpha_1 = \beta_1$ and $\beta_2 = 0$ then $\frac{\hat{\beta}_1}{\hat{\alpha}_1}$ is also biased towards zero.[13] In the more general case the direction of these biases is not certain and could even vary with T.

Given the previous discussion, it should also be clear that the use of lagged or future weather outcomes, alone or in combination, as instruments would also lead to inconsistent estimates of permanent weather effects if the ξ_t's are not independent. If the ξ_t's are independent, then the sample mean, $\bar{x}_j$, formed by using non-contemporaneous (that is, t^{th} period) values of w_{tj} would lead to consistent estimation of the permanent income elasticity, $\frac{\beta_1}{\alpha_1}$.[14]

Unless the researcher has numerous observations on w_t or knows its underlying stochastic process, biased estimates of the permanent income elasticity are likely to result from the use of self-reported weather outcomes of short duration and close proximity to the income and consumption observations. An alternative would be to use information on the direct environmental characteristics that are related to weather, the predominant factor being rainfall. Suppose information on the amount of rainfall and the number of days of rain could be collected annually for several decades for each of the geographically destinct N households with the terminal year several decades prior to the income-consumption data. Ignore for the moment the exact way in which this rainfall data is aggregated and let R_{tj} be some aggregate index of rainfall over the several decades (t^*) for household j. Then

$$(12) \qquad R_{t*j} = \gamma_j \bar{w}_j + \eta_{t*j}$$

where $E\eta_{t*j} = 0$, $E\eta_{t*j}\bar{w}_j = 0$; η_{t*j} is the measurement error that arises because the rainfall data is of finite length. Notice that the relationship of rainfall to permanent weather is permitted to vary by household due, say to differential soil quality and terrain, i.e. the identical rainfall pattern does not necessarily translate into identical weather. With the assumption that η_{t*j} and ξ_{tj} are independent in consequence of the long time interval between t and t*, a consistent estimate of the permanent income elasticity is obtained from

$$(13) \qquad \frac{\text{cov}\ (c_{tj}R_{t*j})}{\text{cov}\ (y_{tj}R_{t*j})} = \frac{\beta_1\gamma_j\sigma^2_{\bar{w}_j} + \beta_2\ \text{cov}\ (\xi_{tj}\eta_{t*j})}{\alpha_1\gamma_j\sigma^2_{\bar{w}_j} + \alpha_2\ \text{cov}\ (\xi_{tj}\eta_{t*j})} = \frac{\beta_1}{\alpha_1},$$

independent of the value of β_2.

In order to estimate the transitory income elasticity, consider the use of $w_{tj} - \bar{x}_j$ as a proxy for $w_{tj} - \bar{w}_j$ in equations (10) and (11). It is easily shown that

$$(14) \qquad \frac{\text{cov}\ (c_{tj}(w_{tj} - \bar{x}_j))}{\text{cov}\ (y_{tj}(w_{tj} - \bar{x}_j))} = \frac{\beta_2\sigma^2_{\xi_{tj}}\left[1 - \frac{1 + \theta_{t,t-1} + .. + \theta_{t,t-n+1}}{T}\right]}{\alpha_2\sigma^2_{\xi_{tj}}\left[1 - \frac{1 + \theta_{t,t-1} + .. + \theta_{t,t-n+1}}{T}\right]} = \frac{\beta_2}{\alpha_2},$$

where $\theta_{t,t'}$ is the mean autocorrelation coefficient in ξ_{tj} between period t and t', corresponding to the global distribution of autocorrelation coefficients. Since $w_{tj} - \bar{x}_j$ reflects only transitory elements (it equals $u_j - \xi_{tj}$) and is therefore uncorrelated with permanent weather, a consistent estimate of the transitory income elasticity of consumption is generated. Note, however, that due to non-independence of the ξ_{tj}'s, consistent estimates of α_2 and β_2 separately cannot be obtained in this way.[15]

Suppose now that the weather outcomes as reported by farm households are not relative to a country-wide base, but instead are relative to the farm households "own" normal weather base. Denoting this measure as w^*_{tj}, it is clear that $w^*_{tj} = w_{tj} - \bar{w}_j = \xi_{tj}$. In essence what is reported, in this case, is transitory weather. Thus,

$$
\begin{aligned}
(15)\quad w^*_{tj} &= \bar{w}_j + (\xi_{tj} - \bar{w}_j) \\
&= \bar{w}_j + \xi^*_{tj} ,
\end{aligned}
$$

where $E\xi^*_{tj} = -\bar{w}_j$ and $E\xi^*_{tj}\bar{w}_j = -\sigma^2_{\bar{w}_j}$. If w^*_{tj} is substituted for w_{tj} in the previous analysis, the following conclusions emerge. First, the permanent income elasticity cannot be estimated with the use of reported weather outcomes since the only weather that is reported is transitory.[16] Of course, the usefulness of objective rainfall data is unaffected. Second, the previous method of estimating the transitory income elasticity, namely with the instrument $w_{tj} - \bar{x}_j$, will still yield a consistent estimate of the transitory income elasticity with the instrument $w^*_{tj} - \bar{x}^*_j$. Differenced transitory elements are still transitory.[17] Thus, this technique is robust to the type of self-reported weather outcome data that is available.

III. Data

The data consist of approximately 2100 rural Indian farm households drawn from a national survey of about 4100 rural landed and landless households conducted by the National Council of Applied Economic Research in three consecutive years, 1968-69, 1969-70, 1970-71. These 4100 households were selected as a representative cross-section of the rural Indian population, however, with some oversampling of high income households. Detailed information was collected on the demographic composition of the household, the level of income by source, the level of consumption by type of expenditure, the level of savings by type and the level of asset holdings by type. Information concerning the characteristics of the villages covered in the survey, approximately 260 in number, was also gathered from village representatives. In particular, each year the representative was asked whether or not crop production , presumable on average over all farm households within the village, was adversely affected by weather during the year. It is not clear from the question whether adverse weather is relative to a nation-wide standard or a village standard or even whether all representatives interpreted the question in the same way. The former interpretation will be maintained throughout the remainder of the discussion, in part, because this interpretation seems to be more consistent with the results described below. Recall that the interpretation is not relevant to the methodologies described in the previous section.

The weather outcome variable used in the subsequent analyses is therefore dichotomous (0 = not adverse, 1 = adverse). Strictly interpreted as a measure of w_{tj}, weather comes in only two varieties interpreted as applicable to the country as a whole. The mean value of w_{tj}, $\bar{w}_j$, therefore represents the village probability of adverse weather, on a comparable scale to the country-wide probability of adverse weather, and $\bar{x}_j$ the village sample mean probability over the three years.[18]

The weather spectrum is presumably wider than the simple two-state classification. The dichotomous measure can be viewed, therefore, as containing a degree of pure measurement error. By extension, from previous arguments this causes no difficulty for estimation of the transitory income elasticity but will create additional, though possibly offsetting, biases of permanent income elasticity estimates which employ lagged or future weather outcomes if the measurement error contains any household-specific permanency.[19]

It should be noted, however, that since the weather variable is village level, it is less likely to be correlated with measurement errors in household-level income and consumption variables.

Income, consumption and savings information were collected as "independent" items in the sense that each was obtained as the sum of separate factors with no assurance of satisfying the income identity, $Y = C + S$. It seems, however, implausible that the reporting paridigm of respondents is one of complete independence in that errors in income, for example, do not translate into errors in consumption, savings or both. The fact that the income identity is not, on average, satisfied does not weaken this possibility since the underreporting of savings or consumption may be systematic, as is obvious from the complete lack of data on the holdings of gold and jewelry. Given the data, however, two consumption measures may be formulated--a direct measure calculated as the sum of individual consumption expenditures (food, clothing, etc.) and an indirect measure calculated as income minus savings with the latter defined as the change in household net worth. In addition, expenditures on consumer durables are separately reported, although the service flow from durables is not. Consumption can therefore, be defined inclusive and exclusive of consumer durable expenditures.

Households were chosen on the basis of the following characteristics in each of the three years: those that were classified as cultivators, those that had positive total gross income, those for which savings did not exceed income, those that had positive consumption and those that did not reside in "green revolution" districts. In total, there were 2061 households. Descriptive statistics are presented for each year separately with explicit definitions and further notes. It is worth repeating that all figures are in nominal rupees.

Table 1

Descriptive Statistics by Year. Means and Standard Deviations (no. observations = 2061)

	1968-69	1969-70	1970-71
Farm profits[1]	3283 (4268)	3606 (3620)	4011 (4246)
Total Gross Income[2]	4329 (4660)	4509 (3897)	4838 (4320)
Consumption Expenditures Exc. Durables	3251 (2492)	3426 (2397)	3543 (2568)
Consumption Expenditures Inc. Durables	3271 (2515)	3478 (2442)	3601 (2621)
Savings Exc[3] Durables	151 (4349)	560 (3125)	657 (3147)
Savings Inc.[3] Durables	178 (4357)	612 (3173)	715 (3201)
Fraction Experiencing Adverse weather	.483 (.50)	.322 (.47)	.165 (.37)
Price of un-irrigated land per acre (village level)	-	-	2510 (2547)

Notes to Table 1

(1) All figures are in nominal rupees. Wholesale prices of all commodities increased by 3.7% from 1968-69 to 1969-70 and by 5.5% from 1969-70 to 1970-71. Farm profits are basically revenues including the market value of goods consumed on the farm minus the cost of all hired inputs.

(2) This is the total earnings of all household members and includes wages, rents, interest, dividents, profits from farm and non-farm businesses and pensions. Taxes are unavailable, but negligible for rural households. Income includes a valuation of non-monetized investments such as home and land improvements using household labor with the inputed value of home labor set at the village level wage rate. It is, however, a relatively small proportion of income or savings.

(3) Savings is defined as the difference between the change in the value of assets (physical and financial) and the change in liabilities adjusted for capital transfers. The figures in parentheses are standard deviation of consumption so as to maintain comparability with the direct consumption measures.

Several features are noteworthy. First, savings in the first year of the survey appears to be severely underreported. Second, consumer durables expenditures accounts for only a very small fraction of total consumption expenditures. Third, farm profits are approximately 80 percent of total gross income. Fourth, given that average farm size is about 10 acres, the price of an average sized farm is about six times that of average farm profits.[20] The per-acre price of land is an alternative proxy for permanent income explored in the next section.

IV. Results

Consider first the estimates of the transitory income elasticity (see eq. 14) given in Table 2. Since there are three years of data, the estimates are derived from a pooled sample, including in the regression separate year effects (dummies). Since the weather variable is village level, the number of real observations is maximally only about 10% as large as the number of households. Indeed self-reported weather patterns are in almost every case identical for all villages within the same district so that the actual number of independent observations is probably closer to 80. Given this actually rather small sample size, the longitudinal feature of the data takes on greater significance.

In the first row, an estimate of α_2 is reported followed by four estimates of β_2 corresponding to the two alternatives consumption measures each exclusive and inclusive of expenditures on durables. Recall that both α_2 and β_2 are individually biased, but equiproportionately. The point estimate is that for a given permanent probability of adverse weather, the occurrence of adverse weather reduces income by 6.6 percent during that year. Interestingly, the point estimate for α_1 using $\bar{x}$ as the sample estimate of the permanent probability is 24.9 percent (the standard error is 3.5 percent). An increase in permanent adverse weather reduces farm profits by almost 4 times as great an amount as does a similar increase in transitory adverse weather, a finding that is consistent with the notion that adverse weather may have cumulative effects on the productivity of the land.

The transitory income elasticity of consumption, β_2/α_2, is essentially zero when the indirect consumption measure is used and is negative (with a

Table 2

Estimated Proportional Transitory Weather Effects on Income and Consumption: Pooled Three Year Sample[1]

	Dependent Variable				
	Total Gross Income	Direct Consumption exc. Durables	Direct Consumption inc. Durables	Indirect Consumption exc. Durables	Indirect Consumption inc. Durables
α_2, β_2 [1]	-.066 (.032)	+.022 (.026)	+.024 (.026)	-.002 (.030)	-.005 (.030)
β_2/α_4 [2] (Transitory Income Elasticity)		-.343 (.533)	-.360 (.543)	.070 (.420)	.023 (.440)

(1) Standard errors in parentheses

(2) Standard errors are those obtained from a TSLS-IV procedure in which the predicted values of (ln) total gross income obtained from a first stage regression on $w_t - \bar{x}$ are used in a second stage (ln) consumption regression. All standard errors of income elasticity estimates in the tables that follow were obtained in this manner.

large standard error) when the direct consumption measure is used. The results are qualitatively the same whether durables are included or excluded from consumption. Savings systematically exclude the purchase or sale of gold, silver and semi-precious stones so that the indirect consumption measure includes some part of savings which should have a positive transitory response according to the theory. The ordering of the elasticities appears consistent with this fact. These results, therefore, strongly support the proposition that consumption is unrelated to transitory income fluctuations as postulated in the permanent income hypothesis.

The implication is that Indian farm households either have enough accumulated savings to maintain consumption during periods of transitorily adverse weather or they are able to finance consumption from external borrowing. It appears from data on crop yields that in none of the three years of the survey was there particularly severe adverse weather on a country-wide basis. Capital market imperfections might be evident under more extreme conditions.

In Table 3, estimates of the permanent income elasticity of consumption are presented based upon alternative instrumental variable measures of permanent income for the consumption variables which exclude durables for both the pooled three year sample and for the last year alone. The latter is included to accommodate comparisons among lagged and double lagged instruments.[21] The first row shows the elasticity based upon current income and is the lowest estimate for the direct consumption measure. The estimate for the indirect consumption measure is much higher due to the common measurement error in income which appears on both sides of the equation. The estimates based upon self-reported adverse weather are within the range of estimates of the other instruments that have been previously suggested

Table 3

Alternative Instrumental Variable Estimates of the Permanent Income Elasticity

	Pooled Three Year Sample (1968-69, 1969-70, 1970-71)		1970-1971 Sample	
	Direct Consumption exc. Durables	Indirect Consumption exc. Durables	Direct Consumption exc. Durables	Indirect Consumption exc. Durables
y_t	.656 (.006)	.842 (.005)	.740 (.009)	.803 (.008)
$\bar{x}$	.722 (.066)	.640 (.062)	.785 (.069)	.738 (.064)
y_{t-1}	-	-	.798 (.011)	.841 (.010)
w_{t-1}	-	-	.834 (.064)	.770 (.057)
c_{t-1}	-	-	.849 (.012)	.856 (.011)
price land	.790 (.035)	.952* (.030)	.807 (.052)	.875 (.048)
Rainfall[(1)] Distribution Parameters based on 1921-1950 rainfall data	.907 (.037)	1.024* (.030)	.927 (.037)	.951* (.032)

*Signifies no significant difference of the coefficient from unity at 5% level.

(1) Instruments are average yearly rainfall and its square, average number of days of rain per year and its square, the interaction of the two averages, and the coefficients of variation of rainfall and days of rain.

the literature. As anticipated, the sample mean probability ($\bar{x}$) provides the lowest elasticity estimate. The lagged weather instrument (w_{t-1}) yields a higher elasticity relative to $\bar{x}$ by about 6 percent for the direct consumption measure and 4 percent for the indirect measure. This estimated elasticity falls within the range of estimates which are based on lagged income and lagged consumption for the direct measure of consumption but is somewhat lower than either for the indirect measure. The lagged consumption instrument yields the highest value as suggested would be the case by Liviatan, although the increase over lagged income is quite small, 6 percent and 2 percent for the respective consumption variables. Bhalla (1979) reports, with the identical data though a slightly larger sample given the inclusion of green revolution districts, an estimated elasticity of .86 (.012) and .89 (.013) respectively using the direct consumption measure lagged two years as an instrumental variable. It is useful to note at this point that the hypothesis of unitary permanent income elasticity requires the discounted consumption of future generations to be equally valuable to the current generation as is own discounted consumption. If bequests are considered a luxury, the permanent income elasticity of current generation consumption would be less than unity.

If the price of unirrigated land within a village reflected only permanent features (weather, soil quality, etc) it would be a viable proxy for permanent income. However, if the demand for land, as a form of savings, fluctuates with transitory income, the price per acre will also fluctuate even if the market for land is national in scope, since transitory components of income do not net out necessarily in any single year. Thus, the price of land may not be unrelated to transitory income, with estimates of the permanent income elasticity based on it biased towards zero. Nevertheless, the instrumental variable estimates using the price of land are within the same range as the other estimates already discussed except in one case where the estimated elasticity is not statistically different from unity at conventional levels.

The final row of estimates in Table 3 make use of objective rainfall data. For each of the 79 districts (there are about 100 in the sample inclusive of green revolution districts) for which data was available, information on the annual amount of rainfall and the annual days of rain was collected from 1921-1950. Means and standard deviations were calculated for these two measures for each district. The actual instruments employed in the estimation as depicted in Table 3 are given in the notes to Table 3. As discussed in the previous section, the objective rainfall data should yield consistent estimates of the permanent income elasticity under fairly reasonable assumptions about the stochastic weather process. As seen, all elasticities so derived exceed those obtained with the use of alternative instruments and in the case of the indirect consumption measure the elasticity estimate does not significantly differ from unity. Moreover, in the single year sample, rejection of this hypothesis is marginal for the direct consumption measure. Therefore, the rainfall proxy provides greater support for this proposition of the permanent income hypotheses than do the proxies upon which most other researchers have relied, at least for this data set.

V. Some Qualifications

An essential assumption of the methodology employed in this paper is that Indian farm households understand well the relationship between weather, e.g., rainfall, and farm profitability. Given the traditional nature of agricultural production, this may be approximately correct. Yet, some mechanization has occurred, for example, through the limited introduction of tractors, which may have altered the impact of weather on crop yields. Also, to the extent that new methods of coping with adverse weather have been introduced, the perfect knowledge presumption would not be warranted. Rainfall would then not be a flawless instrument for permanent income unless the researcher knew how farmers formed their expectation about the impact of rainfall on weather, and thus on yields, under the new technological conditions.[22] In addition, since with technological change the weather index shifts, transitory and permanent weather cannot be isolated from longitudinally self-reported weather.

A second issue of a more general nature concerns the treatment of family size, i.e., the treatment primarily of children. If children are consumption goods only, then expenditures on children to the extent that they coincide period by period with the child-service flow should be viewed as family consumption, which is the treatment here. To the extent that children are, in part, investment goods some of the expenditures on children should be netted out of consumption since children should be treated as any hired factor input. That part would also be subtracted from household income. However, what matters for this work is not simply whether children are investment or consumption goods but if, as investment goods, the demand for their services is related to permanent weather conditions. If rents are earned from children as labor, then the number of children in a family would be related to weather if the demand for labor is sensitive to weather. If, for example, the demand for labor is greater where weather is permanently more adverse, family size will rise due to this direct effect. However, some time of the family members must be used in the care of children, time which is also now more valuable. The net effect is, therefore, uncertain. Ignoring this effect, measured farm profits will be higher since "own" child labor costs are not excluded from farm profits and measured consumption will also be higher by the level of expenditures on children that are, in reality, only a factor payment. Actually farm profits rise by even more if rents are extracted from children that cannot be extracted from hired labor. Regardless, the measured permanent income elasticity would, except under unusual circumstances, be biased by this inappropriate treatment of children.

A similar problem arises with the treatment, or lack of treatment, of labor supply in the formulation of the permanent income hypothesis. If leisure is a consumption good, the appropriate concept of income is full income, namely measured income plus the value of non-market time (see Becker (1965)), and the appropriate concept of consumption is inclusive of the value of leisure. Even if farm profits were correctly defined exclusive of (imputed) own family labor costs, and profits were the sole source of family income, there is no particular reason for goods consumption to have a unitary permanent income elasticity. With information on the level of own family labor inputs, the correct permanent income elasticity of consumption inclusive of leisure could be estimated using the weather methodology. We ignore the difficult task of valuing non-market time for those family members who do not participate in the market sector. The previously estimated transitory income elasticity is also subject to bias given that the demand for labor may be affected by transitory weather. The direction of these biases are not obvious and unfortunately, a test of the theoretically appropriate model must await collection of the requisite data. The point is that the empirical methodology developed in this paper is not flawed by these considerations.

VI. Conclusions

In this paper, I have formulated a methodology combining weather data with income and consumption data for rural Indian farm households to test the permanent income hypothesis. The environment closely approximates the perfect certainty world in which the permanent income hypothesis can be directly tested without resorting to additional assumptions about the stochastic process generating lifetime income. The results provide strong support for the notion that transitory income does not affect consumption and mild support to the notion that the elasticity of consumption with respect to permanent income is unity.

Footnotes

[1]See Mayer (1972) for a comprehensive review of the literature.

[2]See Sargent (1978) for a rational expectations approach.

[3]Liviatan (1963) first suggested the non-contemporaneous income or consumption instrumental variables approach. Although he discussed the biases created by serial correlation, he did not introduce the added complexity of measurement error, a formal treatment of which is given in Bhalla (1979).

[4]Liviatan demonstrated that the use of lagged consumption would provide an upper bound estimate for the permanent income elasticity and thus, a strong test of the unitary proposition if the estimate fell short of unity. This result is not necessarily robust, however, to the introduction of measurement error (see below).

[5]Notice that the way in which equation 2 is formulated it is not necessary that ε_t and η_t be uncorrelated. However, if $E(\varepsilon_t \eta_t) \neq 0$, a test of the $\beta = 0$ proposition could be conducted only if η_t was known, given ε_t is known.

[6]If $m_{jt} = m_j$, $\Delta m_j = 0$ and $\mathrm{cov}\,(m_{jt} \Delta m_j) = 0, j = 1,2$.

[7]Similar considerations apply to the use of first-differenced consumption as an instrument for transitory income.

[8]It is unnecessary to make any assumptions about the degree of certainty concerning lifetime income patterns as is easily verified by replacing $y_{t-1} = y^p + \varepsilon_{t-1}$ by $y_{t-1} = y^p_{t-1} + \varepsilon_{t-1}$ and similary for c_{t-1}.

[9]In these derivations it is also assumed that $\text{cov}(\eta_t \varepsilon_{t-1}) = 0$.

[10]The value of "own" family labor in agricultural production would also be subtracted from farm profits if family labor supply was considered as subject to choice. In a later section this complication is discussed and a methodology for testing an augmented "full income" model is presented. Only lack of data precludes implementation.

[11]Actually, the number of households in each region is irrelevant in the analysis that follows.

[12]The notation implies that the T years of weather observations are prior to the year in which income and consumption is observed. This, of course, is unnecessary under the assumption that households know $\bar{w}$ with certainty. Future observations are of no value to them, though they are equally useful to the researcher. Note, also, that the moments of ξ_{tj} are the means of the global distributions which do correspond to the within-household moments if all households have the same weather distribution.

[13]If ξ's are independent, then equations 10 and 11 reduce to

$$\text{plim } \hat{\alpha}_1 = \alpha_1 + (\alpha_2 - \alpha_1)\rho$$

$$\text{plim } \hat{\beta}_1 = \beta_1 + (\beta_2 - \beta_1)\rho$$

where $\rho = \sigma_u^2 / \sigma_{\bar{x}}^2$. The propositions in the text follow directly.

[14]For example

$$\text{plim } \frac{\hat{\beta}_1}{\hat{\alpha}_1} = \frac{\text{cov } (c_t w_{t-1})}{\text{cov } (y_t w_{t-1}} = \frac{\beta_1 \sigma_{\bar{w}} + \beta_2 \text{ cov } (\xi_t \xi_{t-1})}{\alpha_1 \sigma_{\bar{w}}^2 + \alpha_2 \text{ cov } (\xi_t \xi_{t-1})}$$

Clearly, if cov $(\xi_t \xi_{t-1}) = 0$, the expression reduces to β_1/α_1. If cov $(\xi_t \xi_{t-1}) > 0$ and $\beta_2 = 0$, the permanent effect is biased towards zero (recall that $\beta_1, \alpha_1, \alpha_2 < 0$).

[15]Since var $(w_t - \bar{x}) = \frac{\sigma_\xi^2}{T} [(T-1) - 2\sum\sum_{t'>t''} \theta_{t't''}]$

$$\text{plim } \hat{\alpha}_2 = \frac{\text{cov } (y_t(w_t - \bar{x}))}{\text{var } (w_t - \bar{x})} \neq \alpha_2$$ and similarly for plim $\hat{\beta}_2$.

[16]If fact, the use of lagged or future values of w^*_{jt} lead to estimates of the <u>transitory</u> income elasticity. For example,

$$\frac{\text{cov } (c_t w^*_{jt-1})}{\text{cov } (y_t w^*_{jt-1})} = \frac{\beta_1 \text{ cov } (\bar{w}_j \xi_{jt-1}) + \beta_2 \text{ cov } (\xi_{jt} \xi_{jt-1})}{\alpha_1 \text{ cov } (\bar{w}_j \xi_{jt-1}) + \alpha_2 \text{ cov } (\xi_{jt} \xi_{jt-1})}$$

$$= \frac{\beta_1}{\alpha_1}$$

since cov $(\bar{w}_j \xi_{jt-1}) = 0$.

[17]It is necessary that the interpretation not change from year to year for the same village.

[18]Interpreted as a measure of w^*_{jt}, adverse weather is itself transitory. The true probability of adverse weather would not differ across villages given the within-village basis of the measure. The observed probability differs only due to sampling variability.

[19]The easiest way to see this is simply to permit ξ_{jt} or ξ_{jt}^* to include a measurement error component. Note that equation (14) is unaffected while the interpretation of equations (10) and (11) are altered though their form is not. See also the equation in fn. 14 which uses w_{t-1} as a proxy for permanent income.

[20]Since some land is irrigated, this is an underestimate of the correct multiple. The price of land is, unfortunately, only reported for the last year.

[21]Actually double-lagged instruments were very similar to the single-lagged instruments so that they are not reported. In addition, the inclusion of durables has only a very minor impact on any of the results.

[22]In essence, equation 12 is altered so that

$$R_{jt}^* = \gamma_{jt}\bar{w}_j + \eta_{jt}^*,$$

i.e., the relationship of the characteristics of rainfall to permanent weather changes over time. But, γ_{jt} is unknown and must be forecasted by farmers, possibly on the basis of previous γ_j's.

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