RATE OF TIME PREFERENCE, INTERTEMPORAL ELASTICITY OF SUBSTITUTION, AND LEVEL OF WEALTH

Masao Ogaki and Andrew Atkeson*

Abstract—The rate of time preference (RTP) and the intertemporal elasticity of substitution (IES) are two important factors shaping intertemporal consumption decisions. Models in which the RTP and/or the IES differ systematically between rich and poor households have different empirical and policy implications for economic development, growth, and the distribution of income and consumption from those of standard models in which these parameters are constant across households. In this paper, we estimate a model in which both RTP and IES are allowed to differ across rich and poor households using household-level panel data from India. Our empirical results are consistent with the view that the RTP is constant across poor and rich households, but the IES is larger for the rich than it is for the poor.

I. Introduction

THE RATE of time preference (RTP) and the intertemporal elasticity of substitution (IES) are two important factors shaping consumers' intertemporal consumption decisions. In the theoretical literature, many authors have studied models in which the RTP changes with the level of wealth or consumption (see, e.g., Uzawa (1968) and Epstein (1983)). We call these wealth-varying RTP models. Others have studied models in which the IES changes with the level of wealth or consumption (see, e.g., Rebelo (1992), Chatterjee (1994), Easterly (1994), and Ogaki, Ostry, and Reinhart (1996)). We call these wealth-varying IES models. In the context of models using the expected utility framework with time-separable utility, the parameters governing the IES are intimately related to those governing risk aversion. Thus in addition to the theoretical literature that discusses models in which the IES varies with the level of wealth, there is a large theoretical literature analyzing models in which the coefficient of relative risk aversion changes with the level of wealth, which implicitly analyzes models in which the IES varies with the level of wealth.

In a variety of applications, models with different assumptions about how the RTP and the IES vary across households have strikingly different implications. For example, consider, in the context of a model economy with complete contingent markets, the implications of various assumptions about preferences for the evolution of the distribution of consumption. The assumption that all agents have the same RTP and IES yields the result that the ratio of the consumption of the rich to that of the poor is constant over time. The assumption that rich consumers are more patient than poor consumers, thus having a lower RTP, yields the result that the ratio of the consumption of the rich to that of the poor grows at a constant rate over time. Moreover, this growth rate of the ratio of the consumption of the rich to that of the poor does not depend on intertemporal prices. The assumption that rich consumers have a higher IES than poor consumers yields implications that depend on the path of intertemporal prices. If intertemporal prices exceed the RTP, then the ratio of the consumption of the rich to that of the poor increases. If intertemporal prices fall below the RTP, then the ratio of the consumption of the rich to that of the poor shrinks over time.[1] In an economy in which intertemporal prices are fluctuating both above and below the RTP, the assumption that the IES rises with the level of wealth implies that the rich have more volatile consumption growth than the poor. Also, given the links between the IES and the coefficient of relative risk aversion, these models would also each have different implications for the evolution of the distribution of asset holdings or wealth as well as for the allocation of aggregate risk across consumers.

To date there is little empirical work in which wealth-varying RTP models or wealth-varying IES models are estimated. Lawrance (1991) is a prominent exception. She estimated a wealth-varying RTP model with the Panel Study of Income and Dynamics (PSID) data set. In Lawrance's model, the IES is assumed to be constant as in the standard macroeconomic models with isoelastic utility functions. Atkeson and Ogaki (1991) estimate a wealth-varying IES model using panel data on the consumption of Indian households. In this empirical work, we assume that the RTP is constant across households.

The RTP measures the slope of the indifference curve between consumption at two adjacent dates when the consumption is equal at both dates. Loosely speaking, this feature of preferences controls the mean of the consumption growth rate. In a deterministic economy, the IES measures the extent to which consumption growth between two dates changes when the real interest rate between those dates changes.[2] Thus the IES controls the consumption growth volatility in economies with fluctuating real interest rates. The common assumption that the RTP and the IES are constant across poor and rich households implies that the mean and the volatility of consumption growth are constant across poor and rich households, unless borrowing constraints or other market imperfections cause them to differ.

In this paper, we use Indian panel data to estimate a model that allows both the RTP and the IES to change systematically between rich and poor households. Our goal in this paper is to provide evidence to distinguish separately the extent to which the RTP and the IES varies with the level of

Received for publication March 31, 1994. Revision accepted for publication July 1, 1996.

* Ohio State University and University of Pennsylvania, respectively.

Some of the results presented were included in earlier versions of Atkeson and Ogaki (1991). We thank three anonymous referees, James Stock, and seminar participants at many institutions for comments at various stages of this work and R. Anton Braun for his comments that motivated us to write this paper. We gratefully acknowledge financial support by the National Science Foundation under Grant SES-9213930.

[1] We will explain these statements in detail in section III. Also see Ogaki (1992).

[2] We give formal definitions of the RTP and the IES in economies with uncertainty in section III.

household wealth. As our example above illustrates, to distinguish variation in the RTP from variation in the IES, we will need to use data consistent with the hypothesis that intertemporal prices are fluctuating above and below the rate of time preference. In our application, this means that we require data in which aggregate consumption grows in some time periods and shrinks in others. One advantage of the Indian panel data we use is that they satisfy this requirement. Our empirical results with these data are consistent with the view that the RTP is constant across poor and rich households, but the IES is larger for the rich than it is for the poor.

The remainder of this paper is organized as follows. In section II we describe our data and present and estimate a statistical model which summarizes the extent to which the mean and the volatility of consumption growth vary across households. In section III we present economic models which might be used to interpret these statistical results. In section IV we conclude.

II. Data Description

In this section we describe the household-level panel data collected in India by the Institute for Crop Research in the Semi-Arid Tropics (ICRISAT) and our statistical model of household consumption growth. We discuss the data in detail in the appendix.[3] We use panel data for three villages (Aurepalle, Shirapur, and Kanzara) from fiscal year 1975–1976 to fiscal year 1984–1985. (In what follows we denote each fiscal year by its first calendar year.) Since the construction of food consumption was changed in 1976 and the data for nonfood consumption are missing for most categories after 1982, we choose 1976–1981 as our sample period.

A. *Choice of Data*

These Indian panel data have been used to study consumption smoothing and risk sharing models by many authors.[4] We find these data attractive for three reasons. First, the saving behavior of households in less developed countries is of general interest. Second, we suspect that the dependence of the IES on the level of wealth is more likely to be important for very poor households whose consumption level is near some subsistence level. Third, as we shall see, aggregate consumption in these data rises in some periods and falls in others, so that these data do not immediately contradict the hypothesis that intertemporal prices exceed the RTP in some periods and fall below the RTP in others.

TABLE 1.—CONSUMPTION PER EQUIVALENT ADULT

	1976	1977	1978	1979	1980	1981	1976–81
			Average Total Consumption				
Aurepalle	502	490	544	750	738	660	614
Shirapur	1063	980	749	869	787	664	852
Kanzara	852	847	758	993	937	815	867
			Minimum Total Consumption				
Aurepalle	179	308	334	359	249	229	...
Shirapur	304	491	485	364	423	242	...
Kanzara	393	370	294	460	419	432	...
			Maximum Total Consumption				
Aurepalle	1300	913	984	1574	1945	1510	...
Shirapur	1703	1723	1974	1525	1596	1676	...
Kanzara	2694	1509	1290	2189	2085	1945	...
			Average Food Consumption				
Aurepalle	313	381	408	538	502	423	408
Shirapur	604	555	644	543	623	521	582
Kanzara	490	489	418	578	571	479	504
			Minimum Food Consumption				
Aurepalle	221	178	173	214	288	187	...
Shirapur	238	137	274	221	308	102	...
Kanzara	221	178	173	214	288	187	...
			Maximum Food Consumption				
Aurepalle	646	658	766	1044	1132	829	...
Shirapur	1133	1063	1166	888	1075	1088	...
Kanzara	1441	870	704	1284	1409	1081	...
			Average Nonfood Consumption				
Aurepalle	190	101	156	214	240	236	158
Shirapur	337	313	345	352	329	364	235
Kanzara	369	359	353	426	364	345	267
			Minimum Nonfood Consumption				
Aurepalle	40	27	83	68	67	32	...
Shirapur	65	112	136	129	114	48	...
Kanzara	134	151	113	133	131	133	...
			Maximum Nonfood Consumption				
Aurepalle	908	377	415	711	831	688	...
Shirapur	681	698	894	870	777	1013	...
Kanzara	1019	1274	759	836	929	885	...

In table 1 we report average, minimum, and maximum consumption per equivalent adult in terms of 1983 rupees for each of the three villages. These numbers are reported to facilitate the interpretation of the estimates of the subsistence levels that are reported below. From table 1 we can see that average consumption fluctuates substantially over time in each village and that the maximum and minimum consumption levels across households are substantially different in our data.

B. *Statistical Model for Data Description*

In this section we present the statistical model that we use to summarize certain features of these panel data. We use this model to summarize the extent to which the mean consumption growth rate and the volatility of consumption growth vary systematically across rich and poor households. Later on we provide an economic interpretation of this statistical model in which differences in the mean growth rate of consumption across rich and poor households are determined by differences in the RTP across rich and poor households, and differences in the volatility of the growth

[3] Following Townsend (1994), we use the consumption data in ICRISAT's summary data. There are two ways of estimating consumption using the ICRISAT data. ICRISAT's method is to infer it from transactions. The other method is to retrieve consumption by applying flow accounting identities to the production and storage data, which Ravallion and Chaudhuri (1997) propose. Their consumption data are very different from ICRISAT's consumption data, and the difference is correlated with income. We refer the reader to Ravallion and Chaudhuri (1997) and Townsend (1994, pp. 554–555) for a discussion of the suitability of these consumption data. It does not seem clear which consumption data set is more reliable.

[4] See, e.g., Bhargava and Ravallion (1993), Jacoby and Skoufias (1993), Lim (1992), Morduch (1990, 1991), Rosenzweig (1988), Rosenzweig and Binswanger (1993), Rosenzweig and Stark (1989), Rosenzweig and Wolpin (1993), and Townsend (1994).

rate of consumption across rich and poor households are determined by differences in the IES across rich and poor households. We present the statistical model first because the assumptions we need to interpret our model as an economic model are stronger than the ones we need to implement our statistical model. Hence our statistical model may be consistent with a variety of economic models.

Consider the following statistical model of household consumption growth. Let $C_h(t)$ denote the consumption of household h at date t, and let household consumption growth be given by

$$\ln [C_h(t+1) - \gamma] - \ln [C_h(t) - \gamma] = \phi(t) + b_y y_h^c + v_h(t) \tag{1}$$

where $\phi(t)$ varies over time and across villages but is constant across the households in a village at date t, y_h^c is a proxy of permanent income, and $v_h(t)$ has zero mean and is uncorrelated with the level of the household's permanent income and the household's income growth.

Our focus in this paper is on estimating the parameters γ and b_y. We can gain some intuition for the relationship between these parameters and the systematic variation across poor and rich households in the mean and the volatility of their consumption growth as follows. First consider a case in which $\gamma = 0$ and $v_h(t) = 0$. If the parameter b_y is positive, then the growth rate of consumption is higher for rich households than for poor households. If b_y is negative, then the reverse is true.

Now consider a case in which $b_y = 0$ and $v_h(t) = 0$. In this case, household consumption growth is given by

$$\frac{C_h(t+1)}{C_h(t)} = \exp [\phi(t)] + \frac{\gamma\{1 - \exp [\phi(t)]\}}{C_h(t)}.$$

Thus, in this case, if the parameter γ is positive and the constant $\phi(t)$ is also positive, then the consumption growth rate of households with high levels of consumption is higher than that of households with low levels of consumption. On the other hand, if the parameter γ is positive and the constant $\phi(t)$ is negative, then the consumption of households with high levels of consumption shrinks faster than that of households with low levels of consumption. In this sense, if γ is positive, we say that the consumption growth of rich households is more volatile than that for poor households. If γ is negative, then the reverse is true.

We have chosen this statistical model for two reasons. First, this model is parsimonious. We are forced to use a parsimonious model here because our data set has only five time periods. Second, as we discuss later on, the parameters of this statistical model have a simple economic interpretation in the context of an economic model in which household consumption is chosen as if in an economy with complete markets.

We estimate this model as follows. Let y_h^p be another proxy of permanent income of household h, $y_h(t)$ the current income of household h at date t, and $z_h(t) = [1, \ln(y_h^p), \ln[y_h(t+1)] - \ln[y_h(t)]$ a vector of instrumental variables. Because we assume that the error term in equation (1) is uncorrelated with income variables, these are valid instruments. As a statistical model, model (1) may be misspecified in many dimensions. For the purpose of this paper, one important type of misspecification is when the error term in equation (1) is correlated with income variables. If it is correlated with the level of household permanent income, then our parameters γ and b_y are not capturing the systematic differences in consumption growth across households. If the error term is correlated with household income growth, then household income growth will be an important missing variable. With these concerns in mind, we test the validity of the statistical model by testing whether or not the error term is correlated with the instrumental variables.

Let $p = (p_1, \ldots, p_{T+2})$ be a $(T+2)$-dimensional vector of unknown parameters. The true value of p is $p^0 = [\phi(1), \ldots, \phi(T), \gamma, b_y]'$. We define a three-dimensional vector $\xi_t^h(p)$ so that $\xi_t^h(p^0) = z_h(t) y_h(t) \exp(-\gamma/A)$, where A is a constant. Here we normalize the disturbance by $\exp(-\gamma/A)$ to avoid a trivial solution $\phi(t) = 0$ for $t = 1, \ldots, T, \gamma = -\infty$, and $b_y = 0$. Let $\xi^h(p) = [\xi_1^h(p), \ldots, \xi_T^h(p)]'$. Then we have 3T orthogonality conditions

$$E_H[\xi(p^0)] = \operatorname*{plim}_{N\to\infty} \left(\frac{1}{N}\right) \sum_{h=1}^{N} [\xi^h(p^0)] = 0 \tag{2}$$

where E_H is the expectation operator over households. A subscript H is attached to emphasize that the expectation is taken over households. We have these 3T orthogonality conditions for each village. We pool these orthogonality conditions for the three villages and estimate p for each village with the generalized method of moments (GMM).[5]

C. *Empirical Results*

In table 2 we report results for real total consumption expenditure per equivalent adult. In the first panel we report estimates of γ and b_y and test statistics. The first, second, and third rows report results when no restriction is imposed for alternative proxies of permanent income used as y_h^c. In the fourth row one restriction $b_y = 0$ is imposed, and in the fifth row, two restrictions $b_y = \gamma = 0$ are imposed. For the first and second rows we use dummy variables based on land holding class as y_h^c. For the first row we use the dummy variable that takes on the value of -1 for landless laborers

[5] See, e.g., Hansen (1982) and Gallant and White (1988). We assume that the regularity conditions of Gallant and White are satisfied. Hansen/Heaton/Ogaki's Gauss GMM package (see Ogaki (1993b)) is used for the GMM in the present paper. In pooling the data for three villages, we allow $\xi(p^0)$ to have different covariance matrices in different villages. Ogaki (1993a, sec. 4.3) provides a more detailed explanation as to how the data for villages are pooled.

TABLE 2.—GMM RESULTS FOR TOTAL CONSUMPTION

Permanent Income Proxy	γ	s.e.	b_y	s.e.	J^a	d.f.	p-Value (%)	C^b	d.f.	p-Value (%)
Landless labor dummy	177.6	6.70	−0.021	0.049	34.44	28	18.7	0.255	1	61.4
Large farm dummy	177.4	7.22	−0.009	0.033	34.60	28	18.2	0.182	1	76.0
Consumption	177.6	6.70	−0.023	0.053	34.46	28	18.6	0.237	1	62.6
	177.2	7.45	0	...	34.70	29	21.5	...		
	0	...	0	...	98.89	30	0.0	64.428	2	0.0
	$\phi(1)$	s.e.	$\phi(2)$	s.e.	$\phi(3)$	s.e.	$\phi(4)$	s.e.	$\phi(5)$	s.e.
Aurepalle	0.017	0.198	0.163	0.041	0.475	0.052	−0.020	0.053	−0.150	0.068
Shirapur	−0.124	0.034	0.050	0.049	−0.129	0.062	0.147	0.057	−0.095	0.062
Kanzara	−0.008	0.036	−0.087	0.052	0.358	0.045	−0.139	0.034	−0.143	0.036

Notes: [a] χ^2 test statistic for overidentifying restrictions.
[b] Likelihood ratio type test statistic for restrictions imposed.

and 0 for the others. For the second row, the dummy variable takes on the value of 1 for large farms and 0 for the others. For the third row, we use the level of real per-capita total consumption in 1975 as y_h^c.

The J statistic reported in each row is Hansen's (1982) χ^2 test for the overidentifying restrictions. The C statistics reported in the first, second, third, and fifth rows are the difference between the J of each row and the J of the fourth row, which are called likelihood ratio type test statistics.[6] The C statistic is the fifth row tests the restrictions $b_y = \gamma = 0$, which corresponds to the hypothesis that there is no systematic difference in the consumption growth of the rich and the poor. The C test provides strong evidence against this hypothesis. The C statistics in the first, second, and third rows test the restriction $b_y = 0$ for the alternative proxies for permanent income used as y_h^c. There is little evidence against this hypothesis. Consistent with the C test results, γ is estimated to be statistically significantly positive, but b_y are not significantly different from zero. The J statistic in the fourth row tests the hypothesis that there exists no systematic component in consumption growth that can be explained by the income variables in the instruments once the effects of the parameters γ and $\phi(t)$ in equation (1) are taken into account. We do not reject this hypothesis; hence model (1) is a valid model of data description for our purpose.

We report estimates of $\phi(t)$ for Aurepalle, Shirapur, and Kanzara in the second, third, and fourth panels of table 2 when b_y is restricted to be 0. In this case $\phi(t)$ is the average growth rate of $C(t) - \gamma$. We have both significantly positive values of $\phi(t)$ and significantly negative values of $\phi(t)$. This is important because, as we will discuss below, the wealth-varying IES and the wealth-varying RTP models can be discriminated sharply only when the data contain both the periods in which aggregate consumption grows and those in which it shrinks.

We report results when $C_h(t)$ is taken as food in table 3 and results when $C_h(t)$ is taken as nonfood in table 4. The results for food and nonfood are qualitatively similar to those for total consumption. We find that no evidence against the hypothesis b_y is 0, and that the estimates of γ are significantly positive.

Thus for each of these categories of consumption, we find that our results are consistent with the view that the consumption growth mean is the same between rich and poor households, and that rich households have more volatile consumption growth than poor households.

III. Interpreting the Results

In this section we discuss economic models that may be used to interpret our empirical results in the previous section. In the first subsection we describe an economic model in which consumers have preferences with wealth-varying IES and RTP and in which markets allow for full risk sharing. We explain that the results are consistent with the hypothesis that the IES rises with the level of wealth and that the RTP is constant across wealth levels. In the second subsection we show that this economic model can be used to formally motivate our statistical model. In the third subsection we speculate on how our results might be interpreted in the context of models with incomplete markets. In the fourth subsection we report some test results concerning the suitability of our statistical model in the context of a model with incomplete markets.

A. *Model of Wealth-Varying RTP and IES*

In this section we present the model of consumers' intertemporal allocation of consumption expenditure that we use to motivate our estimation. In particular, we discuss the different implications of wealth-varying RTP and wealth-varying IES models for consumption growth in the context of a model with complete markets.

[6] See, for example, Ogaki (1993a) for an explanation of the likelihood ratio type test in the GMM procedure. In order to compare J statistics with the C test, the same distance matrix needs to be used for unrestricted and restricted estimations. The distance matrix used is based on the estimation with the restriction $b_y = 0$. The initial distance matrix is an identity and the GMM estimation is iterated three times. The constant A for normalization was set to 200 for total consumption expenditure and food in tables 2 and 3 and to 50 for nonfood consumption in table 4. The final results were virtually the same when A was increased to 300 for total consumption and food and to 100 for nonfood, but convergence for the initial distance matrix needed more iterations.

TABLE 3.—GMM RESULTS FOR FOOD CONSUMPTION

Permanent Income Proxy	γ	s.e.	b_y	s.e.	J^a	d.f.	p-Value (%)	C^b	d.f.	p-Value (%)
Landless labor dummy	101.5	3.93	0.063	0.048	30.57	28	33.6	1.711	1	19.1
Large farm dummy	101.4	4.14	0.056	0.034	29.62	28	38.2	2.666	1	10.3
Consumption	101.4	4.30	−0.083	0.360	30.69	28	33.1	1.597	1	20.6
	101.5	3.70	0	...	32.28	29	30.8	...	...	
	0	...	0	...	56.93	30	0.0	64.428	2	0.0
	$\phi(1)$	s.e.	$\phi(2)$	s.e.	$\phi(3)$	s.e.	$\phi(4)$	s.e.	$\phi(5)$	s.e.
Aurepalle	0.362	0.077	0.057	0.034	0.383	0.050	−0.090	0.050	−0.274	0.049
Shirapur	−0.101	0.044	0.146	0.059	−0.193	0.063	0.158	0.058	−0.216	0.075
Kanzara	−0.025	0.040	−0.190	0.053	0.375	0.035	−0.051	0.043	−0.152	0.063

Notes: [a] χ^2 test statistic for overidentifying restrictions.
[b] Likelihood ratio type test statistic for restrictions imposed.

Consider an economy with H households, each of which consumes a good in each of T time periods. Let the consumer $h, h = 1, \ldots, H$, have time and state separable utility with an intratemporal utility function $u(C_h(t))$. Let a vector $s(t)$, $s(t) = 1, 2, \ldots, S$, denote the state of the world in each period and the vector $e(t) = [s(0), s(1), \ldots, s(t)]$ be the history of the economy. The consumer h maximizes

$$U_h = \sum_{t=0}^{T} \sum_{e(t)} (\beta_h)^t \operatorname{Prob}(e(t)|e(0))u(C_h(t,e(t))) \tag{3}$$

subject to a life-time budget constraint

$$\sum_{t=0}^{T} \sum_{e(t)} \prod_{\tau=0}^{t} R[\tau-1, e(\tau-1), e(\tau)]^{-1} C_h(t, e(t)) \le W_h(0). \tag{4}$$

Here $W_h(0)$ is consumer h's initial wealth and T can be either a finite number, as in the life-cycle model, or infinity, as in the dynasty model. The term Prob $(e(t)|e(\tau))$ denotes the conditional probability of $e(t)$ given $e(\tau)$, and $R[t-1, e(t-1), e(t)]$ is the (gross) asset return of the state contingent security for the event $e(t)$ in terms of the good in the event $e(t-1)$ at period $t-1$. We will often suppress $e(t)$ to simplify the notation below.

In equation (3), β_h is consumer h's discount factor. Following Lawrance (1991), we assume that β_h can be different across consumers, but is constant over time for each consumer. This constant discount factor assumption greatly simplifies the empirical work. One interpretation of this assumption is as an approximation to a model in which the discount factor actually changes as a consumer becomes wealthier, as in Uzawa (1968), but is roughly constant for each household over the short sample period (six years) covered in our data because household consumption is also roughly constant over this time period. This interpretation seems valid because the variation of consumption across households is generally much larger than the range of consumption fluctuations for each household in our data set.

In our model, the allocation of household expenditure over time is guided by the intertemporal first-order condition

$$\frac{u'(C_h(t, e(t)))}{u'(C_h(t+1, e(t+1))} = \beta_h R^*[t, e(t), e(t+1)].$$

Taking the logarithum of both sides of this equation and using a first-order Taylor approximation around $C_h(t)$ gives the result that the growth of consumption $\{\hat{C}(t) = \log$

TABLE 4.—GMM RESULTS FOR NONFOOD CONSUMPTION

Permanent Income Proxy	γ	s.e.	b_y	s.e.	J^a	d.f.	p-Value (%)	C^b	d.f.	p-Value (%)
Landless labor dummy	26.8	1.45	−0.021	0.047	28.03	28	46.3	0.192	1	66.1
Large farm dummy	26.8	1.45	−0.010	0.036	28.15	28	45.7	0.073	1	78.7
Consumption	28.8	1.44	−0.014	0.059	28.17	28	45.6	0.053	1	81.9
	26.8	1.44	0	...	28.22	29	50.6	...	...	
	0	...	0	...	35.69	30	0.0	35.687	2	0.0
	$\phi(1)$	s.e.	$\phi(2)$	s.e.	$\phi(3)$	s.e.	$\phi(4)$	s.e.	$\phi(5)$	s.e.
Aurepalle	−0.970	0.124	0.828	0.083	0.294	0.072	0.047	0.065	0.124	0.118
Shirapur	−0.141	0.047	0.051	0.071	0.050	0.068	0.021	0.066	0.060	0.079
Kanzara	−0.027	0.039	0.043	0.054	0.234	0.056	−0.211	0.025	−0.153	0.039

Notes: [a] χ^2 test statistic for overidentifying restrictions.
[b] Likelihood ratio type test statistic for restrictions imposed.

$[C(t+1)] - \log[C(t)]\}$ is given approximately by

$$\hat{C}^h(t) \cong \sigma_h(t)\{r(t) - \delta_h\} \tag{5}$$

where $\delta_h = \ln(1/\beta_h)$ is the RTP, $r(t) = \ln[R^*(t)]$, $R^*(t) = R(t)\ \text{Prob}\,(e(t+1)|e(t))$, and $\sigma_h(t) = -u'(C_h(t))C_h(t)/u''(C_h(t))$ is the IES. From equation (5), $\sigma_h(t) \cong \partial\hat{C}_h(t)/\partial r(t)$. If there is no uncertainty, $r(t)$ is the real interest rate.

The distinct implications for consumption growth of models in which the RTP varies systematically with wealth and of models in which the IES varies systematically with wealth can be seen from equation (5). If δ_h falls systematically as wealth rises, as Lawrance's (1991) estimates suggest, then the consumption growth rate of the poor is always lower than the consumption growth rate of the rich. As long as σ is constant, there will be no systematic difference in the consumption growth volatility between the rich and the poor. On the other hand, if σ_h rises systematically with wealth, then the consumption growth rate of the rich will be higher than that of the poor in the period in which $r(t) > \delta$, and the consumption of the rich will shrink faster than that of the poor in the period in which $r(t) < \delta$. Hence the rich will have more volatile consumption growth than the poor as r varies around δ. Note that in an economy with constant $r(t)$, it is impossible to discriminate between a model in which δ_h falls with wealth and a model in which σ_h rises with wealth and δ_h is constant and is less than $r(t)$. However, we can discriminate between these models in economies in which $r(t)$ fluctuates by examining how the consumption growth volatility changes with wealth.

Thus our empirical results that the consumption growth mean is the same for rich and poor households and that consumption growth of rich households is more volatile than that of poor households are consistent with the view that the RTP is constant, but the IES rises as households become richer.[7]

B. Motivating the Statistical Model

The model in the previous subsection can be used to formally motivate (1) when we parameterize the utility function by the quasi-homothetic Geary–Stone utility function,

$$u(C_h) = \frac{1}{1-\alpha}[(C_h - \gamma)^{(1-\alpha)} - 1] \tag{6}$$

where $\alpha > 0$. We will refer to the parameter γ as the subsistence parameter and the parameter α as the curvature parameter. Then the IES is

$$\sigma_h = \frac{1}{\alpha}\left(1 - \frac{\gamma}{C_h}\right). \tag{7}$$

If $\gamma > 0$, then the IES of the poor is smaller than that of the rich. For a poor household, C_h is close to γ and σ is close to 0. For a rich household, γ/C_h is close to 0 and σ is close to $1/\alpha$. Thus the IES rises with the level of wealth. On the other hand, the IES falls with the level of wealth if $\gamma < 0$.[8]

The intertemporal first-order condition of the model is

$$\left[\frac{C_h(t, e(t)) - \gamma}{C_h(t+1, e(t+1)) - \gamma}\right]^{-\alpha} = \beta_h R^*[t, e(t), e(t+1)]. \tag{8}$$

We assume that consumption $C_h(t)$ is measured with error in the following form:

$$C_h^m(t) - \gamma = [C_h(t) - \gamma]\epsilon_h(t) \tag{9}$$

where $C_h^m(t)$ is measured consumption and $\epsilon_h(t)$ is a multiplicative measurement error, which can be serially correlated but is assumed to be independent across households. We assume that $\epsilon_h(t)$ is positive and $\ln[\epsilon_h(t)]$ has mean 0. We assume that β_h satisfies

$$\ln(\beta_h) = \beta_0 + \beta_1 y_h^c + \epsilon_h^a \tag{10}$$

where y_h^c is a proxy of permanent income, and ϵ_h^a reflects a measurement error in the proxy of permanent income that is assumed to be independent across households. Then from equations (8)–(10) we get equation (1), where $\phi(t) = (1/\alpha)[\ln R^*(t) + \beta_0]$, $b_y = \beta_1/\alpha$, and

$$v_h(t) = \ln[\epsilon_h(t+1)]\ln[\epsilon_h(t)] + \left(\frac{1}{\alpha}\right)\epsilon_h^a. \tag{11}$$

C. An Incomplete Market Interpretation

It is much more difficult to derive a statistical model of household consumption growth suitable for use in a short panel such as ours from an economic model in which incomplete risk sharing is assumed. We suspect, though, that our empirical results may also be consistent with a model with incomplete markets with borrowing constraints and homothetic preferences. In particular, imagine that agents have a constant relative risk aversion utility function. Then borrowing constraints will have two effects on the consumption growth volatility of households that are close to their

[7] Since a positive γ implies more volatile consumption growth for the rich than for the poor, our empirical results from the Indian data are in line with Mankiw and Zeldes's (1991) finding that consumption growth is more volatile for stockholders than nonstockholders in the PSID. In fact, because of the links between the IES and the coefficient of relative risk aversion, a model with wealth-varying IES would predict that the wealthy should hold a disproportionate share of aggregate risk and have more volatile consumption than the poor.

[8] It should be noted that there is no theoretical reason to exclude the case where $\gamma < 0$. In fact, in this context this subsistence parameter is merely a convenient way to allow the curvature of the utility function to vary with the level of expenditure. Clearly, if $\gamma < 0$, then γ is not interpreted as the subsistence level. If $\gamma < 0$, then the consumption growth of the poor will be more volatile than that of the rich.

TABLE 5.—GMM TEST RESULTS

Error Specification	Risk Sharing	γ_a[a]	γ_s[a]	γ_k[a]	J[b]	d.f.	C[b]	d.f.
			Total Consumption					
Multiplicative error	Across villages	176.5	176.5	176.5	140.69	39	105.99	10
		(6.7)	...	...	(0.0)		(0.0)	
Multiplicative error	Within village	174.5	208.9	272.9	26.90	28	7.79	2
		(20.1)	(28.6)	(28.8)	(46.9)		(2.0)	
Additive error	Within village	306.5	306.5	306.5	30.93	29	...	
		(44.0)	...	...	(36.9)			
Additive error	Within village	320.4	414.7	448.2	29.49	27	0.88	2
		(49.6)	(186.0)	(122.5)	(33.7)		(64.3)	
			Food Consumption					
Multiplicative error	Across villages	102.3	102.3	102.3	193.38	39	161.09	10
		(0.0)	...	...	(0.0)		(0.0)	
Multiplicative error	Within village	102.3	101.5	102.6	32.21	27	0.07	2
		(82.4)	(3.7)	(78.9)	(22.4)		(96.5)	
Additive error	Within village	206.5	206.5	206.5	29.98	29	...	
		(37.2)	...	...	(41.5)			
Additive error	Within village	199.7	117.6	276.9	29.10	27	0.87	2
		(45.2)	(232.9)	(60.8)	(35.6)		(64.6)	
			Nonfood Consumption					
Multiplicative error	Across villages	26.8	26.8	26.8	181.74	39	153.52	10
		(1.4)	...	...	(0.0)		(0.0)	
Multiplicative error	Within village	26.6	32.5	104.2	20.32	27	7.90	2
		(2.2)	(15.5)	(40.9)	(81.7)		(1.9)	
Additive error	Within village	64.2	64.2	64.2	21.75	29	...	
		(9.1)	...	...	(83.0)			
Additive error	Within village	63.7	172.8	41.6	20.40	27	1.35	2
		(9.2)	(60.2)	(191.5)	(81.4)		(50.9)	

Notes: [a] Standard errors are in parentheses.
[b] p-values in percentage are in parentheses.

borrowing constraints. Each of these effects works in opposite directions. First, households that are close to their borrowing constraints will try to avoid facing borrowing constraints in the future, and thus will be especially concerned about protecting themselves against negative shocks, while households with a lot of liquid assets may act as if they were not affected by the possibility of facing borrowing constraints in the future. Thus poor households may act as if they were more risk averse than rich households, even though they have identical preferences. Second, when a household actually hits its borrowing constraint, then its consumption growth depends more strongly on its current income growth than is the case for an unconstrained household. This effect works in the direction of increasing the consumption volatility of households that are borrowing constrained since these households cannot smooth consumption as much as they might wish. The answer to the question of which effect will dominate in equilibrium depends on many factors. In any case, as long as the first effect dominates, borrowing constraints can make the consumption growth of rich households more volatile than that of poor households.

D. Additional Test Results

Our statistical model of household consumption growth can be motivated by an economic model with complete markets in which the parameters γ and b_y are preference parameters. This statistical model may also be consistent with the equilibrium of a model with incomplete markets in which agents' IES and RTP are constant across wealth levels. As we will discuss below, it is very difficult to discriminate between these two models with the data sample that we have available, and thus it is beyond the scope of this paper to try to distinguish these models. Our primary interest in this paper is to present evidence that casts doubt on Lawrance's (1991) hypothesis that it is the RTP and not the IES that varies with the level of wealth.

Some authors, using virtually the same data set as ours, have found evidence against the null hypothesis of complete markets in favor of an alternative model with borrowing constraints and incomplete markets. Morduch (1990) and Bhargava and Ravallion (1993) in particular find statistically significant correlations between consumption and income and wealth variables. Morduch interprets his results as evidence for borrowing constraints and Bhargava and Ravallion (1993) interpret their results as evidence against the permanent income hypothesis. We note that tests such as theirs, run on data generated from a complete-markets wealth-varying IES model such as ours, may reject the null hypothesis of complete markets because, in our model, consumption growth can be correlated with the level or growth of household income. But more importantly, their results, namely, that household consumption growth may be correlated with household income or income growth, may raise some concern about the power of our J tests of the overidentifying restrictions given that we estimate a parameter (γ) that these authors did not estimate.

In order to address the issue of the power of the J test, we report some additional test results in table 5. The first row for each of three consumption measures reports results when equation (1) is estimated with the assumption that full risk sharing is achieved across the three villages. Since there are virtually no direct trades across these villages, it is very unlikely that full risk sharing actually is achieved across the three villages. If the J test has power to detect correlation between consumption and income growth, then the J test should reject the null hypothesis of complete risk sharing. As reported in the table, the J test presents overwhelming evidence against complete risk sharing across the villages for each of three consumption measures. We also report the likelihood ratio type test statistic, C, for the restriction that the consumption over the subsistence level grows at the same rate for all villages. The C test also overwhelmingly rejects this hypothesis.

Even though these results are in favor of the complete-markets hypothesis within each village, this hypothesis should not be taken literally. This hypothesis is used with an idea that the hypothesis may be a good enough approximation for consumption behavior to identify preference parameters with our model.

In our economic model with complete markets and wealth-varying IES, the parameter γ is a preference parameter and is assumed to be the same across all three villages. Since this interpretation suggests that this parameter is a structural parameter, tests for the hypothesis that γ is equal across the villages are of interest. In the second row for each consumption measure, we report the test results for this hypothesis when the multiplicative error specification of equation (9) is used. For total consumption and nonfood consumption, we reject this hypothesis at the 5% level, but not at the 1% level. Since the p-values reported are approximations based on asymptotic theory, these are not strong evidence against the hypothesis. For food consumption, we do not find any evidence against this hypothesis.

As discussed above, the statistical model in this paper can be interpreted as a structural model in which consumption is measured with positive multiplicative measurement error, as in equation (9). Observe that if the assumption of positive multiplicative measurement error is misspecified, however, it can bias our estimates of γ downward. Ogaki, Atkeson, and Zhang (1996) estimate subsistence levels with an additive measurement error model to allow estimates of γ to be greater than the minimum consumption level observed. For the purpose of comparing the estimates of γ in three villages, the additive error model may be better. For this reason, we also report results when we use the additive error specification. The third row for each consumption measure reports the results when γ is restricted to be the same across the villages. The fourth row reports the results when γ is allowed to be different, and the likelihood ratio-type tests for the hypothesis that γ is the same. We do not reject this hypothesis for any consumption measure.

These estimates for γ from the additive error model are much larger than those from the multiplicative error model, which suggests that the latter estimates of subsistence levels may be biased downward. Rosenzweig and Wolpin (1993) estimate the subsistence level in a single consumption good model by analyzing investments in bullocks in the ICRISAT data. The estimate of the subsistence level from the additive error model for total consumption multiplied by the average family size of 6 is closer to Rosenzweig and Wolpin's estimate of the subsistence level than that from the multiplicative error model. Similarly, the sum of estimates of γ for food and nonfood from the additive error model multiplied by the average family size of 6 is closer to Rosenzweig and Wolpin's estimate of the subsistence level than that from the multiplicative error model.

Thus we find only weak evidence against the hypothesis that γ is the same across villages when the multiplicative error model is used and no evidence against the hypothesis when the additive error model is used. Because the additive error model is more reliable for the purpose of estimating the level of the subsistence level, we conclude that this test result also favors the model of wealth-varying IES.

VI. Conclusions

In this paper we have estimated a model in which the RTP and the IES can rise or fall as a household becomes richer. Our empirical results are consistent with the view that the IES rises with the level of wealth, whereas the RTP does not vary with the level of wealth.

Our empirical results can be also be interpreted as an atheoretical data description that rich households have more volatile consumption growth than poor households, while the consumption growth mean is constant across rich and poor households. A class of models with borrowing constraints may also be consistent with this data description.

REFERENCES

Atkeson, Andrew, and Masao Ogaki, "Wealth-Varying Intertemporal Elasticities of Substitution: Evidence from Panel and Aggregate Data," *Journal of Monetary Economics* 38 (1996), 506–534.

Bhargava, Alok, and Martin Ravallion, "Does Household Consumption Behave as a Martingale? A Test for Rural South India," this REVIEW 75 (1993), 500–504.

Chatterjee, Satayajit, "Transitional Dynamics and the Distribution of Wealth in a Neoclassical Growth Model," *Journal of Public Economics* 54 (1994), 97–119.

Easterly, William, "Economic Stagnation, Fixed Factors, and Policy Thresholds," *Journal of Monetary Economics* 33 (1994), 525–557.

Epstein, Larry G., "Stationary Cardinal Utility and Optimal Growth under Uncertainty," *Journal of Economic Theory* 31 (1983), 133–152.

Gallant, A. Ronald, and Halbert White, *A Unified Theory of Estimation and Inference for Nonlinear Models* (New York: Basil Blackwell, 1988).

Hansen, Lars Peter, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica* 50 (1982), 1029–1054.

Jacoby, Hanan, and Emmanuel Skoufias, "Testing Theories of Consumption Behavior Using Information on Aggregate Shocks: Income Seasonality and Rainfall in Rural India," manuscript, University of Rochester and University of Colorado at Boulder (1993).

Lawrance, Emily C., "Poverty and the Rate of Time Preference: Evidence from Panel Data," *Journal of Political Economy* 99 (Feb. 1991), 54–77.

Lim, Youngjae, "Disentangling Permanent Income from Risk Sharing: A General Equilibrium Perspective on the Rural Market in Developing Countries," Ph.D. dissertation, University of Chicago (1992).

Mankiw, N., Gregory and Stephen P. Zeldes. "The Consumption of Stockholders and Nonstockholders." *Journal of Financial Economics* 29 (March 1991), 97–112.

Morduch, Jonathan. "Risk, Production, and Saving: Theory and Evidence from Indian Households," manuscript, Harvard University, 1990.

——— "Consumption Smoothing Across Space: Tests for Village-Level Responses to Risk," manuscript, Harvard University, 1991.

Ogaki, Masao, "Growth in Open Economies: A Comment," *Carnegie-Rochester Conference Series on Public Policy* 36 (1992).

——— "Generalized Method of Moments: Econometric Applications," in G. S. Maddala, C. R. Rao, and H. D. Vinod (eds.), *Handbook of Statistics,* vol. 11: *Econometrics* (Amsterdam: North-Holland, 1993a).

——— "GMM: A User's Guide," Rochester Center for Economic Research Working Paper 348 (1993b).

Ogaki, Masao, Andrew Atkeson, and Qiang Zhang, "Subsistence Level Estimation and Tests for Full Risk Sharing," manuscript, Ohio State University and University of Pennsylvania (1996).

Ogaki, M., Jonathan D. Ostry, and Carmen M. Reinhart, "Saving Behavior in Low- and Middle-Income Developing Countries: A Comparison," *International Monetary Fund Staff Papers* 43 (1996), 38–71.

Ravallion, Martin, and Shubham Chaudhuri, "Risk and Insurance in Village India: Comment" (1997).

Rebelo, Sergio, "Growth in Open Economies," *Carnegie-Rochester Conference Series on Public Policy 36* (1992).

Rosenzweig, Mark R., "Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries," *Economic Journal* 98 (Dec 1988): 1148–1170.

Rosenzweig, Mark R., and Binswanger, "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments," *Economic Journal* 103 (1993), 56–78.

Rosenzweig, Mark R., and Oded Stark, "Consumption Smoothing, Migration, and Marriage: Evidence from Rural India," *Journal of Political Economy* 97 (Aug. 1989), 905–926.

Rosenzweig, Mark R., and Kenneth I. Wolpin, "Credit Market Constraints, Consumption Smoothing and the Accumulation of Durable Production Assets in Low-Income Countries," *Journal of Political Economy* 101 (Apr. 1993), 223–244.

Townsend, Robert M., "Risk and Insurance in Village India," *Econometrica* 62 (1994), 539–591.

Uzawa, H., "Time Preference, the Consumption Function, and Optimum Asset Holdings," in James N. Wolfe (ed.), *Value, Capital and Growth: Papers in Honour of Sir John Hicks* (Edinburgh: Edinburgh University Press, 1968).

APPENDIX

We explain the data in this appendix. We use food, including milk, sweets, and spices, as the measure of food consumption. For nonfood consumption, we subtracted food and ceremonial expenses from total consumption expenditures. Ceremonial expenses are removed because they often jump from zero to large amounts. Nonfood consumption consists of narcotics, tea, coffee, tobacco, pan, and alcoholic beverages; clothing, sewing of cloth, and other tailoring expenses, thread, needles, chap pals and other footwear; travel and entertainment; medicines, cosmetics, soap, and barber service; electricity, water charges, and cooling fuels for household use; labor expenses for domestic work; edible oils and fats (other than gee); and others, including complete meals in hotels, school and educational materials, stamps, stationery, grinding and milling charges, and so on. Unfortunately the ICRISAT consumption data do not include housing and transportation, because the market values of these categories of consumption are hard to measure in these villages. Total consumption expenditure is the sum of food and nonfood consumption.

To construct real consumption per male adult equivalent, nominal consumption at t is divided by the family size measure constructed by Townsend (1994) and the corresponding price index at t for each village. The price indexes for total consumption expenditure, food, and nonfood are the consumer price index, the price index for food, and the price index for nonfood, respectively. These real variables are valued at 1983 prices.

There are about 40 households for each year in each of the three villages in the data. Some households drop out of the sample and others are added to the sample over the years in the ICRISAT data. We exclude these households from our sample. There is one household in the village of Aurepalle with zero income in 1980. Because we take the log of income, this household is excluded. The number of households in our sample for the village of Aurepalle is 35; that for Shirapur, 33; and that for Kanzara, 36.