RISK AVERSION, SCALE ECONOMIES AND TESTS OF RISK SHARING

DISSERTATION

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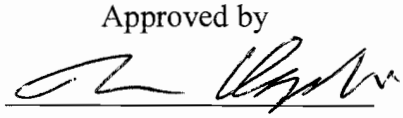

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ABSTRACT

It has often been argued that the relative risk aversion (RRA) coefficient should decrease as a household becomes wealthier. However, existing tests of full risk sharing hypothesis in the empirical literature are derived using preferences that exhibit either *increasing* or constant RRA (CRRA). In this paper, we model decreasing RRA using Stone-Geary utility, which is the CRRA utility augmented by a "subsistence" parameter. Decreasing RRA implies that consumption of wealthy households will fluctuate more than that of poor ones under full risk sharing in an economy with aggregate risk, because rich households are more willing to bear risk. Using IFPRI and ICRISAT data, I find evidence in support of the decreasing RRA hypothesis. I also find evidence in support of the full risk sharing hypothesis at the village level and evidence against it at the inter-village level by accommodating decreasing RRA. When restricting the "subsistence" parameter to be zero (implying CRRA), I am able to replicate the previous results in the literature: reject full risk sharing hypothesis at both levels. My tests, however, reject this restriction and favor the decreasing RRA in almost all cases. These results suggest that it is important to allow for decreasing RRA in testing full risk sharing hypothesis when data containing low-income households are investigated.

Dedicated to my parents

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Although the evidence on Life Cycle-Permanent Income Hypothesis (LC-PIH) is mixed, the notion of consumption smoothing has been widely accepted. Indeed, a large portion of the research on consumption is on consumption smoothing, either over time or across states.

Since Mace (1991) and Cochrane (1991), our understanding of consumption has furthered, in the sense that we now have a new dimension to look at in talking about individual/household consumption: the interaction among agents in the form of risk sharing, or consumption insurance. With the addition of this new hypothesis, individual consumption does not just track individual current/permanent income at any point in time, as Keynesian/LC-PIH proponents would predict, it also depends on the interactions among the agents in response to risks through market or nonmarket activities. This form of consumption smoothing is independent of that of LC-PIH. Maybe the merit of this

hypothesis can be best stated as John Cochrane put it in his 1991 *J.P.E.* paper, " ... [It] can be viewed as the cross sectional counterpart to the permanent income hypothesis: full insurance implies that consumption should not vary *across individuals* in response to idiosyncratic shocks, just as constant borrowing and lending opportunities imply that consumption should not vary *over time* in response to forecastable shocks."

Besides the additional understanding on consumption, the research on risk sharing also provides suggestive evidence on the representative agent paradigm. The representative agent model is generated by the joint hypotheses of intergenerational altruism and complete markets. If complete risk sharing, an implication of the complete markets hypothesis, is not supported by the data, then one may not want to accept the representative agent model.

The tests on complete risk sharing up to now are inconclusive. The common findings are that consumption of different individuals does comove although their income may not; individual income may still have explanatory power on their consumption cross-sectionally, but the significance of aggregate average consumption change (growth rate) at a point in time in explaining individual consumption change (growth rate) can not be rejected. These results hold for both developed and developing economies.

However, in the empirical literature of risk sharing, a certain parameterized form of utility function usually has to be used to derive the testable implications. When functional forms are misspecified, tests can yield misleading results. Even though one cannot entertain a general form of the utility function because it is always possible to find

a utility function that is consistent with any observation, it is important to use a flexible enough functional form to allow for important likely features of preferences over risky consumption.

How the relative risk aversion (RRA) coefficient varies with wealth has important implications on dynamic consumption decisions. It has often been argued that it is very likely that the RRA coefficient decreases as a household becomes richer (see, e.g., Mas-Colell, Whinston, and Green (1995), pp. 192-193, for a discussion). Indeed, Rosenzweig and Binswanger (1993) find that farmers are in general risk averse, but the wealthier they are, the less their investment portfolios are affected by increasing weather risk. This is consistent with, and could be caused by, decreasing RRA. However, isoelastic, exponential, and quadratic utility functions are typically used in the empirical literature of risk sharing. The isoelastic utility functions imply constant RRA, and exponential and quadratic utility functions imply that the RRA coefficient *increases* with the level of wealth. If the RRA coefficient decreases with the level of wealth, then wealthier households are willing to bear more risk. As a result, consumption of richer households could fluctuate more than that of poorer households even under complete risk sharing when aggregate shocks are present. Such an allocation of risk may result from systematically different investment strategies between rich and poor households: the poor may choose to hold lower risk and lower return assets than the rich. Again, Rosenzweig and Binswanger (1993) find empirical evidence for such a systematic difference in

portfolio strategies, using the household level panel data from India collected by the International Crops Research Institute in the Semi-Arid Tropics (ICRISAT).

This paper aims to enhance our understanding of consumption risk sharing along two dimensions: by explicitly accommodating different forms of risk aversion, and by incorporating economies of scale in household consumption.

The empirical results of this paper, based on two household level data sets, *ICRISAT* and *Pakistan Rural Survey*, show that decreasing RRA may well be the case and it matters for the tests of risk sharing. More specifically, I will show that starting with a simple but general utility function that allows increasing, constant, and decreasing RRA as special cases, one can show that the data support the hypothesis of decreasing RRA. Furthermore, incorporating this feature in the tests of full risk sharing could reverse the test results based on current approaches in the literature. Moreover, in the context of the model, if one ignores decreasing RRA and force RRA to be constant (a testable restriction), then one will be able to replicate the results in the current literature. This restriction itself, however, can be easily rejected. Thus this paper provides different insights on policy regarding welfare improvement in rural areas.

The motivations of economies of scale are two-fold. First, there have been lots of studies on the scale effect of household size on consumption, but there has not been research done in the area of risk sharing to incorporate it explicitly. The sample households in these two data sets were traditional farming households. Many of them consisted of a few families. So it should be both important and interesting to investigate

the effect of size on household consumption and its implication on risk sharing in the two data sets. Of course scale economies in consumption is just one way to study the size effect. Altruism among household members provides another avenue that size could matter in their intertemporal optimization problem. Second, it serves as a sensitivity analysis of the results obtained from the simple model that incorporates decreasing RRA.

I apply my tests to the IFPRI and ICRISAT panel data of households. These data sets are of interest because they contain data of low income households, for whom decreasing RRA may well be the case. A unique feature of the IFPRI data set is that consumption and income data were collected separately from different members of each household. This feature is attractive for my purpose, because the tests here, like most of the existing tests of full risk sharing, require the assumption that the measurement error in consumption is not correlated with income variables. Since the consumption and income data were separately collected, this assumption is more likely to be valid in my tests. The ICRISAT data set has been used extensively in development economics in general, and the risk sharing literature in particular. The reason to include it here is that we think it is important to compare the results from different data sets. After all, a good model should be able to "survive" as many data sets as possible in the empirical tests. In addition, it should also be very interesting to compare our results based on this data set with those reported in the literature where the implication of decreasing RRA has been ignored.

Incomplete risk sharing can be caused by moral hazard and adverse selection problems, which are in turn caused by private information. Without private information,

various arrangements can be used by the members of the community to share risk even when financial markets are not well developed. Private information is more likely to be present in a large community, or in an economy with more complicated production technologies than in a small community with simple production technologies. Hence full risk sharing can be a good approximation of the consumption growth pattern for a village economy in low-income countries. On the other hand, full risk sharing across villages which are farther apart is not likely to be a good approximation. In addition to private information, social conflict such as discrimination or even hatred among different groups of the society can also cause incomplete risk sharing. These considerations provide us with a measure of the power of my tests: a powerful test for the null hypothesis of full risk sharing should be able to reject full risk sharing *across* villages.

The rest of the paper is organized in the following way. Section 2 below reviews the literature, and points out the problem with the current approaches. Chapter 2 presents a model incorporating different forms of risk aversion and its testable implication. The econometric method to carry out the estimation and inference is also discussed there. Section 1 of Chapter 3 is a description of the two data sets used in this research. The following section discusses the empirical results. Chapter 4 presents a full risk sharing model that allows for economies of scale in household consumption and the empirical results based on it. Chapter 5 concludes the paper.

1.2. Literature Review

The theoretical clue of risk sharing can be traced to Peter Diamond (1967) and Robert Wilson (1968). But the explicit test of the hypothesis started in Mace (1991). Since then, Cochrane (1991), Altug and Miller (1990), Townsend (1994) and (1995), Udry (1994), and Hayashi, Altonji, and Kotlikoff (HAK henceforth) (1996), among others, have examined the hypothesis using either regression analysis or GMM approach with household level datasets. The regression-based test, such as Mace (1989), Cochrane (1989) and Townsend (1994), checks the statistical dependence of individual consumption changes (growth rates) with individual income changes (growth rates). The rationale is as follows. The full risk-sharing theory predicts that after any idiosyncratic risks are insured away, individual consumption changes (growth rates) is determined by aggregate average consumption change (growth rate). Thus, any idiosyncratic variable should not have explanatory power on individual consumption change (growth). The most interesting and important idiosyncratic variable in terms of consumption theory, of course, is individual income change (growth). Therefore it is usually included in the idiosyncratic variables set. The GMM-based approach, such as Altug and Miller (1990) and HAK (1996), examines essentially the same relationship by looking at the orthogonality conditions generated from the theoretical models.

Mace (1991) and Townsend (1994), although based on different datasets, both find some evidence that complete markets model is a good benchmark. Using CEX,

Mace tests the hypothesis that individual consumption changes and growth rates are independent of individual income changes and growth rates and employment status in the American economy. She finds few rejections of the theory. Townsend (1994) examines village-level risk sharing in southern India and finds substantial comovement in individual consumption, although comovement in individual income is much less. Mace's results have been criticized by Nelson (1994) on the ground that she does not take into account the measurement error in income changes, which may bias the regression coefficient of the income change variable downward to zero and thus favors the complete markets hypothesis. It is also on the measurement error ground that Ravallion (1997) challenges Townsend's result. His point is that the ICRISAT data set used in Townsend's analysis was not designed for collecting consumption data and therefore its consumption measures were very noisy. By the means of flow accounting, he is able to construct different consumption measures, and shows that there appears to be systematic measurement error in the recorded consumption measures that Townsend uses. If one takes into account the measurement error structure embodied in the data, then he will get quite different results from Townsend (1994) by using the same approach of the latter.

Altug and Miller (1990) does not reject complete risk sharing using PSID. However, HAK (1992) and (1996), using information on split-off households in the same dataset, reject both altruism and complete risk sharing. One problem in testing risk sharing is to distinguish self-insurance from risk sharing. HAK (1996) is very careful in handling this problem. They show that Altug and Miller (1990)'s test has no power

against the alternative of self-insurance. Then they correct for the problem by choosing proper instruments. The rejections from their studies seem to be a decisive blow to the complete market hypothesis since common sense suggests that an extended family will be more likely to achieve full risk sharing than any other cohorts in the society.

Townsend (1995) is a review of the current research on village level risk sharing in developing economies. The most important insight this paper offers is that even inside each village, the distribution of shocks, such as rainfall, crop diseases, and so on is not uniform; each village is also different from the others in terms of its ability to cope with risks. Some villages are able to come up with efficient risk-sharing mechanisms, but others are just not. It does not depend on the average wealth level of a village. Rather, it depends on if there exist credit and risk institutions and other informal social mechanisms in a village that function as explicit or implicit markets for allocating idiosyncratic risks. Besley (1995) documents various nonmarket institutions for credit and risk sharing in developing countries.

A common feature of all the tests mentioned above is that they are based on investigating the relationship between individual consumption and individual income, without paying much attention to the implied risk aversion of the assumed utility function. To improve on this aspect, in Chapter 2, my model starts with a simple yet general specification of utility, which entertains increasing, constant and decreasing relative risk aversion as special cases.

CHAPTER 2

THEORY AND METHODOLOGY

2.1. Introduction

This chapter presents a simple complete markets model that accommodates increasing, constant, and decreasing relative risk aversion. This flexibility is obtained by introducing a (what I call for convenience) "subsistence" parameter, into the isoelastic CRRA utility. (The new utility function is called Stone-Geary utility.) The central message this model delivers is that full risk sharing does not necessarily imply that individual consumption variation should be statistically independent of individual income variations. On the contrary, they *can* be correlated with each other. What should be independent of income variation cross-sectionally in the presence of full risk sharing is the growth of the consumption net of the "subsistence" parameter. Besides, this model implies that consumption growth differs systematically between the rich and the poor.

The econometric method carrying out the estimation and inference of the model is presented in Section 3.

2.2. A Simple Model and Its Implications

2.2.1. *An Arrow-Debreu Economy*

Consider an economy with H households. Let a vector $s(t)$, $s(t)=1,2,...,S$, denote the state of the world in each period and the vector $e(t)=[s(0),s(1),...,s(t)]$ be the history of the economy. Let household h, $h=1,...,H$, have time and state separable utility with an intratemporal utility function $u(C_h(t),e(t))$, where $C_h(t)$ is per capita consumption of household h. In this paper household size is measured by the number of male-adult-equivalent. Therefore the per *capita* here, and henceforth, is per *male-adult equivalent*. The advantage of doing so is that all demographic changes will have been taken care of. Let β denote the common discount factor in the economy. Then household h's problem is to maximize

$$U_h = \sum_{t=0}^{T_h} \sum_{e(t)} \beta^t \Pr(e(t) \mid e(0)) u(C_h(t,e(t))), \tag{1}$$

where T_h is the life-time of the household, and $\Pr(e(t)|e(0))$ denotes the conditional probability of $e(t)$ given $e(0)$, subject to a life-time budget constraint

$$\sum_{t=0}^{T_h} \sum_{e(t)} \left(\prod_{\kappa=0}^{t} R(\kappa-1, e(\kappa-1), e(\kappa)) \right)^{-1} C_h(t,e(t)) \le W(0), \tag{2}$$

where $W(0)$ is household h's per male-adult equivalent initial wealth; $R(\kappa-1, e(\kappa-1), e(\kappa))$ is the gross asset return of the state contingent security for the

event $e(\kappa)$ in terms of the good in the event $e(\kappa-1)$ at period $\kappa-1$.[1] ($e(\kappa)$ is suppressed below for the sake of simplicity.) Now assume that

$$u(C_h(t)) = \frac{(C_h(t)-\gamma)^{1-\alpha}-1}{1-\alpha}, \tag{3}$$

where γ is the preference parameter that governs whether the RRA coefficient increases or decreases with the level of wealth. The RRA coefficient, θ_h, of a household h implied by (3) is

$$_h = \alpha\left(\frac{C_h}{C_h-\gamma}\right). \tag{4}$$

If γ is zero, then the RRA coefficient is α, since (3) reduces to the CRRA case. If γ is positive, then the RRA coefficient is large for a poor household whose consumption is close to γ. But as the household becomes richer, the RRA coefficient falls and approaches α. If γ is negative, then the RRA coefficient rises with the level of wealth. For positive γ, one interpretation of this preference parameter is that it is subsistence consumption. Therefore we will call γ subsistence consumption in this paper, though other interpretations are also possible.

In the empirical work reported in Chapter 3, three measures of real consumption will be used for the ICRISAT data: total consumption, food consumption, and nonfood consumption. This practice, of course, is based on the assumption that the residual consumption expenditures that were not included in these three measures of consumption reported in the datasets are separable from the three measures. Leisure is also assumed to

[1] *R(-1, e(-1),e(0))* is assumed to be 1.

be separable from consumption. For the Pakistani data, I only use the food consumption data due to the constraint of the data set.

The intertemporal first order condition for the optimization problem of household h is

$$\frac{C_h(t+1)-\gamma}{C_h(t)-\gamma} = \phi(t+1) \tag{5}$$

for any state of the world, where $\phi(t+1) = [\beta R(t,e(t),e(t+1))Pr(e(t+1)|e(t))]^{1/\alpha}$.

Equation (5) holds for each h. Since $\phi(t+1)$ is independent of h, $C_h - \gamma$, the consumption in excess of the subsistence parameter, should grow at the same rate for all households in any state of the world. This is because idiosyncratic risk is insured away through the complete asset markets in the model. Equation (5) is the testable implication of the model that I will pick up later.

2.2.2. *Consumption Growth of the Rich and the Poor*

The existence of wealth-varying RRA coefficient implies consumption growth differs systematically between the rich and the poor in our model. Intuitively, households with higher RRA coefficients will be more willing to bear risk and will experience more volatile consumption growth than those with lower RRA coefficients. One way to see implications on consumption growth is to examine the exact solution for consumption growth. Let $\overline{C_h} = C_h - \gamma$. Let $\hat{x}$ be the growth rate of any variable x, and $\ln x$ be the natural log of x. Then

(6) $$\hat{C}_h(t) = \ln[\overline{C_h}(t)\exp(\hat{\bar{C}}(t)) + \gamma] - \ln(\overline{C_h}(t) + \gamma),$$

where $\hat{\bar{C}}(t)$ is the common growth rate of $\overline{C_h}(t)$ at t. (6) implies

$$sign(\hat{C}_h(t)) = sign(\hat{\bar{C}}(t)).$$

Differentiating the right hand side of (6) with respect to $\overline{C_h}(t)$ yields

(7) $$\frac{\partial \hat{C}_h(t)}{\partial \overline{C_h}(t)} = \frac{\gamma(\exp(\hat{\bar{C}}(t)) - 1)}{(\overline{C_h}(t)\exp(\hat{\bar{C}}(t)) + \gamma)(\overline{C_h}(t) + \gamma)}.$$

Assuming that γ is positive, (7) implies

$$sign\left(\frac{\partial \hat{C}_h(t)}{\partial \overline{C_h}(t)}\right) = sign\,(\exp(\hat{\bar{C}}(t)) - 1)$$

(8) $$= sign\,(\hat{\bar{C}}(t)).$$

Hence the rich households' consumption grows at faster rates in a state in which aggregate consumption grows, declines at faster rates in the states in which aggregate consumption declines.

Note that $\hat{\bar{C}}(t)$ is in fact $\phi(t) - 1$. Therefore, a positive $\hat{\bar{C}}(t)$ implies

$$\beta R(t-1, e(t-1), e(t))\Pr(e(t)|e(t-1)) > 1,$$

i.e.

$$\ln R(t-1, e(t-1), e(t))\Pr(e(t)|e(t-1)) > -\ln\beta$$

The right-hand side of the inequality is just the rate of time preference, δ, while the left-hand side is the real rate of return of the state-contingent security for state $e(t)$, $r(t, e(t-1), e(t))$. With this said, it is easy to see that (8) can be rewritten as

(8') $$sign\left(\frac{\partial \hat{C}_h(t)}{\partial \overline{C}_h(t)}\right) = sign\left(\phi(t) - 1\right)$$

$$= sign\left(r(t, e(t), e(t+1)) - \delta\right).$$

According to the second equality of (8'), in states in which the real return of assets is higher than the rate of time preference, the consumption growth rates of the rich households are higher than those of the poor households; but in states in which the real rate of return falls below the time preference rate, the consumption of rich households declines faster than poor households. Since the rate of time preference is a constant, the implication of the model is very clear: accompanying the fluctuations in real returns of assets around the time preference rate, the fluctuations in consumption of the rich households are larger than those of the poor households. Therefore the rich households bear more risk than the poor households in the equilibrium.

The implications above are obtained with the aid of the assumption that γ is positive. It is natural for me to make this assumption, since I interpret it as subsistence consumption. (As a curvature parameter, γ can be either positive or negative.) As I shall

see in the empirical part below, the estimates of γ are indeed all positive, statistically significant, and economically meaningful, except for one district in the Pakistani data.[2]

These results suggest that consumption growth is correlated with the level of wealth and hence current and lagged income across households in our model. The direction of correlation depends on whether or not aggregate consumption grows or declines. Our results also suggest that consumption growth can be correlated with income level and income growth even under complete risk sharing. For example, consider the case where the economy in our model grows over time. In a growing economy, rich households' consumption grows at a faster rate. In general, higher consumption growth of rich households is attained by higher saving rates that result in higher income growth. Thus consumption growth will be positively correlated with income growth across households. It is possible that such nonzero correlation of consumption growth and income variables is misinterpreted as evidence for liquidity constraints or incomplete markets in our model economy if subsistence levels are ignored. This problem may be alleviated by examining the correlation of consumption growth and labor income growth, instead of that of consumption growth and total income growth. This, however, is not a final solution if faster rates of human capital accumulation and resulting higher labor income growth are used to achieve higher consumption growth of rich households.

[2] Even for this district (Dir), the estimate of γ becomes positive and significant when we pool the data from all the districts in the sample. Please refer to Tables 8 and 9.

If we make an additional assumption that the real risk free interest rate is constant as in Hall (1978), then the common growth rate of $\overline{C}$ is a martingale difference with possibly a drift (using a log normal assumption or a linear approximation). However, we do not assume that the real risk free interest rate is constant.

2.3. Econometric Method

As discussed in the previous section, complete risk sharing implies that the growth rate of $C_h - \gamma$ is identical for all households in each state of each period (see eq. (5)). We now assume that consumption is measured with error:[3]

(9) $$C_h^m(t) = C_h(t) + \xi_h(t),$$

where $C_h^m(t)$ is measured consumption in per adult-equivalent terms, and $\xi_h(t)$ is measurement error. Then combining (5) and (9), we obtain

(10) $$C_h^m(t+1) - \phi(t+1)C_h^m(t) - \gamma + \gamma\phi(t+1) = e_h(t+1),$$

where $e_h(t+1) = \xi_h(t+1) - \phi(t+1)\,\xi_h(t)$.

Now assume that $\xi_h(t)$ is uncorrelated with household *h's* permanent and current incomes at time *t*. Let y_h^p be a proxy of its permanent income, and $y_h(t)$ be its current income. Let $Z_h(t) = (1, y_h^p, \Delta y_h(t))'$ be a vector of instrumental variables. Let ψ =

[3] Ogaki and Atkeson (1997) discuss the choice between additive and multiplicative measurement errors. They suggest that an additive specification would be better for the purpose of testing risk sharing.

$(\phi(2),\ldots,\phi(T),\gamma)$ be the T-dimensional vector of unknown parameters and ψ_0 be the corresponding vector of their true values. T is the number of the time periods of the sample. In addition, let $f(C_h^m(t+1),\psi)$ be the 3-dimensional vector

$$f(C_h^m(t+1),\psi) = Z_h(t+1)[C_h^m(t+1) - \phi(t+1)C_h^m(t) - \gamma + \gamma\phi(t+1)] \equiv f_{h,t+1} \tag{11}$$

and

$$f_h(\psi) = (f_{h,2}(\psi), f_{h,3}(\psi), \ldots, f_{h,T}(\psi))'.$$

Then we have *3(T-1)* orthogonality conditions

$$E_H\left(f_h(\psi_0)\right) = p\lim_{N\to\infty} \frac{1}{N}\sum_{h=1}^{N} f_h(\psi_0) = 0, \tag{12}$$

where E_H is the expectation operator over households. Here H is attached to emphasize that the expectation is taken over households. Assume a central limit theorem applies to $f_h(\psi_0)$ so that $(1/N)^{1/2}\sum_{h=1}^{N} f_h(\psi_0)$ converges to a normal random vector with mean zero and covariance

$$\Omega = plim_{N\to\infty} \frac{1}{N}\sum_{h=1}^{N} f_h(\psi_0) f_h(\psi_0)'. \tag{13}$$

ψ can be estimated by Hansen (1982)'s generalized method of moments (GMM) using (12) as othorgonality conditions. In the estimation, we first pool the orthogonality conditions for all the households in each village, then stack the matrix of orthogonality

conditions for all the villages in the same district. $f_h(\psi_0)$ is allowed to have different covariance matrices for different villages when the data are pooled.[4]

I consider two types of tests. One type of test is the χ-square test of the overidentifying restrictions, which is called Hansen's ***J*** test. Under the null hypothesis of full risk sharing, the disturbance term in (10) is uncorrelated with the income variables in the set of the instrumental variables. Therefore, the ***J*** test statistic has an asymptotic χ-square distribution. Under the alternative hypothesis of incomplete risk sharing, the disturbance in (10) will be correlated with income variables. Hence the ***J*** test statistic will tend to be large.

The other type of test is based on variable addition. I add the income difference term to (10) to obtain:

$$C_h^m(t+1) - \phi(t+1)C_h^m(t) - \gamma + \gamma\phi(t+1) - \eta\Delta y_h(t+1) = e_h(t+1) \tag{14}$$

Under the null hypothesis of full risk sharing, $\eta = 0$, because the first order condition of the model indicates that individual income change should play no role in explaining individual consumption when the effect of γ is accounted for. However, under the alternative hypothesis of incomplete risk sharing, individual income variables will affect individual consumption growth even after controlling for the effect of γ and the effect of the aggregate shock. For example, take the alternative hypothesis of Keynesian consumption function, $C_h(t) = a + b\,y_h(t)$, where $0<b<1$. Under this hypothesis, a

[4] Hansen/Heaton/Ogaki's GAUSS GMM package is used for the GMM estimation in this paper.

GMM estimation for (14) would result in $\phi(t) = 1$, and $\eta = b$, and therefore η would be positive. Thus I can test the hypothesis of full risk sharing by testing the null of $\eta = 0$. This additional term could increase the power of the full risk sharing test, since by augmenting the model this way it is easier to pick up the correlation between the consumption and income variables if it indeed exists.

In the empirical work, I pool the data from different villages, and the variable addition testing is conducted at two levels. At the village level, I test whether or not η estimate is significantly different from zero for each village. At the pooled district level, I test whether or not the η estimates of the villages in the same district are jointly significant. This is done by computing the likelihood-ratio-type test statistic, which is the difference between the constrained Hansen's $\boldsymbol{J}$ statistic and the unconstrained $\boldsymbol{J}$ statistic.[5]

The variable addition tests are more powerful than Hansen's $\boldsymbol{J}$ test against the alternative hypothesis of incomplete risk sharing. Hansen's $\boldsymbol{J}$ test tests against any correlation of the instrumental variables and the disturbance term. The variable addition tests are specifically directed toward the positive correlation between consumption and income which incomplete risk sharing implies. In addition, the variable addition test based on the income coefficient in each village can be used to test against incomplete risk sharing for each village even when data are pooled for many villages. Indeed, my empirical results are consistent with this argument.

[5]See, e.g., Ogaki (1993) for a description of the likelihood-ratio-type test.

The results from the variable addition tests and Hansen's ***J*** tests are consistent in most cases. The only exceptions are for two Pakistani villages, where the variable addition test based on the income-difference coefficient rejects the null hypothesis of complete risk sharing, but Hansen's ***J*** test does not reject it.

Another experiment that I will do is to examine what happens if we force $\gamma = 0$ in the estimation and testing. As pointed out in the Introduction, the current literature generally ignores the role of γ. Forcing $\gamma = 0$ is equivalent to what other researchers have done in their tests. If I can replicate the result of rejecting the null of full risk sharing at village level when I impose this restriction, but can not reject it when allowing γ to be estimated, then I can be confident that it is the restriction $\gamma = 0$ that is driving the rejection of the model. In turn, we can test if this restriction itself is "reasonable" or not. If it is decisively rejected, then we conclude that it should not have been imposed in the estimation and testing, i.e. γ should have been allowed to be different from zero. Then, if by taking into account the effect of estimating γ, indeed I do not reject the null hypothesis, I conclude that the theory presented in Section 2 is not rejected by the data.

CHAPTER 3

DATA AND EMPIRICAL RESULTS

3.1. Introduction

I use two data sets in this paper, *Pakistan Rural Survey* and *ICRISAT-India*. They were chosen for two reasons. First, the consumption of the individuals in these two countries is low and thus decreasing RRA may well be the case. Second, to compare my results with those obtained in other studies, it is also desirable to use them. Especially, the second one has been studied extensively. Collected by International Crops Research Institute at Semi-Tropic Areas (ICRISAT) in India, it is very well known. Hence only a brief data description on it is provided in this chapter. The first one was collected by the International Food Policy Research Institute (IFPRI). In co-operation with the government of Pakistan, *IFPRI* conducted this survey project from 1986 to 1991 to study food security at rural Pakistan. This data set is relatively new so I will describe it in some detail. These two data sets give me altogether 55 village economies for analysis.

As can be seen from sections below, empirical results from both data sets are consistent with each other and support the simple model outlined in Chapter 2. The evidence from each data set is equally strong.

3.2. The IFPRI-Pakistani Data Set

It covered 52 villages in four districts of three provinces: Punjab, Sind, and Northwest Frontier. The four districts are Attock, Faisalabad, Badin, and Dir. About 946 households were interviewed 12 times between April 1986 and September 1989. There were six rounds of interviews in the first year, and three interviews in each of the subsequent two years. In every round, households were asked detailed questions on their production activities and incomes, food and nonfood consumption, labor supply, financing of production, and other household information. Data were also collected on village infrastructure and current prices in each round. The time span between the interviews ranged from five weeks to twenty-eight weeks. Since the intention of the survey was to study food security, the survey was designed to cover the poorest districts in the three provinces. Therefore this data set is not a representative sample of rural Pakistan.

However, the villages and the households were chosen using a stratified random sample. Specifically, two markets were first chosen randomly within each district. Then villages were grouped according to their distances from the markets: those within five kilometers, those within ten kilometers, and those between ten and twenty kilometers

away from the markets. From each group, villages were selected randomly, and households were then picked out at random from the complete list of village families. In the present paper, the empirical analysis will be based on 633 households in 31 villages due to the lack of data for some villages and households. For example, all the data for Village 15 to Village 20, and Village 52 are missing. Besides, from the sample, I have to exclude the households with incomplete information on any of the following: the age-sex composition, the food consumption and the income level for each of the three years. Concerned about sample size, I also exclude the villages with less than 11 households. The number of people who resided in these households was somewhere between 5,000 and 6,000.

In each interview, a male questionnaire and a female questionnaire were used separately for collecting different data. Here I only outline the contents of the questionnaires that are related to this paper. The male questionnaire consisted of about 170 questions and was mainly about production, marketing, financing, various revenues, male labor supply and hiring, and nonfood expenditures. Examples include questions on the ownership (or rent) of land, the planting, production, sales and inventories of grain and other crops, asset sales, orchard sales, other incomes (both cash and in-kind) from agriculture and non-agriculture activities, farm expenditures, non-farm expenditures on durables, clothing and personal expenditures, pensions received, transfers received (from both home and abroad) and made, taxes paid, expenditures on ceremonies, borrowings and repayments, and savings accounts.

The female questionnaire had around 120 questions, and was mainly about demographics, food consumption, health status of children, and female labor supply. Food consumption data included purchases of 37 food items, and consumption from gifts and own production. The respondent was asked about the frequency of purchases, the price paid, the quantity purchased, and the value of purchases of most items. Food away from home was recorded. Also included in the questionnaire were expenditures on fuel, clothing, tobacco, cosmetics, soaps, laundry, entertainment, travel, gifts to friends and relatives, and payments to artisans. Demographic information on each member of the household and their status (present, traveling, dead, new member and so on) were recorded.

For the empirical work, what I need is the size of the household adjusted by its age-sex structure and status of members, household income, a measure of consumption and the corresponding price index.

I calculate the adjusted household size with the age-sex weights used by Townsend (1994). These weights are the male-adult equivalence scales provided by Ryan, Bidinger, Pushpamma, and Rao (1985). They are presented in Table 4.

Since these weights are obtained from dietary studies, they are most appropriate for the purpose of obtaining per male-adult-equivalent *food* consumption. Whether it is proper to extend them to calculate the per capita nonfood and per capita total consumption is not clear to me. The household size in each round is calculated first, then

annual household size is obtained as the weighted average of household sizes in each round. I have also calculated village-specific food price indexes for all the villages.

The annual income and food consumption expenditure data calculated by IFRPI are used in empirical analysis. The income measure includes nine subcategories: rental earnings in crops, net crop profits, farm wage income, non-farm income, net livestock profits, returns to capital, remittances, pension, and zakat. Since data on total consumption are not readily available, I test risk sharing for food consumption.[6] Assuming that food consumption is separable from other consumption categories, the model in Chapter 2 applies to food consumption. For my purpose, using food consumption is attractive for three reasons. First, my tests assume that the measurement error in reported food consumption is uncorrelated with income variables. Because food consumption and income variables are essentially collected from different household members, this assumption is more likely to be valid. Second, the aforementioned age-sex weights were obtained from dietary studies, and are more appropriate if used only for food consumption. It is not clear how to obtain appropriate adult-equivalent scales for nonfood consumption. Third, the notion of subsistence consumption, if interesting at all, is more likely to be sensible for food than for nonfood. All data are in annual terms.

There are both advantages and disadvantages in using this data set. The largest advantage is, of course, the fact that it contains 31 usable villages, so that I have enough

[6]Although some nonfood consumption data were collected, they were in nominal terms. It is not clear to me how to obtain real nonfood consumption since prices for nonfood items were not recorded.

sample economies to test the validity of the model presented in Chapter 2. The disadvantage is that for some villages, the number of households sampled/usable is relatively small. Overall, the number of households in each village ranges from 12 to 40.

In upper panel of Table 1, I report district and village annual average real per male-adult-equivalent food consumption. These numbers are reported to facilitate the interpretation of the estimates of the "subsistence" parameter reported in the ensuing tables. Figures 2 to 5 graphs the variation of household consumption over the three years at each village for all the four districts. Summary statistics of income and household size are provided in Tables 2 and 3.

3.3. ICRISAT-India Data

ICRISAT conducted intensive interviews in southern rural India between 1976 and 1985. This paper uses data from three villages for which the complete consumption data are available: Aurepalle, Kanzara, and Shirapur. Three measures of consumption, food, nonfood, and total consumption, were constructed. Since the construction of food consumption was changed in 1976 and the data for nonfood consumption are missing for most categories after 1982, 1976-1981 is chosen as the relevant sample period for total consumption. For food consumption, all the data between 1976 and 1984 will be used.

I use food including milk, sweets, and spices as the measure of food consumption. For nonfood consumption, food and ceremonial expenses are subtracted from total consumption expenditure. 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, other tailoring expenses, thread, needles, chap pals and other footwear; travel and entertainment; medicines, cosmetics soap, 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. 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 some year t is again divided by the family size measure used in Townsend (1994) and the corresponding price index at t for each village. The price index 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 forty 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 years. These households were excluded from the sample. The number of households in our sample for the village of Aurepalle is 35; that for Shirapur, 33; and that for Kanzara, 36.

The average consumption per adult-equivalent is provided in the lower panel of Table 1.

3.4. Empirical Results

In this section, we report our empirical results for the two panel data sets.

3.4.1. *Results for the Pakistani Data*

The test results for different districts in the Pakistani data are presented in Tables 5, 6, 7, 8, and 9. In each table, the first row reports the baseline results in which γ is restricted to be equal across all villages in the sample, and full risk sharing is assumed within each village by restricting $\phi(t)$ to be equal across the households in each village. In each district, the $\boldsymbol{J}$ test in the first row does not reject the null hypothesis of full risk sharing at the five percent level. For the baseline case, the point estimate of γ is positive and statistically significant in all districts except for Dir. For Dir, the point estimate is negative, but it is not significantly different from zero. Because the standard error for γ is larger for Dir than is for the other three districts, the data for Dir do not seem to contain much information about γ. Hence the evidence provided by the γ estimates clearly favors the decreasing RRA hypothesis.

In the second, third, fourth, and fifth rows, the likelihood ratio type test statistic, $\boldsymbol{C}$, is reported, which is the difference between the $\boldsymbol{J}$ value for each row and that for the first row. In the second row, we impose the restrictions that $\phi(t)$ is the same *across* villages for each t =1,2. If full risk sharing is achieved *across* villages, then these restrictions must be satisfied. We find overwhelming evidence against these restrictions

for each district from the ***C*** statistic reported in the second row. Because full risk sharing is not likely to be achieved across villages given that private information is more likely to be a problem there, this indicates that the ***J*** test's power against incomplete risk sharing is at least not zero.

The third row reports the variable addition test results. If the coefficient on the income change is significant for a village, we reject the full risk sharing hypothesis for that village. The ***C*** test tests the joint hypothesis that all the coefficients on the income changes are equal to zero. We do not reject the full risk sharing hypothesis for most villages except for Village 1 in Table 4 and Village 22 in Table 6. The ***C*** test does not reject the null hypothesis of full risk sharing within villages.

The fourth row reports the results when γ is allowed to be different across villages. The ***C*** test does not reject the restriction that the parameter is equal across villages. The fifth and sixth rows report the results when γ is restricted to be zero. This corresponds to Townsend's (1994) model, except that he uses an exponential utility function. The ***C*** test strongly rejects this restriction in the fifth row for all districts except for Dir. The ***C*** test statistic reported in the sixth row is the difference between the ***J*** value in this row and that in the fifth row. The ***J*** test in the fifth row, and the ***C*** test in the sixth row test the null hypothesis of full risk sharing with $\gamma = 0$. These tests reject the null hypothesis of full risk sharing in all districts except for Dir. These results indicate that one can find evidence against full risk sharing when decreasing RRA is ignored.

Table 9 reports the results when the data for all four districts are pooled. The first row reports the baseline results in which γ is restricted to be equal across all the villages in the whole sample, and full risk sharing is assumed within each village. Here the γ estimate turns out to be positive and significant. In the second row, we find overwhelming evidence against the null hypothesis of full risk sharing *across* districts. The $\boldsymbol{C}$ statistic in the fourth row tests the hypothesis that γ is the same across all the households in the whole sample. This hypothesis is rejected at the 5 percent level, though not at the 1 percent level. The p values reported here, however, are based on the asymptotic approximation. It is possible that the approximation error is larger when the data for Dir are included, given the large standard error for γ found for Dir. Indeed, when the data for Dir are excluded from the sample, I do not reject the hypothesis that γ is the same across all the households at the 10 percent level.

3.4.2. *Results for the Indian Data*

Tables 10 and 11 present the results for the ICRISTA data. The first row of each table reports the baseline results. The $\boldsymbol{J}$ test in the first row does not reject the null hypothesis of full risk sharing at any conventional significance level. The point estimate of γ is positive and statistically significant, indicating that the data also support the hypothesis of decreasing RRA here.

In the second row, we impose the restrictions that $\phi(t)$ is the same across villages for each t. As in the Pakistani data, we find overwhelming evidence against these restrictions for each district from the $\boldsymbol{C}$ statistic reported in the second row. This

result is expected because full risk sharing is not likely to be achieved across villages given that they are far apart. The third row reports the variable addition test results. No coefficient on the income change is significant at the 5 percent level, and the ***C*** test does not reject the null hypothesis of full risk sharing within villages. The fourth row reports the results when γ is allowed to be different across villages. The ***C*** test does not reject the restriction that the subsistence level is the same across villages.

The fifth and sixth rows report the results when γ is restricted to be zero. As before, this corresponds to Townsend's (1994) model (except that he uses an exponential utility). The ***C*** test strongly rejects this restriction in the fifth row. The ***J*** test in the fifth row, and the ***C*** test in the sixth row test the null hypothesis of full risk sharing with $\gamma = 0$. The ***J*** test in the fifth row rejects the null hypothesis of full risk sharing within each village. The ***C*** test in the sixth row does not reject the null hypothesis at the fifteen percent level, but the income coefficient for Shirapur rejects it for the village at the one percent level. As in the Pakistani data, these results indicate that one can find evidence against full risk sharing when decreasing RRA is ignored.

CHAPTER 4

THE SCALE ECONOMIES MODEL

4.1. Introduction

Demographic effects are known to be important for household consumption decisions. In Chapter 2, the household size effects are treated in a simple fashion. The model there is based on a household utility maximization problem in which households maximize per male-adult equivalent utility by choosing per male-adult-equivalent consumption. We do not worry about the scale effect of household size on consumption, for example. But there have been reports on economies of scale in household consumption.

Deaton and Paxson (1995) find that household size and structure matter in poverty line estimation. Townsend (1994) finds that the household size, the number of adults and the number of children enter negatively his benchmark regression of per capita consumption on aggregate consumption and idiosyncratic variables, which could be interpreted either as economies of scale or lack of insurance. Besides, Attanasio and Weber (1993) also confirm that demographic variables are important in understanding

household consumption. Most notably, Julie Nelson (1988) reports "significant economies of scale in the consumption of food, shelter, clothing, household furnishings and operations, and transportation …" using data from Consumer Expenditure Survey. For example, in terms of food consumption, she finds that a two-adult household can live as cheaply as a household with an adult-equivalent household size of 1.19. While it is a little bit surprising for us to see such an extent of scale economies in food consumption, since food is primarily a private good, one has to take these evidences seriously and see if indeed this would affect the results reported earlier in Chapter 3. Besides, Deaton and Paxson (1995) also mention that they have uncovered economies of scale in food consumption for data from U.S., Britain, India, Taiwan, and South Africa. Others report similar evidence for households in Tunisia and Pakistan. Lastly, the sizes of the sampled households are indeed very large for the data used in this paper.

There are, of course, different ways to deal with the household size problem. For instance, there are theoretical studies, such as Barro and Becker (1989), endogenizing fertility/household size choice. They study the role of altruism in intergenerational resources allocation. Conceptually altruism is different from risk sharing, though the former helps to generate risk sharing among agents both *ex ante* and *ex post*, if we extend altruism beyond the parent-children relationship. Broadly speaking, altruism means other people's welfare or consumption level is an argument of your utility function, while risk sharing does not share this feature. At this point, I assume that the household sizes are

exogenously determined. Hence, I will concentrate on the economies of scale in this chapter.

4.2. Characterizing Economies of Scale in Household Consumption

Intuitively, economies of scale in consumption means that it takes less consumption expenditure in *per capita* terms for a large household to attain a certain standard of living than a small household. This is because members of the large household can take advantage of scale and share the consumption of household public goods, and can share responsibilities involving household production more easily.[7] Since the flip side of this statement is that *when the scale effect exists,* a member of a larger household with the same level of *per capita* consumption expenditure as a small household achieves a higher standard of living than that of the small household, I define economies of scale in terms of the utility of an adult-equivalent.

Hence the definition: economies of scale exists only if $u_h(C) > u_{h'}(C)$ when $S_h > S_{h'}$, $\forall C > \gamma$, where C is per capita consumption expenditure, S is adult-equivalent household size, γ is the subsistence level, and h and h' are household indexes. This definition can best be seen in Figure 1. The utility of an individual is not only a function

[7] Again, household size here is measured by the number of male-adult equivalents. So a household with two adults and a household with one adult and one baby do not have the same size. Given that much of the scale economies in consumption is generated by scale economies in household production, it is important to make this adjustment.

of the consumption expenditure he or she is allotted, but the size of the household he or she lives in would also play a role in determining the level of his or her utility. This motivates us to use the following utility function to capture the effect of household size,

$$u(C_h(t); S_h(t)) = S_h(t)^{\eta} \frac{C_h(t)^{1-\alpha} - 1}{1-\alpha},$$

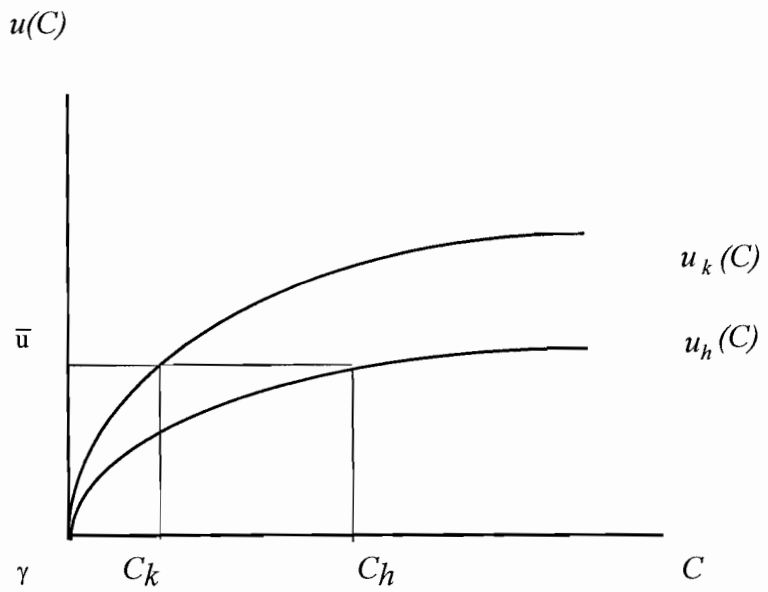

Figure 5 Scale Economies in Household Consumption

where $S_h(t)$ is the size in terms of male-adult-equivalent and $C_h(t)$ is per equivalent consumption of household *h*. If the scale effect exists, then we should have $\eta > 0$. Hence we can test the existence of the scale effect by looking at the sign and magnitude of the estimated η. Further, if we assume that the utility function shifts up less and less

as household size increases, then the following second order condition should be satisfied:

$$\frac{\partial^2 (S_h(t)^{\eta})}{\partial S_h(t)^2} = (\eta - 1)\eta S_h(t)^{\eta-2} < 0$$

which implies $0 < \eta < 1$.

4.3. The Model

4.3.1. *The Social Planner Problem*

The essence of risk sharing test is to test Pareto Optimality in resources allocation under uncertainty. Usually in the consumption literature, the total consumption of a household is modeled as the solution to a utility maximization problem, in which a household is treated as an individual maximizer. But recently researchers have cast doubt on this modeling strategy. For example, Browning *et al* (1994) show that there is empirical evidence against the notion that households behave as if they are maximizing a single criterion. Therefore a household level utility index may not have a utility-theoretic foundation. In terms of risk sharing test, what this means is that the first order condition derived from such models may not guarantee Pareto efficiency. In addition, introducing scale economies in such a model will only complicate the problem further. To get around these problems, it is more desirable to set up a social planner problem so that we know that we are testing Pareto optimality.

Suppose that we have a village social planner that maximizes the weighted life-time expected utility of all the individuals potentially living in this village subject to two constraints as specified in (16) and (17). (16) is just the usual resources constraint. (17) is the subsistence constraint, where A_{it} is the age-sex weights for individual *i* at time *t*, γ is the subsistence consumption for a male adult. What (17) means is that for any individual *i*, the total amount of consumption that is allocated to him or her should cover at least the minimum consumption requirement corresponding to his or her age and sex. In (15) below, *N* is the number of individuals that will ever reside in this village. If some individual *j* is not born yet or has died, or has emigrated, then he or she will be assigned a zero welfare weight and zero age-sex weight by the social planner. A_{it} denotes the age-sex weights for individual *i* at time *t*.

(15) $$max \qquad U = \sum_{i=1}^{N} \lambda^{i} \sum_{t=0}^{T_i} \sum_{e(t)} \beta^{t} \, Pr(e(t)|e(0)) u(C_i(t,e(t)))$$

s.t.

(16) $$\sum_{i=1}^{N} C_i(t,e(t)) \le Y(t,e(t)) \qquad \text{for any t, and e(t)}$$

(17) $$C_i(t,e(t)) \ge A_{i,t}\gamma \qquad \text{for any } t, i, \text{ and e(t)}$$

Now assume

(18) $$u(C_i(t)) = S_h(t)^{\eta} \frac{(C_i(t)/A_{i,t} - \gamma)^{1-\alpha} - 1}{1-\alpha},$$

where C_{it} / A_{it} transforms the individual consumption into male-adult-equivalent terms. The intuition behind this transformation is that individuals may derive *different* levels of utility from a *given* amount of consumption because of their differences in age and sex. Therefore we need it to take into account the effect of these differences in age and sex on the individual utility. In other words, by taking this transformation, the utility of each individual is transformed into the male-adult-equivalent utility.

The static F.O.C. is

$$\lambda^{i} S_{h}(t)^{\eta}(C_{i}(t)/ A_{i,t} - \gamma)^{-\alpha} \frac{\beta^{t} \Pr(e(t)| e(0)}{A_{1,t}} = \mu_{t},$$

or

$$C_i(t) - A_{i,t}\gamma = \lambda_i^{1/\alpha} S_h(t)^{\eta/\alpha} \varphi(t) A_{i,t}^{1-1/\alpha}, \tag{19}$$

where $\varphi(t) = \left[\frac{\mu_t}{\beta^t Pr(e(t)|e(0))} \right]^{-1/\alpha}$.

Assuming equal weights λ_h for individuals in the household *h,* summing (19) over all the individuals in household *h* at each period *t* yields

$$\sum_{i=1}^{N^h(t)} C_i(t) - \gamma \sum_{i=1}^{N^h(t)} A_{i,t} = \lambda^{1/\alpha} S_h(t)^{\eta/\alpha} \varphi(t) \sum_{i=1}^{N^h(t)} A_{i,t}^{1-1/\alpha} \tag{20}$$

where $N^h(t)$ is the number of individuals in this household. Note that $S_h(t) = \sum_{i=1}^{N^h(t)} A_{i,t}$

Let

$$C^h(t) = \sum_{i}^{N^h(t)} C_i(t) \quad ,$$

$$\phi(t+1) = \varphi(t+1) / \varphi(t).$$

The intertemporal F.O.C. is

$$(21) \qquad \frac{C^h(t+1) - \gamma S_h(t+1)}{C^h(t) - \gamma S_h(t)} = \left[\frac{S_h(t+1)}{S_h(t)}\right]^{\eta/\alpha} \frac{\sum_{i=1}^{N^h(t+1)} A_{i,t+1}^{1-1/\alpha}}{\sum_{i=1}^{N^h(t)} A_{i,t}^{1-1/\alpha}} \phi(t+1),$$

which re-arranging becomes

$$(22) \qquad \frac{C^{h,*}(t+1) - \gamma}{C^{h,*}(t) - \gamma} = \left[\frac{S_h(t+1)}{S_h(t)}\right]^{\eta/\alpha - 1} \frac{\sum_{i=1}^{N^h(t+1)} A_{i,t+1}^{1-1/\alpha}}{\sum_{i=1}^{N^h(t)} A_{i,t}^{1-1/\alpha}} \phi(t+1),$$

where $C^{h,*}$ is per male-adult equivalent consumption in household *h*.

Hence in the presence of scale economies, (22) is the relationship between the growth rates of consumption net of subsistence level and household size when full risk sharing is achieved. The household size growth rate, sometimes seen as an "idiosyncratic shock", is present now as an equilibrium feature.

4.4 The Empirical Results

The estimation and the test of the model can be done by following the same procedure outlined in Section 3 of Chapter 2. The main problem is that now we have an additional parameter α in the first order condition. It appears that we can estimate it along with other parameters since we do have enough moment conditions. But this is misleading, since what α controls is the risk aversion coefficient in this model. Without the asset returns term in the econometric model, α just can not be identified from the data.[8] Therefore we have to pursue another approach, i.e. to plug different values for α into (22), and then carry out the estimation and tests. The values that I select are 2 and 4.79. The first choice is standard. The second one comes from Atkeson and Ogaki (1996)'s result for food consumption based on ICRISAT-India data.

Since the model in Chapter 2 amounts to assuming that there is no scale economies in household consumption, and the results in Chapter 3 is based on such an assumption, I first restrict η to be zero and see if the earlier results would survive. Compared with equation (5) in Chapter 2, equation (22) has two additional terms on the right hand side. Obviously, if the changes in household size and age-sex structure are not very large over the time for most households, then (5) is a good approximation of (22). Therefore the results based on (22) can be expected to be in line with those based on (5).

[8] Indeed when I try estimating it together with other parameters, no convergence was obtained.

Tables 13 to 16 report the tests results based on (22) for α=2. Results based on α=4.79 are in Tables 17 to 20. The two sets of results are identical to each other. For districts Attock and Badin, the point estimates of γ are positive and significant, and therefore still support the decreasing RRA hypothesis. Village level risk sharing is not rejected for either district. Across-village full risk sharing is strongly rejected; variable addition test yields almost the same results as in Chapter 3: it still picks out Village 22 for incomplete risk sharing, although now Village 25 is also found to belong to that group. Restricting γ to be zero replicates the rejection of full risk sharing at the village level, just as in Chapter 3. For Dir, the γ estimate is again negative but insignificant. However, the results for Faisalabad (a negative and significant estimate of γ) now turn into favoring increasing RRA hypothesis, although other tests for this district generate similar results to those in Chapter 3. The negative estimate of γ is a little bit puzzling here, and awaits further research.

I also tried to estimate η along with other parameters to see if this would help solve the puzzle. For the case of α =2, estimated η =.1865 with a standard error of .0648. For the case of α=4.79, it becomes .0139 with a standard error of .0718. Both γ estimates are still negative and significant. So the problem is not with the restriction of η=0. Some of the η estimates for other districts are also not very sensible in the sense that they change dramatically when using different values of . There might be an identification problem here. For example, if consumption does not change much from this year to next, and household size happens not to change much so that the right hand

side of (22) is close to 1, then a large negative γ coupled with any value of η could make (22) hold.

The major modeling difference between the model here and those in the literature on scale economies is that they are based on static first order condition of the household utility maximization problem. Their results are obtained by looking into a cross section of households. But my model is based on the intertemporal first order condition since I am testing risk sharing, and the results are obtained by focusing on the size change of the same households over the time. Hence, the precision of my estimates is likely to be lower than that of the estimates obtained from a cross section of households, for the variation of household sizes there is much larger.

However, no matter what the value η estimate takes, the testing results always remain the same as those in Chapter 3 for each district. Therefore, judged by this token, the model that handled demographics in a simplistic way, presented in Chapter 2, has survived. The results reported in the last chapter are thus well established.

CHAPTER 5

CONCLUSIONS

In this paper, I have tested full risk sharing hypothesis while taking into account the effect of estimating a parameter which allows the RRA coefficient to vary with the level of wealth. Strong evidence of decreasing RRA has been found. For 29 out of 31 villages in the Pakistani data and every village in the Indian data, I do not reject the hypothesis of full risk sharing within each village. Townsend (1995) finds that different villages in low-income countries have strikingly different institutional arrangements to cope with risk. Hence, it is not surprising that evidence against full risk sharing for two villages was found while I do not find such evidence for others.

I, however, find strong evidence against risk sharing across villages in both data sets. Because it is more difficult to cope with the private information problem across villages, this result is also very sensible.

When I restrict "subsistence consumption" parameter to be zero (which implies CRRA), my tests replicate the well-known results of rejecting the full risk sharing hypothesis even within villages in both datasets, except for one district, Dir, in the Pakistani data. However, except for this district, these tests always reject the restriction

of $\gamma = 0$ in both datasets. Thus, these test results show that misleading results may be obtained when decreasing RRA is ignored in testing full risk sharing hypothesis. In the empirical risk sharing literature, isoelastic, quadratic and exponential utility functions are often used. Because these utility functions imply either CRRA or increasing RRA, the test results based on these preference specifications need to be interpreted with caution.

Moreover, the tests based on the scale economies model (with the restriction of no scale effect) yield very similar results to those based on the simple model, although the results for one district (Faisalabad) appears to be an "anomaly".

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APPENDIX 1 TABLES

1. IFPRI-Pakistan

District Average

Year	Faisalabad	Attock	Badin	Dir	Whole Sample Average
1986-87	2849	3545	2184	2841	2820
1987-88	2900	3108	1973	3519	2822
1988-89	2142	2293	2017	2806	2296
1986-89	2630	2982	2058	3055	2646

Village Average

	N	1986-87	1987-88	1988-89	1986-89
Faisalabad					
Vil. 1	25	3572	2908	2212	2897
Vil. 2	26	2212	2113	1857	2061
Vil. 3	25	2866	3572	2155	2864
Vil. 4	20	2779	3151	2362	2764
Vil. 5	25	2661	2908	2116	2562
Vil. 6	26	3010	2833	2200	2681
Attock					
Vil. 7	18	3591	4113	2409	3371
Vil. 8	21	3628	3193	2210	3010
Vil. 9	16	3990	2990	2327	3102
Vil. 10	20	3632	3476	2470	3193
Vil. 11	23	3102	3000	2157	2753
Vil. 12	19	3615	2389	2024	2676
Vil. 13	20	3131	2824	2242	2732

Table 1: Per Male-adult Equivalent Food Consumption

Table 1, continued

Vil. 14	16	3898	2889	2596	3128
Badin					
Vil. 21	17	2131	2390	2285	2269
Vil. 22	19	2414	2018	1950	2127
Vil. 23	18	1793	1720	1875	1796
Vil. 24	14	1807	1743	1801	1786
Vil. 25	15	2159	2073	1914	2049
Vil. 26	13	2755	2322	2064	2380
Vil. 29	23	2439	2070	2154	2221
Vil. 30	21	2103	1699	1966	1922
Vil. 34	12	2359	1891	2119	2123
Vil. 37	22	1896	1829	1941	1888
Vil. 39	12	2340	2095	2155	2197
Dir					
Vil. 41	40	2878	3447	3152	3159
Vil. 42	12	2624	3359	2807	2930
Vil. 45	27	2706	3231	2386	2774
Vil. 47	32	2842	3804	2836	3161
Vil. 48	13	3145	3853	3043	3347
Vil. 51	23	2872	3481	2518	2957

2. ICRISAT-India

	N	1976	1977	1978	1979	1980	1981	1982	1983	1984	1976-84
Aurepalle	35	313	381	408	538	502	423	414	409	526	423
Shirapur	33	604	555	644	543	623	521	388	351	351	528
Kanzara	36	490	489	418	578	571	479	418	578	571	363

Notes: 1. The figures here are in 1986 Pakistani Rupee (when 1 Rupee =US$.063), and 1975 Indian Rupee, respectively.
2. *N* indicates the number of households in the sample in each village.

District Average

Year	Faisalabad	Attock	Badin	Dir	Average
1986-87	5974	4382	3987	5403	4873
1987-88	5713	3378	4938	5803	4942
1988-89	5781	3394	4671	4526	4586
1986-89	5822	3718	4532	5244	4800

Village Average

		1986-87	1987-88	1988-89	1986-89
Faisalabad					
Vil.	1	4184	4075	4188	4149
Vil.	2	4645	4558	3464	4222
Vil.	3	2955	4548	3903	3802
Vil.	4	7816	6565	5495	6626
Vil.	5	7817	6149	10718	8228
Vil.	6	8739	8490	6906	8045
Attock					
Vil.	7	3992	4744	2998	3911
Vil.	8	4995	3972	2861	3943
Vil.	9	5969	3066	6416	5151
Vil.	10	5597	5065	4943	5202
Vil.	11	3154	2437	2355	2649
Vil.	12	2545	2292	2481	2439
Vil.	13	2999	2680	2352	2677
Vil.	14	4858	2289	2437	3195
Badin					
Vil.	21	4499	4508	4266	4424
Vil.	22	4283	5027	4668	4659
Vil.	23	2730	3225	3298	3084
Vil.	24	3453	3352	2915	3240
Vil.	25	4007	6854	7271	6044
Vil.	26	4837	8792	5234	6288
Vil.	29	4712	4748	5420	4960
Vil.	30	3913	3831	4027	3923
Vil.	34	4368	5783	4544	4898

Table 2: Per Male-adult Equivalent Income

Table 2, continued

Vil.	37	2417	3879	4048	3448
Vil.	39	5599	6657	6453	6236
Dir					
Vil.	41	4378	5698	4694	4924
Vil.	42	4275	5857	3992	4708
Vil.	45	3478	3918	3411	3602
Vil.	47	7372	5630	4636	5879
Vil.	48	8761	9216	4516	7498
Vil.	51	5398	6482	5672	5851

Notes : 1. The figures here are in Pakistani Rupee.
2. In 1986, 1 Rupee=US$.063.

District Average

Year	Faisalabad	Attock	Badin	Dir
1986-87	5.9	5.3	6.0	7.6
1987-88	6.1	5.2	6.1	7.5
1988-89	6.0	5.2	6.3	7.2

Village Average

	1986-87	1987-88	1988-89
Faisalabad			
Vil. 1	6.5	6.7	6.4
Vil. 2	6.0	6.2	6.2
Vil. 3	5.2	5.2	5.4
Vil. 4	5.9	6.3	6.3
Vil. 5	6.4	6.6	6.4
Vil. 6	5.6	5.6	5.6
Attock			
Vil. 7	4.9	4.7	5.0
Vil. 8	5.1	4.9	4.8
Vil. 9	5.6	5.6	5.8
Vil. 10	5.7	5.6	5.5
Vil. 11	5.4	5.4	5.5
Vil. 12	5.5	5.2	5.2
Vil. 13	5.7	5.8	5.8
Vil. 14	4.4	4.2	4.2
Badin			
Vil. 21	4.6	4.6	4.6
Vil. 22	5.7	6.0	6.1
Vil. 23	7.7	8.0	8.2
Vil. 24	6.8	7.1	7.4
Vil. 25	6.2	6.4	6.6
Vil. 26	5.7	5.9	6.1

Table 3: Male-adult Equivalent Household Size

Table 3, continued

Vil. 29	6.9	6.8	7.1
Vil. 30	6.0	6.1	6.3
Vil. 34	5.0	4.9	4.9
Vil. 37	5.9	5.8	5.8
Vil. 39	5.2	5.1	5.0
Dir			
Vil. 41	7.5	7.1	6.9
Vil. 42	10.0	10.0	9.7
Vil. 45	6.9	7.3	7.3
Vil. 47	7.2	7.2	6.8
Vil. 48	7.0	7.1	6.9
Vil. 51	8.1	8.0	7.4

Age (Year)	Male	Female
≥19	1	.9
13 to 18	0.94	.83
7 to 12	.67	.67
4 to 6	.52	.52
1-3	.32	.32
0 to 1	.05	.05

Sources: Ryan, Bidinger, Pushpamma, and Rao (1985)

Table 4: The Male-Adult Equivalence Scale

Risk Sharing	γ	coeff. $\Delta y_1(t+1)$ **	coeff. $\Delta y_2(t+1)$	coeff. $\Delta y_3(t+1)$	coeff. $\Delta y_4(t+1)$	coeff. $\Delta y_5(t+1)$	coeff. $\Delta y_6(t+1)$	*J* ***	*C* ***
Within	1511*	...	...	...	...	...	...	25.7	...
Vil.	(124)							(.316,23)	
Across	1447	...	...	...	...	...	...	115.2	89.55
Vil.	(80)							(.000,33)	(.000,10)
Within	1474	.1659	.0012	.0361	-.0168	.0013	-.0046	19.7	5.95
Vil.	(146)	(.0797)	(.0190)	(.0316)	(.0504)	(.0153)	(.0108)	(.289,17)	(.429,6)
Within	...****	...	...	...	...	...	...	19.7	7.73
Vil.								(.459,18)	(.172,5)
Within	0	...	...	...	...	...	...	71.3	45.6
Vil.								(.000,24)	(.000,1)
Within	0	.2808	.0273	.0134	-.0626	-.0053	.0002	49.2	22.1
Vil.		(.0699)	(.0139)	(.0308)	(.0486)	(.0106)	(.0105)	(.000,18)	(.001,6)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the *J* and *C* statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 1 for Vil. 1.

***: *J* is a χ^2 statistic, and *C* is a likelihood ratio type statistic.

****: The subsistence estimates for Villages 1 to 6 are (with standard errors in parenthesis) as follows: 1851 (215), 1467 (240), 1131 (803), 1326 (335), 1738 (206), -512 (2411), respectively.

Table 5: GMM Results for Food Consumption- Faisalabad, Pakistan

Risk Sharig	γ	coeff. $\Delta y_7(t+1)$ **	coeff. $\Delta y_8(t+1)$	coeff. $\Delta y_9(t+1)$	coeff. $\Delta y_{10}(t+1)$	coeff. $\Delta y_{11}(t+1)$	coeff. $\Delta y_{12}(t+1)$	coeff. $\Delta y_{13}(t+1)$	coeff. $\Delta y_{14}(t+1)$	J ***	C ***
Within Vil.	1867* (117)	...	...	...	...	...	...	...	...	37.8 (.187,31)	...
Across Vil.	1820 (77)	...	...	...	...	...	...	...	...	556.9 (.000,45)	519.1 (.000,14)
Within Vil.	1749 (148)	.0214 (.0423)	.0013 (.0284)	.0785 (.0472)	-.0304 (.0163)	.0221 (.0606)	.0257 (.0211)	-.0618 (.0501)	.0079 (.0203)	28.1 (.212,23)	9.7 (.290,8)
Within Vil.	...****	...	...	...	...	...	...	...	...	24.4 (.441,24)	13.4 (.063,7)
Within Vil.	0	...	...	...	...	...	...	...	...	122.0 (.000,32)	82.2 (.000,1)
Within Vil.	0	.0525 (.0397)	.0437 (.0184)	.0151 (.0161)	-.0573 (.0135)	.0199 (.0640)	.0509 (.0171)	-.0736 (.0557)	.0387 (.0140)	57.8 (.000,24)	64.2 (.000,8)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the J and C statistics, where the numbers in parenthesis are p-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 7 for Vil. 7.

***: J is a χ^2 statistic, and C is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 7 to 14 are (with standard errors in parenthesis): 1998 (294), 1978 (172), -1445 (2175), 1936 (347), 1532 (607), 2018 (259), 1.9e+5 (1.9e+7), 2256 (265), respectively.

Table 6: GMM Results for Food Consumption- Attock, Pakistan

Risk Sharig	γ	coeff. $\Delta y_{21(t+1)}$ **	coeff. $\Delta y_{22(t+1)}$	coeff. $\Delta y_{23(t+1)}$	coeff. $\Delta y_{24(t+1)}$	coeff. $\Delta y_{25(t+1)}$	coeff. $\Delta y_{26(t+1)}$	coeff. $\Delta y_{29(t+1)}$	coeff. $\Delta y_{30(t+1)}$	coeff. $\Delta y_{34(t+1)}$	coeff. $\Delta y_{37(t+1)}$	coeff. $\Delta y_{39(t+1)}$	*J* ***	*C* ***
Within Vil.	1441* (84)	…	…	…	…	…	…	…	…	…	…	…	44.2 (.420,43)	…
Across Vil.	1701 (48)	…	…	…	…	…	…	…	…	…	…	…	326.0 (.000,63)	282.2 (.000,20)
Within Vil.	1434 (100)	.046 (.038)	.110 (.050)	-.047 (.046)	.002 (.067)	.019 (.012)	.015 (.022)	.005 (.013)	.025 (.036)	.044 (.034)	.046 (.036)	.029 (.032)	28.8 (.630,32)	15.4 (.165,11)
Within Vil.	…****	…	…	…	…	…	…	…	…	…	…	…	29.4 (.647,33)	14.8 (.140,10)
Within Vil.	0	…	…	…	…	…	…	…	…	…	…	…	92.9 (.000,44)	48.7 (.000,1)
Within Vil.	0	.040 (.038)	.124 (.052)	-.079 (.042)	.041 (.066)	.027 (.013)	.051 (.011)	-.010 (.012)	.047 (.036)	.033 (.028)	.040 (.035)	-.005 (.020)	50.4 (.000,33)	42.5 (.000,11)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J*** and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 21 for Vil. 21, an so on.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 21 to 39 are (with standard errors in parenthesis): 1627 (385), 2018 (74), 1625 (147), 1760 (86), 1850 (18), 1254 (138), 1453 (334), 1405 (174), 2082 (221), 7172 (2e+5), 1768 (355), respectively.

Table 7: GMM Results for Food Consumption- Badin, Pakistan

Risk Sharing	γ	coeff. $\Delta y_{41}(t+1)$ **	coeff. $\Delta y_{42}(t+1)$	coeff. $\Delta y_{45}(t+1)$	coeff. $\Delta y_{47}(t+1)$	coeff. $\Delta y_{48}(t+1)$	coeff. $\Delta y_{51}(t+1)$	*J* ***	*C* ***
Within Vil.	-207* (905)	…	…	…	…	…	…	19.8 (.652,23)	…
Across Vil.	976 (387)	…	…	…	…	…	…	58.3 (.004,33)	38.48 (.000,10)
Within Vil.	-317 (1555)	.0387 (.0340)	.0019 (.0324)	-.0003 (.0110)	.0024 (.0064)	-.0055 (.0202)	.0235 (.0261)	15.2 (.570,17)	4.62 (.593,6)
Within Vil.	…****	…	…	…	…	…	…		
Within Vil.	0	…	…	…	…	…	…	19.9 (.703,24)	.06 (.806,1)
Within Vil.	0	.0380 (.0339)	.0035 (.0318)	.0008 (.0098)	.0022 (.0063)	-.0088 (.0139)	.0018 (.0186)	17.2 (.511,18)	2.7 (.845,6)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J*** and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 41 for Vil. 41.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

****: No convergence achieved for this case.

Table 8: GMM Results for Food Consumption- Dir, Pakistan

Risk Sharig	γ_F *	γ_A	γ_B	γ_D	coeff. $\Delta y_F(t+1)$ *	coeff. $\Delta y_A(t+1)$	coeff. $\Delta y_B(t+1)$	coeff. $\Delta y_D(t+1)$	***J*** ***	***C*** ***
Within Vil.	1812 (27)**	1812	1812	1812	…	…	…	…	146.2 (.076,123)	…
Across Dist.	1767 (29)	1767	1767	1767	…	…	…	…	1093.2 (.000,177)	947.1 (.000,54)
Within Vil.	1787 (27)	1787	1787	1787	.0010 (.0077)	.0007 (.0087)	.0135 (.0048)	.0054 (.0060)	138.0 (.112,119)	8.2 (.086,4)
Within Vil.	1639 (105)	1824 (119)	1851 (28)	1103 (468)	…	…	…	…	137.7 (.129,120)	8.5 (.037,3)
Within Vil.	0	0	0	0	…	…	…	…	406.7 (.000,124)	260.6 (.000,1)
Within Vil.	0	0	0	0	.0092 (.0059)	.0155 (.0070)	.0160 (.0049)	.0047 (.0058)	388.0 (.000,120)	18.7 (.001,4)

*: Subscripts *F*, *A*, *B*, and *D* are for Faisalabad, Attock, Badin, and Dir, respectively.

: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J* and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

Table 9: GMM Results for Food Consumption- The Whole Sample, Pakistan

Risk Sharing	γ_A*	γ_S	γ_K	coeff. $\Delta y_A(t+1)$*	coeff. $\Delta y_S(t+1)$	coeff. $\Delta y_K(t+1)$	***J*****	***C*****
Within Vil.	237.3** (15.2)	237.3	237.3	…	…	...	46.2 (.507, 47)	…
Across Vil.	269.7 (14.0)	269.7	269.7	…	…	…	1239.4 (.000, 63)	1193.2 (.000, 16)
Within Vil.	238.4 (16.1)	238.4	238.4	.024 (.013)	.011 (.011)	.005 (.016)	41.3 (.589, 44)	4.9 (.181, 3)
Within Vil.	237.9 (21.4)	233.1 (30.3)	240.5 (30.6)	…	…	…	46.1 (.425, 45)	.0 (.985, 2)
Within Vil.	0	0	0	…	…	…	114.5 (.000, 48)	68.3 (.000, 1)
Within Vil.	0	0	0	.012 (.011)	.033 (.010)	.012 (.016)	102.3 (.000, 45)	12.2 (.007, 3)

*: Subscripts *A, S,* and *K* denote Aurepalle, Shirapur, and Kanzara, respectively.

: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J* and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

Table 10: GMM Results for Food Consumption-India

Risk Sharing	γ_A	γ_S	γ_K	coeff. $\Delta y_A(t+1)$	coeff. $\Delta y_S(t+1)$	coeff. $\Delta y_K(t+1)$	J^{**}	C^{**}
Within Village	485.1* (13.5)	485.1	485.1	…	…	…	36.2 (.168, 29)	…
Across Village	595.9 (34.1)	595.9	595.9	…	…	…	174.2 (.000, 39)	138.0 (.000, 10)
Within Village	466.4 (18.9)	466.4	466.4	.076 (.036)	.072 (.051)	-.003 (.048)	30.3 (.255, 26)	5.1 (.165, 3)
Within Village	481.7 (14.2)	513.5 (30.3)	548.9 (30.6)	…	…	…	35.3 (.132, 27)	.9 (.638, 2)
Within Village	0	0	0	…	…	…	71.5 (.000, 30)	35.3 (.000, 1)
Within Village	0	0	0	.008 (.031)	.026 (.043)	-.084 (.038)	66.2 (.000, 27)	5.3 (.151, 3)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the J and C statistics, where the numbers in parenthesis are p-value and degree of freedom, respectively.

**: J is a χ^2 statistic, and C is a likelihood ratio type statistic.

Table 11: GMM Results for Total Consumption-India

Risk Sharing	γ	η	coeff. $\Delta y_1(t+1)$ **	coeff. $\Delta y_2(t+1)$	coeff. $\Delta y_3(t+1)$	coeff. $\Delta y_4(t+1)$	coeff. $\Delta y_5(t+1)$	coeff. $\Delta y_6(t+1)$	J ***	C ***
Within	-4264*	0	…	…	…	…	…	…	26.0	…
Vil.	(729)								(.303,23)	
Across	-4218	0	…	…	…	…	…	…	102.0	76.0
Vil.	(351)								(.000,33)	(.000,10)
Within	-15001	0	.1297	.0142	-.0044	- .0384	.0016	-.0011	19.3	6.7
Vil.	(3286)		(.0598)	(.0297)	(.0456)	(.0430)	(.0033)	(.0179)	(.310,17)	(.349,6)
Within	***	0							19.2	6.8
Vil.									(.379,18)	(.236,5)
Within	0	0	…	…	…	…	…	…	59.1	33.1
Vil.									(.000,24)	(.000,1)
Within	0	0	.1494	.0110	.0348	-.0021	.0138	.0011	16.8	42.3
Vil.			(.0670)	(.0279)	(.0446)	(.0423)	(.0023)	(.0172)	(.539,18)	(.000,6)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the J and C statistics, where the numbers in parenthesis are p-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 1 for Vil. 1.

***: J is a χ^2 statistic, and C is a likelihood ratio type statistic.

****: The subsistence estimates for Villages 1 to 6 are (with standard errors in parenthesis) as follows: -21335 (11438), 746 (1901), -1213 (2703), -58 (2076), -4564 (756), 92 (1723), respectively.

Table 12: Results of the Scale Economies Model with alfa=2- Faisalabad, Pakistan

Risk Sharig	γ	η	coeff. $\Delta y_{7}^{**}(t+1)$	coeff. $\Delta y_{8}(t+1)$	coeff. $\Delta y_{9}(t+1)$	coeff. $\Delta y_{10}(t+1)$	coeff. $\Delta y_{11}(t+1)$	coeff. $\Delta y_{12}(t+1)$	coeff. $\Delta y_{13}(t+1)$	coeff. $\Delta y_{14}(t+1)$	***J*** ***	***C*** ***
Within Vil.	1867 (118)	0	…	…	…	…	…	…	…	…	37.8 (.194,31)	…
Across Vil.	1735 (83)	0	…	…	…	…	…	…	…	…	468.1 (.000,45)	430.3 (.000,14)
Within Vil.	1737 (159)	0	.0126 (.0398)	.0200 (.0310)	.0724 (.0466)	-.0309 (.0160)	.0191 (.0586)	.0241 (.0206)	-.0080 (.0481)	.0086 (.0202)	29.7 (.157,23)	8.1 (.424,8)
Within Vil.	***	0	…	…	…	…	…	…	…	…	25.3 (.391,24)	12.5 (.085,7)
Within Vil.	0	0	…	…	…	…	…	…	…	…	115.3 (.000,32)	77.5 (.000,1)
Within Vil.	0	0	.0240 (.0428)	.845 (.0277)	.0128 (.0231)	-.0568 (.0146)	.0224 (.0617)	.0496 (.0187)	.0020 (.0564)	.0333 (.0303)	63.9 (.000,24)	26.1 (.001,8)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J*** and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 7 for Vil. 7.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 7 to 14 are (with standard errors in parenthesis): 2016 (292), 1978 (178), -957 (1750), 1946 (346), 1448 (737), 1999 (267), 488 (2161), 2314 (242), respectively.

Table 13: Results of the Scale Economies Model with alfa=2- Faisalabad, Pakistan

Risk Sharig	γ	η	coeff. $\Delta y_{21(t+1)}$ **	coeff. $\Delta y_{22(t+1)}$	coeff. $\Delta y_{23(t+1)}$	coeff. $\Delta y_{24(t+1)}$	coeff. $\Delta y_{25(t+1)}$	coeff. $\Delta y_{26(t+1)}$	coeff. $\Delta y_{29(t+1)}$	coeff. $\Delta y_{30(t+1)}$	coeff. $\Delta y_{33(t+1)}$	coeff. $\Delta y_{37(t+1)}$	coeff. $\Delta y_{39(t+1)}$	*J* ***	*C* ***
Within Vil.	1343* (97)	0	...	...	...	...	...	...	...	...	...	...	...	42.3 (.502,43)	...
Across Vil.	1711 (52)	0	...	...	...	...	...	...	...	...	...	...	...	276.3 (.000,63)	234.0 (.000,20)
Within Vil.	1314 (132)	0	.043 (.034)	.114 (.048)	-.060 (.051)	-.006 (.075)	.021 (.009)	.006 (.017)	.007 (.025)	.017 (.034)	.044 (.052)	.042 (.038)	.024 (.039)	26.7 (.730,32)	15.6 (.,11)
Within Vil.	****	0	...	...	...	...	...	...	...	...	...	...	...	25.9 (.807,33)	16.4 (.089,10)
Within Vil.	0	0	...	...	...	...	...	...	...	...	...	...	...	88.6 (.000,44)	46.3 (.000,1)
Within Vil.	0	0	.031 (.034)	.127 (.050)	-.080 (.042)	-.001 (.066)	.028 (.011)	.040 (.012)	-.001 (.025)	.025 (.034)	.037 (.049)	.038 (.033)	-.012 (.030)	41.2 (.154,33)	47.4 (.000,11)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J*** and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 21 for Vil. 21, an so on.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 21 to 39 are (with standard errors in parenthesis): -4516 (3457), 2017 (72), 1618 (120), 1761 (21), 1850 (87), 1233 (127), 1354 (466), 1291 (276), 2066 (249), 819 (4224), 1361 (944), respectively.

Table 14: Results for Scale Economies Model with alfa=2- Badin, Pakistan

Risk Sharing	γ	η	coeff. $\Delta y_{41}(t+1)$	coeff. $\Delta y_{42}(t+1)$	coeff. $\Delta y_{45}(t+1)$	coeff. $\Delta y_{47}(t+1)$	coeff. $\Delta y_{48}(t+1)$	coeff. $\Delta y_{51}(t+1)$	J **	C **
Within Vil.	-292 (967)	0	…	…	…	…	…	…	19.9 (.650,23)	...
Across Vil.	946 (399)	0	…	…	…	…	…	…	78.7 (.000,33)	58.8 (.000,10)
Within Vil.	-718 (1458)	0	.066 (.0267)	.006 (.0337)	-.010 (.0219)	.001 (.0069)	-.010 (.0296)	.022 (.0185)	14.9 (.603,17)	5.0 (.544,6)
Within Vil.	***	0	…	…	…	…	…	…	17.4 (.496,18)	2.5 (.776,5)
Within Vil.	0	0	…	…	…	…	…	…	20.5 (.667,24)	.6 (.439,1)
Within Vil.	0	0	.063 (.051)	.010 (.031)	-.006 (.015)	.001 (.007)	-.015 (.015)	.020 (.018)	15.2 (.648,18)	4.7 (.583,6)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the J and C statistics, where the numbers in parenthesis are p-value and degree of freedom, respectively.

**: J is a χ^2 statistic, and C is a likelihood ratio type statistic.

***: The estimates of gamms for Vil. 41 to Vil. 51 are: 410 (2537), -4887 (7314), 556 (1276), 378 (1991), -7117 (5466), and 1267 (913), respectively.

Table 15: Results for Scale Economies Model with alfa=2- Dir, Pakistan

Risk Sharing	γ	η	coeff. $\Delta y_1(t+1)$ **	coeff. $\Delta y_2(t+1)$	coeff. $\Delta y_3(t+1)$	coeff. $\Delta y_4(t+1)$	coeff. $\Delta y_5(t+1)$	coeff. $\Delta y_6(t+1)$	*J****	*C****
Within	-16553*	0	…	…	…	…	…	…	25.3	…
Vil.	(1796)								(.337,23)	
Across	-16111	0	…	…	…	…	…	…	79.0	53.7
Vil.	(990)								(.000,33)	(.000,10)
Within	-15001	0	.130	.014	-.004	-.038	.002	-.001	19.3	6.0
Vil.	(3286)		(.060)	(.030)	(.046)	(.043)	(.003)	(.018)	(.310,17)	(.423,6)
Within	****	0							17.3	8.0
Vil.									(.502,18)	(.156,5)
Within	0	0	…	…	…	…	…	…	92.3	67.0
Vil.									(.000,24)	(.000,1)
Within	0	0	.161	.012	.041	.015	.015	.003	25.4	66.9
Vil.			(.060)	(.030)	(.046)	(.039)	(.002)	(.018)	(.115,18)	(.000,5)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the ***J*** and ***C*** statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 1 for Vil. 1.

: ***J is a χ^2 statistic, and ***C*** is a likelihood ratio type statistic.

****: The subsistence estimates for Villages 1 to 6 are (with standard errors in parenthesis) as follows: -49024 (16722), 495 (2604), -3420 (7314), -3041 (7409), -16849 (1840), -7 (2392), respectively.

Table 16: Results of the Scale Economies Model with alfa=4.79- Faisalabad, Pakista

Risk Sharig	γ	η	coeff. $\Delta y_7(t+1)$ **	coeff. $\Delta y_8(t+1)$	coeff. $\Delta y_9(t+1)$	coeff. $\Delta y_{10}(t+1)$	coeff. $\Delta y_{11}(t+1)$	coeff. $\Delta y_{12}(t+1)$	coeff. $\Delta y_{13}(t+1)$	coeff. $\Delta y_{14}(t+1)$	*J* ***	*C* ***
Within Vil.	1866 (117)	0	...	...	...	...	...	...	...	...	37.7 (.190,31)	...
Across Vil.	1788 (79)	0	...	...	...	...	...	...	...	...	521.6 (.000,45)	483.9 (.000,14)
Within Vil.	1745 (152)	0	.018 (.041)	.016 (.030)	.076 (.047)	-.031 (.016)	.021 (.060)	.025 (.021)	-.043 (.050)	.08 (.020)	28.9 (.184,23)	8.8 (.359,8)
Within Vil.	***	0	...	...	...	...	...	...	...	...	24.9 (.411,24)	12.8 (.077,7)
Within Vil.	0	0	...	...	...	...	...	...	...	...	119.0 (.000,32)	81.3 (.000,1)
Within Vil.	0	0	.038 (.040)	.081 (.018)	.015 (.022)	-.058 (.014)	.020 (.060)	.051 (.018)	-.043 (.050)	.034 (.014)	66.8 (.000,24)	52.2 (.000,8)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the *J* and *C* statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 7 for Vil. 7.

***: *J* is a χ^2 statistic, and *C* is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 7 to 14 are (with standard errors in parenthesis): 2002 (295), 1973 (174), -1238 (1974), 1944 (345), 1502 (651), 2010 (263), -541 (4289), 2280 (254), respectively.

Table 17: Results of Scale Economies Model with alfa=4.79- Attock, Pakistan

Risk Sharig	γ	η	coeff. $\Delta y_{21(t+1)}$ **	coeff. $\Delta y_{22(t+1)}$	coeff. $\Delta y_{23(t+1)}$	coeff. $\Delta y_{24(t+1)}$	coeff. $\Delta y_{25(t+1)}$	coeff. $\Delta y_{26(t+1)}$	coeff. $\Delta y_{29(t+1)}$	coeff. $\Delta y_{30(t+1)}$	coeff. $\Delta y_{34(t+1)}$	coeff. $\Delta y_{37(t+1)}$	coeff. $\Delta y_{39(t+1)}$	*J* ***	*C* ***
Within			...	...	...	...	...	...	...	...	...	...	...	43.8	...
	1409	0													
Vil.	(89)													(.437,43)	
Across	1709	0	...	...	...	...	...	...	...	...	...	...	...	307.5	263.7
Vil.	(50)													(.000,63)	(.000,20)
Within	1392	0	.046	.112	-.051	.000	.020	.011	.006	.023	.045	.044	.026	28.4	15.4
Vil.	(109)		(.038)	(.050)	(.045)	(.066)	(.012)	(.021)	(.013)	(.036)	(.034)	(.035)	(.032)	(.649,32)	(.165,11)
Within	****	0	...	...	...	...	...	...	...	...	...	...	...	25.9	17.9
Vil.														(.807,33)	(.057,10)
Within	0	0	...	...	...	...	...	...	...	...	...	...	...	89.5	45.7
Vil.														(.000,44)	(.000,1)
Within	0	0	.040	.125	-.083	.026	.028	.047	-.006	.039	.036	.040	-.010	47.4	42.1
Vil.			(.039)	(.052)	(.042)	(.066)	(.013)	(.010)	(.012)	(.035)	(.029)	(.034)	(.022)	(.049,33)	(.00,11)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the *J* and *C* statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: The subscript of income difference term denotes village identification number, i.e., 21 for Vil. 21, an so on.

***: *J* is a χ^2 statistic, and *C* is a likelihood ratio type statistic.

****: The subsistence level estimates for Villages 21 to 39 are (with standard errors in parenthesis): -4516 (3457), 2017 (72), 1618 (120), 1761 (21), 1850 (87), 1233 (127), 1354 (466), 1291 (276), 2066 (249), 819 (4224), 1361 (944), respectively.

Table 18: Results for Scale Economies Model with alfa=4.79- Badin, Pakistan

Risk Sharing	γ	η	coeff. $\Delta y_{41}(t+1)$	coeff. $\Delta y_{42}(t+1)$	coeff. $\Delta y_{45}(t+1)$	coeff. $\Delta y_{47}(t+1)$	coeff. $\Delta y_{48}(t+1)$	coeff. $\Delta y_{51}(t+1)$	*J* **	*C* **
Within Vil.	-201 (895)	0	...	...	...	...	...	...	19.3 (.684,23)	...
Across Vil.	1033 (341)	0	...	...	...	...	...	...	75.3 (.000,33)	56.0 (.000,10)
Within Vil.	-516 (1522)	0	.048 (.036)	.002 (.032)	-.004 (.013)	.002 (.007)	-.004 (.018)	.020 (.019)	16.0 (.524,17)	3.3 (.770,6)
Within Vil.	***	0	...	...	...	...	...	...	17.4 (.497,18)	1.9 (.863,5)
Within Vil.	0	0	...	...	...	...	...	...	19.3 (.734,24)	.053 (.817,1)
Within Vil.	0	0	.039 (.027)	.026 (.035)	-.005 (.023)	-.001 (.007)	-.055 (.023)	.015 (.021)	16.1 (.583,18)	3.2 (.783,6)

*: Standard errors are in parenthesis under the estimates, except for the two columns for the *J* and *C* statistics, where the numbers in parenthesis are *p*-value and degree of freedom, respectively.

**: *J* is a χ^2 statistic, and *C* is a likelihood ratio type statistic.

***: The estimates of gamms for Vil. 41 to Vil. 51 are: 240 (3407), -8426 (16815), -44 (2044), 317 (2383), -111 (1172), and 1163 (970), respectively.

Table 19: Results for Scale Economies Model with alfa=4.79- Dir, Pakistan

APPENDIX 2 FIGURES ON FOOD CONSUMPTION

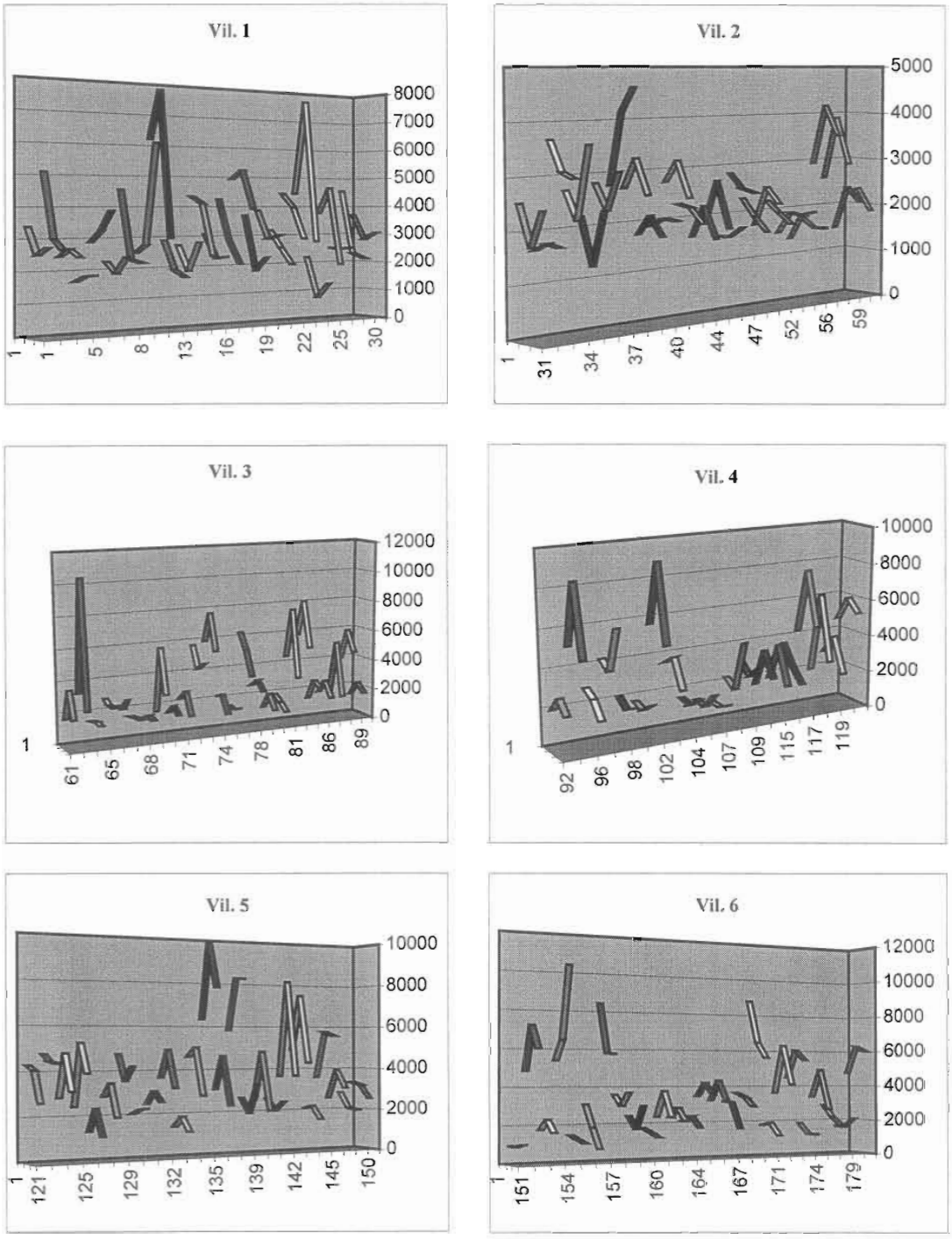


Figure 1. Variations of Food Consumption, Faisalabad (X-axis for year, Y-axis for household, Z-axis for per adult-equivalent food consumption expenditure in Rupee)

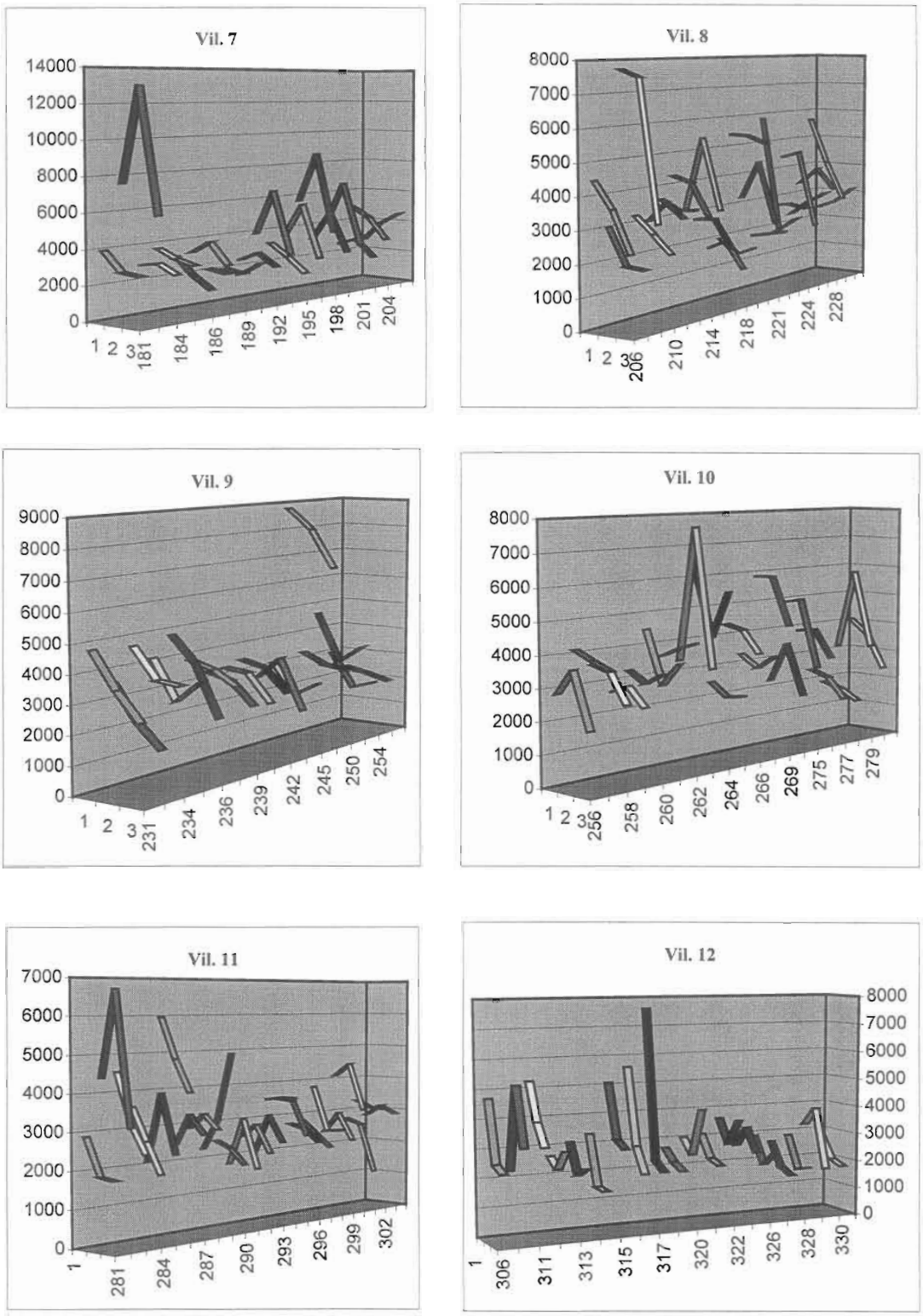
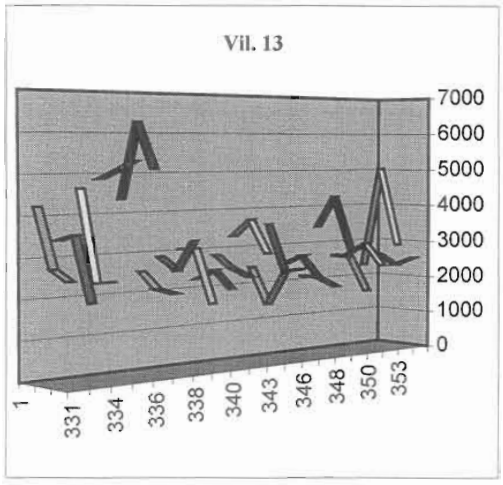
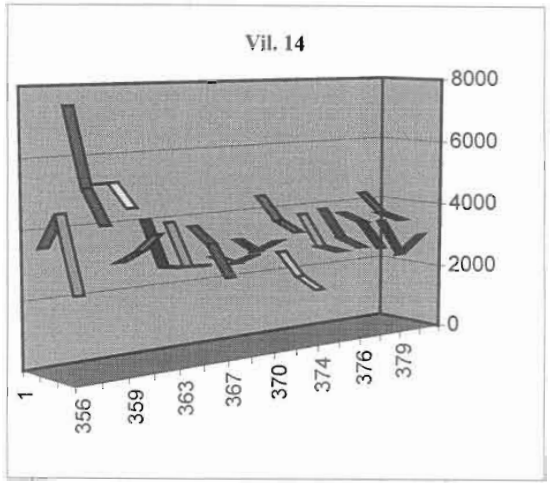


Figure 2. Variations of Food Consumption, Attock
(X-axis for year, Y-axis for household, Z-axis for per adult-equivalent food consumption expenditure in Rupee)

Figure 2, Continued





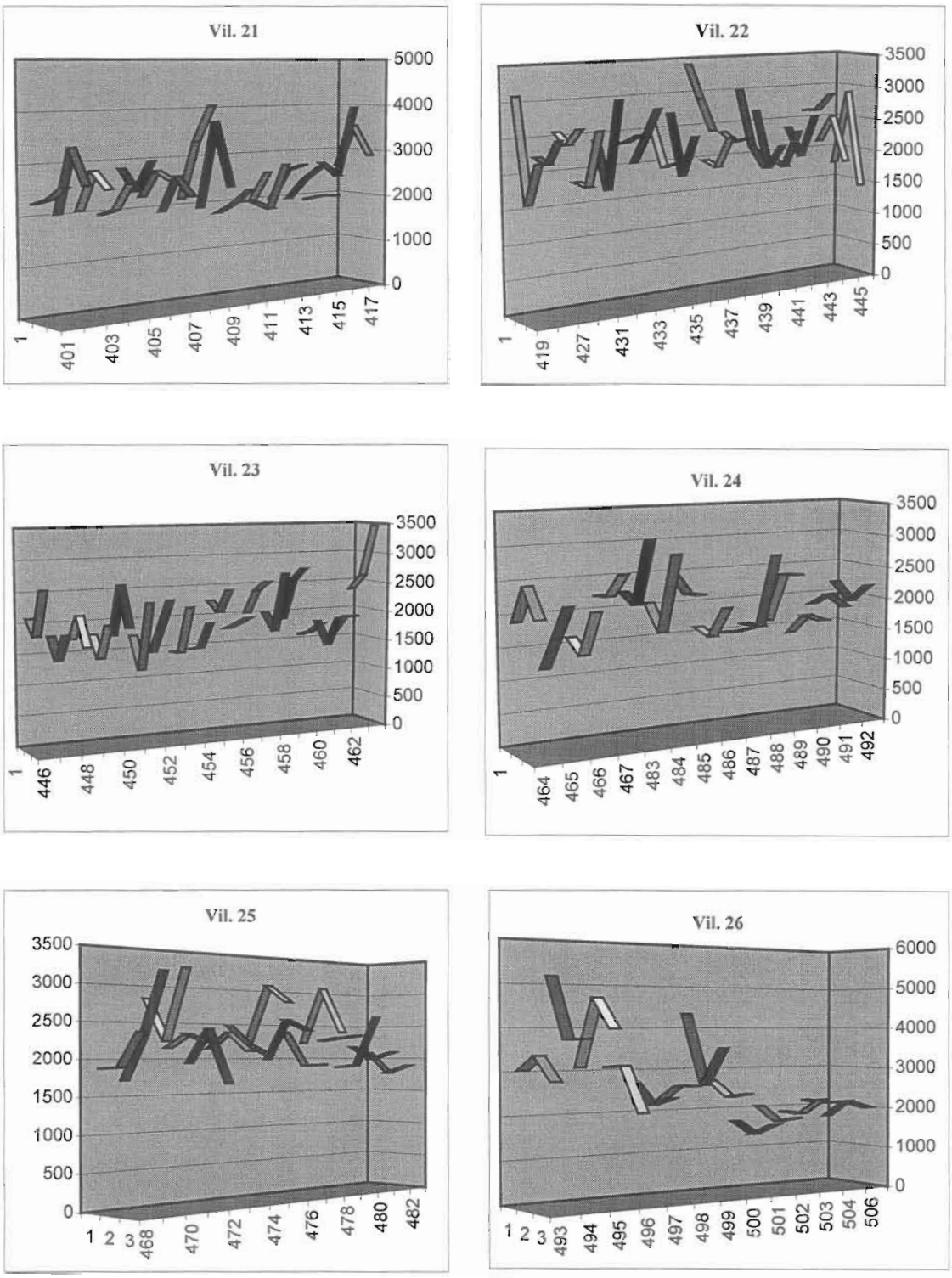
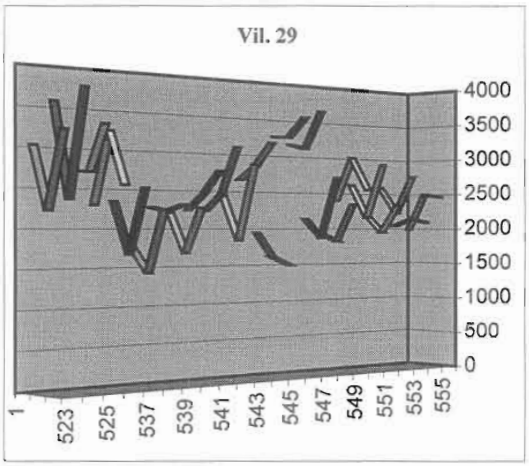
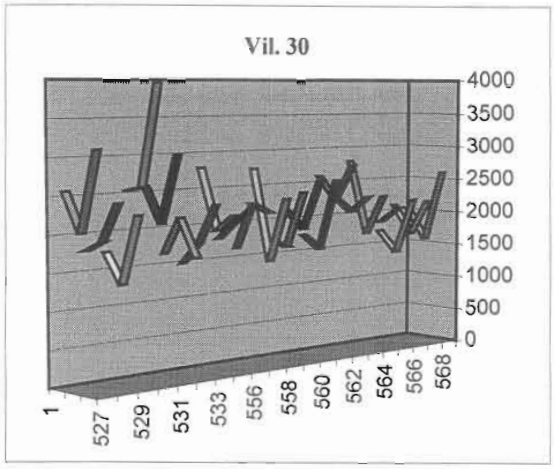
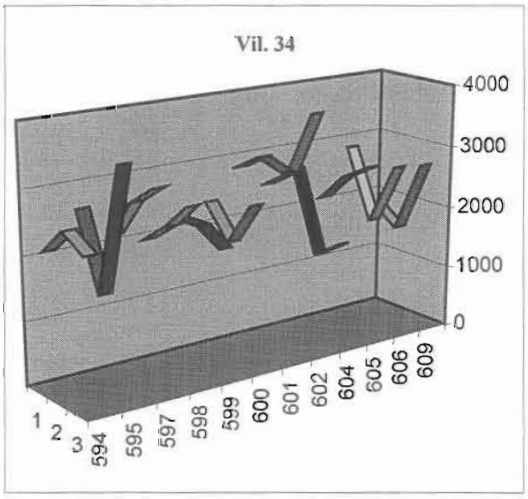


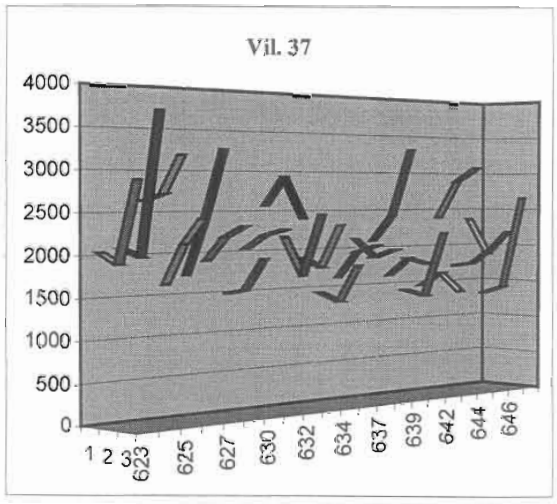
Figure 3. Variations of Food Consumption, Badin
(X-axis for year, Y-axis for household, Z-axis for per adult-equivalent food consumption expenditure in Rupee)

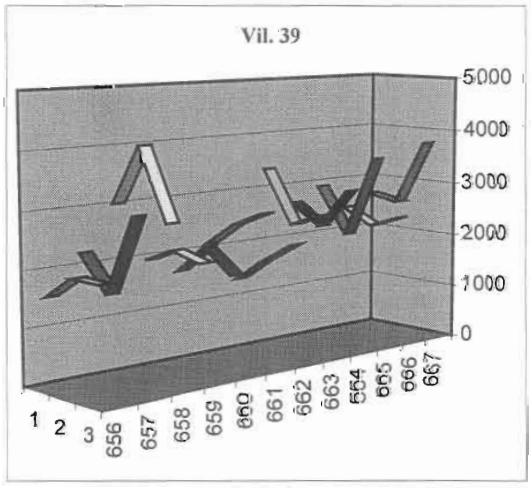
Figure 3, Continued











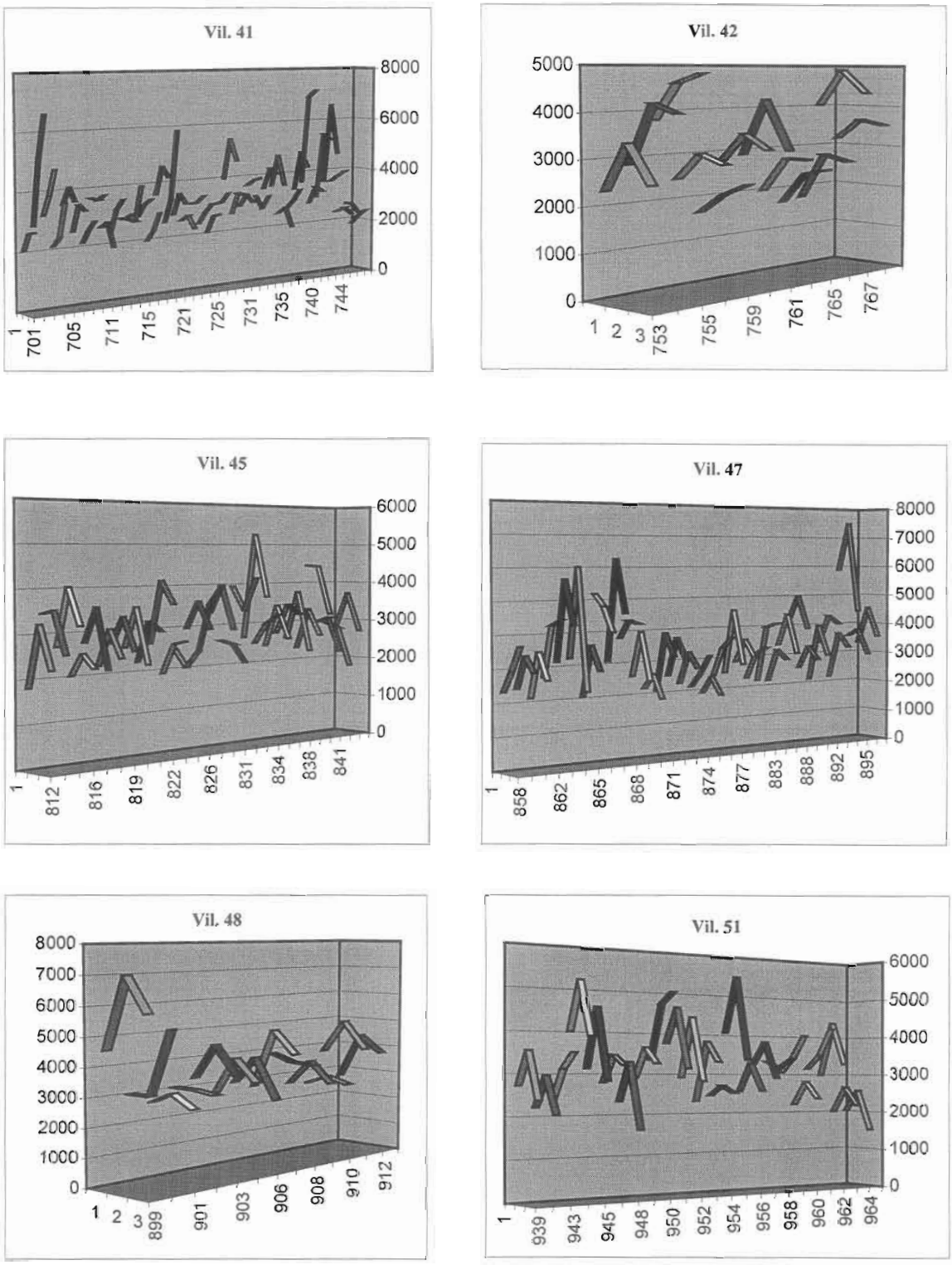


Figure 4. Variations of Food Consumption, Dir
(X-axis for year, Y-axis for household, Z-axis for per adult-equivalent food consumption expenditure in Rupee)