Prices, Credit Markets and Child Growth in Low-Income Rural Areas

Andrew D. Foster

PRICES, CREDIT MARKETS AND CHILD GROWTH IN LOW-INCOME RURAL AREAS*

Andrew D. Foster

In this paper it is argued that fluctuations in child growth in rural areas of Bangladesh during and after severe floods in 1988 can provide insight into the structure of credit markets. A model of intertemporal resource allocation is developed and Euler equations relating growth patterns of children to the cost of borrowing by household are then derived from the model. The evidence indicates that although some of the variation in growth patterns over the relevant period may be attributed to variation in illness and the price of rice, growth patterns for children in landless households were influenced by credit market imperfections.

This paper links two prominent strands of research in economic development. The first strand examines the extent to which households in poor rural economies are able to protect themselves from the adverse weather and other shocks that importantly influence earnings in underdeveloped areas. While it has long been thought that credit market imperfections and other forms of market failure make it difficult for poor individuals in these economies to smooth consumption both within and across years, there remains some question about the magnitude and pervasiveness of these imperfections. While there is evidence that fluctuations in economic conditions result in inefficient allocation of resources (e.g. Morduch, 1990; Rosenzweig and Wolpin, 1993), some recent papers have emphasised the fact that consumption patterns of households in the same village comove in a manner consistent with the idea that a substantial fraction of idiosyncratic variation in income is effectively smoothed (Paxson, 1993; Udry, 1993; Townsend, 1994).

The second strand of the development literature addressed by this paper involves health and nutrition, a subject that derives its interest at least in part from the belief that low levels of nutritional intake and high levels of illness in developing countries adversely affect productivity (e.g. Behrman and Deoalikar, 1988; Dasgupta, 1994). More recently it has been recognised that, because of the importance of health and nutrition-related expenditures as a share of the total budget in many households, data on health and, in particular, measures of body size can provide a useful alternative to data on expenditures or consumption for the purpose of studying many aspects of household behaviour.[1]

In this paper I extend the literature on health and nutrition by using anthropometric data to examine issues raised by recent papers on consumption

[1] Behrman and Deoalikar (1988) and Strauss and Thomas (1994) review this literature.

smoothing.[2] In particular, it is argued that fluctuations in child growth in rural areas of developing countries importantly reflect variation in access to credit. First, a model of intertemporal resource allocation is developed that incorporates the assumption that households care about the anthropometric status of their children. Euler equations relating growth patterns of children to the cost of borrowing by household are then derived from the model. These equations are used to examine fluctuations in child weight in rural Bangladesh during and after the severe floods experienced in that country in 1988. The evidence indicates that although some of the variation in growth patterns during the 6-month period following the flood may be attributed to variation in illness and the price of rice, a basic staple in this setting, growth patterns for children in landless households in the post-flood period were influenced by credit market imperfections. In addition the evidence suggests that credit market segmentation by village is responsible for some, but not all, of the variation in the cost of borrowing for landless households.

I. THEORY

A standard approach to testing for credit market imperfections using micro-level data is to derive from a stochastic dynamic model an Euler equation that characterises how consumption growth should be related to changes in prices and the interest rate under the null hypothesis that individuals may borrow as much as they wish at the market interest rate. Data on household consumption over a fixed interval are then used to test this model against the alternative that individuals are constrained in the credit market.[3]

The most important distinction between this paper and others testing for credit market imperfections is that it focuses on the derivation of equations relating body size at two points in time. The use of measures of body size rather than consumption for the purpose of studying credit market structure has both advantages and disadvantages. The advantages stem largely from issues related to data and measurement. First, in contrast to data on consumption, anthropometric data can be collected very easily in only a few minutes' time. One problem with the existing literature examining credit market imperfections in developing countries is the fact that very few developing-country data sets contain detailed longitudinal consumption data. Those data sets that do contain sufficient information generally cover relatively few villages, making it difficult to evaluate the extent to which there is inter-village variation in access to credit among villages in the same region.[4] As is evident from the present

---

[2] While this is the first paper of which I am aware that uses anthropometric data to examine formally credit market imperfections, the observation that fluctuations in child growth may result from credit market imperfections is not new. In his recent book on well-being and destitution, for example, Dasgupta (1994, p. 254) reports, 'There is also anthropometric evidence of credit constraints in a number of countries... Adults and newborn children in poor households there often display seasonal fluctuations in weight. This does not look much like consumption smoothing to me.'

[3] Zeldes (1989) provides a good example of the application of this approach using micro-level survey data from developed countries. The first version of this paper, dated October 1989, was among the first applications of Euler-equation methods using micro-level developing country data.

[4] The subset of the ICRISAT data used by Townsend (1994), for example, includes only three villages in three distinct agroclimatic areas. While data on three villages can be used to test for credit market

paper, an approach based on body size can permit an assessment of credit market imperfections with much more limited data.

Two other advantages of using anthropometric data are that they refer to a specific point in time and to specific individuals in the household. The former is especially relevant for studies of *intra*-year consumption smoothing but may also be of importance for studying *inter*-year consumption smoothing if there is substantial seasonal variation in prices or other factors. Individual-level data are useful because they provide a way of sidestepping a potential criticism of much of the existing consumption-smoothing literature – that it does not adequately account for the potential effects of consumption on income. Specifically, since anthropometric data can be collected for each individual in a household, it is possible to focus on individuals such as children for whom the productivity effects of consumption are negligible.

The main disadvantages of using body size arise from the nature of the anthropometric 'production function': (1) body size is affected by inputs other than consumption and (2) body size is a kind of stock variable. Concerning the former, because body size may be affected by illness and activity, variation in consumption level does not necessarily imply that there is similar variation in body size: consumption may be increased in periods of high illness or activity to minimise variation in body size. The latter point, that body size is a stock variable simply means that increases in weight or height in one period will *ceteris paribus* increase weight or height in subsequent periods. As is well recognised in the literature on consumer durables, this distinction has significant implications for the interpretation of data on fluctuations in consumption.[5]

Because body size is a stock variable, simple equations relating body size cannot easily be derived from a model in which preferences are defined with respect to consumption levels. It turns out, however, that such equations can be derived, even for quite complex anthropometric production functions, if preferences are defined with respect to the body sizes of its members. For the purposes of this paper I therefore assume that parents care about the weight of a child but not other aspects of the child such as consumption, illness or height and that preferences are separable across time and across children at any point in time.[6] Thus, the expected discounted utility of household j at time s is assumed to be

$$V_{js} = E_s \sum_{t=s}^{T} \beta^{t-s} \left[v(x_{jt}) + \sum_{i=1}^{N_j} u(w_{jit}) \right], \tag{1}$$

imperfections within villages (e.g. Morduch, 1991), they cannot provide much insight into the extent of credit market segmentation across villages in the same region. By contrast the present survey contains information on 10 % of all households in a contiguous area of 74 villages.

[5] Deaton and Muellbauer (1980) provide a concise description of the neoclassical model of consumer durables. Grossman (1972) first considered the implications of the theory of consumer durables for an empirical analysis of health-related behaviours.

[6] It is worth noting that even if households did not care directly about body size, they might behave as if they did if body size were used by the household (as it frequently is by clinics) as a readily measurable signal of attributes of a child that are not themselves easily measured such as health, mortality risk, and even calorie intake (if, for example, the child is breastfeeding or eats some meals outside the home). The question of whether households act as if they care about the body sizes rather than the consumption is, of course, an empirical one that could in principle be addressed with a data set that included information on consumption and activity as well as body size and illness.

where E_s is the expectation conditional on information available at time s, β is the discount factor, w_{jit} is the weight of child i at time t, and x_{jt} is consumption of goods other than those that are inputs in the production of weight. Single period utility is assumed to be increasing and concave in child anthropometric status ($u'(w_{jit}) > 0$, $u''(w_{jit}) < 0$). The stock of assets net of debt is updated according to

$$A_{jt+1} = (1 + r_j)\left(A_{jt} - x_{jt} - p_t \sum_{i=1}^{N_j} c_{jit}\right) + y_{jt}, \tag{2}$$

where r_j is the single-period interest rate that applies to household j, p_t is the price of food for children, c_{jit} is the quantity of food consumed by child i at time t, and y_{jt} is income between periods t and $t+1$ which may depend on x_{jt} but not on c_{jit} or w_{jit}.

Finally, it is necessary to specify the weight production function, which characterises how weight at time t is determined. Existing models of durable goods consumption assume simply that the stock of durable goods depreciates at a constant rate and is augmented directly through additional purchases. This assumption is problematic in the context of child weight because the effect of consumption on weight (or an index of weight) as well as the 'depreciation rate' of weight may be affected by attributes of the child such as his/her sex and age. Moreover, sick children are likely to lose weight faster than healthy children and, if 'catch-up growth' is important (Prader *et al.* 1963), then the pace at which the body depreciates may also depend on body size: low-weight children may grow more rapidly on average than higher-weight children with the same consumption and illness. Thus, I assume

$$w_{jit+1} = f(w_{jit}, z_{jit}, a_{jit}) + f_c(a_{jit}) c_{jit} \tag{3}$$

with $f_{w1} = \partial f(w_{ji1}, z_{ji1}, a_{ji1})/\partial w_{ji1} > 0$, $f_{zw1} = \partial^2 f(w_{ji1}, z_{ji1}, a_{ji1})/\partial w_{ji1}\partial z_{ji1} < 0$, where a_{jit} represents age and sex and z_{jit} represents illness. The term $f_c(a_{jit})$ incorporates the idea that the effect of calories on body size may vary with age and/or sex, while the assumption that $f_{zw1} < 0$ captures the idea that body size depletes more rapidly when a child is ill. While this model is not completely general, it captures the most important features of the process of growth while still providing a structure that can be applied using data on weight and illness at only two points in time.

Consistent with the interpretation of child weight as a kind of consumer durable, first-order conditions for this problem incorporate the marginal rental price associated with increasing weight over a given interval. In particular, suppose one wants to increase nutritional status in period 1 by dw_1. Since parents can only have a direct effect on levels of consumption, this temporary change can be provided by increasing consumption in period 0 and then decreasing consumption in period 1 so as to leave nutritional status in the subsequently period unaffected:

$$dw_1 = f_{c0}\, dc_0 \tag{4}$$
$$dw_2 = f_{w1}\, dw_1 + f_{c1}\, dc_1 = 0,$$

where $f_{c0} = f_c(a_{ji0})$, $f_{c1} = f_c(a_{ji1})$, and $f_{w1} = \partial f(w_{ji1}, z_{ji1}, a_{ji1})/\partial w_{ji1}$. For positive dw_1, this change will deplete assets in period 2 by

$$dA_2 = R(Rp_0\,dc_0 + p_1\,dc_1) = R[Rp_0/f_{c0} - p_1 f_{w1}/f_{c1}]\,dw_1, \tag{5}$$

where $R = 1 + r$ and the subscripts i and j have been dropped for notational simplicity. The marginal cost or rental-equivalent price of this temporary increase in nutritional status evaluated at time 2 is therefore

$$\pi_1 = Rp_0/f_{c0} - p_1 f_{w1}/f_{c1} = p_0/f_{c0}\left[R - f_{w1}\left(\frac{p_1}{p_0}\right)\Big/\left(\frac{f_{c1}}{f_{c0}}\right)\right]. \tag{6}$$

Note that the rental price is increasing in the interest rate r, current prices, and illness (through f_{w21}) and decreasing in the rate of growth of prices $\hat{p}_0$ where $1 + \hat{p}_0 = p_1/p_0$. It is assumed that price variation is sufficiently small given f_{w1} that π_1 and all subsequent values of π_t are positive.

The interpretation of the first part of this expression is straightforward. Increases in the price of rice in the current period (p_0) and decreases in the rate at which consumption is translated into weight gain (f_{c0}) directly increase the cost of reaching a given weight. The second part of this expression describes the costs associated with storing food in the body rather than investing the money and receiving a return r. If, for example, prices are rising then future expenditures on food will provide fewer nutrients than expenditures today; if, in addition, the rate of depreciation of anthropometric status ($1 - f_{w1}$) is low so that the benefits of an increase in consumption today will persist into future periods, there will be little reduction in future body size associated with this transfer of resources toward the present. Illness raises the rental price of weight by decreasing the extent to which current increases in weight translate into future weight.

To proceed further it is necessary to consider a subsequent pair of deviations in consumption that will lower weight for a single period and, in so doing, return the stock of assets to its original path:

$$dA_{t+1} = R^{t-1}dA_2 - \pi_t\,dw_t = 0, \tag{7}$$

where

$$\pi_t = Rp_{t-1}/f_{ct-1} - p_t f_{wt}/f_{ct}. \tag{8}$$

Along the optimal path, and assuming that the optimal consumption path is bounded away from zero, this pair of deviations (or corresponding deviations in the opposite direction) cannot lead an increase (or decrease) in expected utility:

$$u_{w1}\,dw_1 + E_0\,\beta^{t-1}u_{wt}\,dw_t = 0, \tag{9}$$

where, by equations (7) and (5),

$$dw_t = R^t dA_2/\pi_t = R^t\pi_1\,dw_1/\pi_t. \tag{10}$$

One is thus provided with an Euler equation that provides a necessary condition for an optimal solution

$$\frac{u_{w1}}{\pi_1} = (\beta R)^{t-1}E_0\frac{u_{wt}}{\pi_t}. \tag{11}$$

Because the ratio of the marginal utility of weight (u_{wt}) to the marginal rental price of weight (π_t) is just the marginal utility of income in period t, this equation simply states that the marginal utility of income in period one must be equal to the expected marginal utility of income in period t after discounting appropriately.

Assuming constant absolute risk aversion (CARA) in child weight:

$$U(w) = -\frac{1}{\gamma}\exp\left(-\gamma w\right) \tag{12}$$

for $\gamma > 0$ and reintroducing subscripts for child i in household j, equation (11) becomes

$$e^{-\gamma\Delta_{t-1}w_{ji1}}(\beta R_j)^{t-1}\frac{\pi_{ji1}}{\pi_{jit}} = 1 + e_{ji1t}, \tag{13}$$

where $\Delta_{t-1}w_{ji1} = w_{jit} - w_{ji1}$ and e_{ji1t}, with $E_0(e_{ji1t}) = 0$, captures unanticipated shocks experienced by the household between periods 0 and t.[7]

Assuming that the variation across households in interest rates (r_j) and the interval between weight measurements (t_j) is small, that prices change slowly $(\Delta p/p$ is small), that the rate of depreciation $(1 - f_{wt})$ and the effect of consumption on standardised weight (f_{ct}) do not vary a great deal across children or over time, that the stochastic term e_{ji1t} is small, and that the depreciation rate does not depend on weight $(f_{wwt} = 0)$,[8] a linear approximation to equation (13) may be constructed,

$$\Delta_{t-1}w_{ji1} \approx \phi_0 + \phi_t(t_j - 1) + \phi_a\Delta_{t-1}a_{ji0} + \phi_2\Delta_{t-1}z_{ji0} \tag{14}$$
$$+ \phi_p\Delta_{t-1}\ln(p_0) + \phi_{\hat{p}}\Delta_{t-1}\hat{p}_0 + u_{ji1t},$$

where $u_{ji1t} = \phi_r(r_j - \bar{r}) + \epsilon_{ji1t}$, $\epsilon_{ji1t} = \ln(1 + e_{ji1t}) + \sigma_2/2$ (see Zeldes, 1989), $\phi_p = (1/\gamma)$, $\phi_{\hat{p}} = (1/\gamma)[\bar{f}_{w1}/(\bar{R} - \bar{f}_{w1})]$, $\phi_t = (1/\gamma)\ln(\bar{R}\beta)$, and $\phi_r = (t-1)/(\gamma\bar{R})$. The residual of equation (14), u_{ji1t}, which measures growth net of prices, illness and child characteristics will henceforth be termed *residual growth*.

In the absence of credit market imperfections each household will face the same implicit cost of transferring resources across periods $(r_j = \bar{r})$ and thus expected residual growth conditional on characteristics known at time 0, $E_0(u_{ji1t})$, will be zero. This restriction implies that equation (14) may be estimated using an instrumental variables procedure, using as instruments any variables known to the household as of time zero including illness, assets, income, borrowing, prices and price growth at time t.

By including one or more of these instruments on the right-hand side of equation (14) it is also possible to test the model and in particular the assumption that households face the same implicit cost of transferring resources

---

[7] Equation (13) is related to equations derived by Miron (1986), which examines the seasonality of durable goods purchases, and by Mace (1991) in a discussion of tests for full insurance using durable goods. The primary distinctions between the approach used here and that used in these other studies is the use of a more complex equation characterising depreciation (equation 3) and the focus of the estimation on stocks (body size) rather than flows (consumption).

[8] That is the depreciation rate does not itself depend on weight. The implications of this assumption are discussed below.

across periods. As these included instruments must be uncorrelated with ε_{ji1t}, they should have a zero coefficient in the absence of variation in the cost of borrowing.[9] In previous studies the variable that has generally been used for this purpose is initial-period household income (e.g. Zeldes, 1989; Morduch, 1991). The argument is that credit market imperfections will result in a correlation between income and u_{ji1t} because households facing a low-income period are more likely to be constrained in the credit market.

A useful alternative to data on income in settings where credit markets are active is data on recent borrowing. Not only is information on recent borrowing straightforward to collect but because both borrowing and interest rates are directly affected by changes in credit-market structure the relationship between borrowing and interest rate variation is likely to be relatively direct in the presence of credit market imperfections. In order to fix this idea as well as to aid in the interpretation of the estimates of equation (14) when measures of borrowing are included as right-hand-side variables, it is helpful to construct expressions for the theoretical covariance between residual growth and borrowing under different models of credit market structure.

Consider first a model in which regional credit markets work well in the sense that most households can borrow and lend at a fixed regional interest rate $\bar{r}$ but some households face higher rates of interest as a result of an absence of collateral, higher transactions costs, or imperfectly competitive markets. Under these circumstances one might expect households facing a relatively high interest rate to borrow less and, given equation (14), experience more child growth than those facing a lower interest rate. To establish the conditions under which this result holds, it is helpful to consider the implications of small deviations from the perfect credit markets assumption. Let the function $B_j(r)$ denote the amount that household j would borrow in some fixed interval preceding period 1 if it faced an interest rate of r and approximate the amount actually borrowed as a linear function of the amount that the household would borrow at the regional interest rate, $B_j(\bar{r})$ and the deviation of the actual interest rate face by j from the market interest rate,[10]

$$b_j = B_j(\bar{r}) - \delta_b(r_j - \bar{r}), \tag{15}$$

where $\delta_b = -(\partial B_j/\partial r)(\bar{r})$. Treating $B_j(\bar{r})$ and r_j as jointly distributed random variables,

$$\text{Cov}\,(b_j, u_{ji1t}) = \phi_r\{\text{Cov}\,[B_j(\bar{r}), r_j] - \delta_b\,\text{Var}\,(r_j)\}, \tag{16}$$

[9] The usual approach is to assume that the correlation between residual consumption growth comes from credit constraints at a fixed rate of interest as in Zeldes (1989) rather than variation in the interest rate. Although the two approaches are analytically distinct, the distinction matters little in the context of an Euler equation because the cost of borrowing is derived implicitly: a child in a household that faces a binding credit constraint in the initial period will, *ceteris paribus*, borrow less and subsequently grow more, as will a child in a household facing a high cost of borrowing. The assumption that there is variation in the interest rate rather than explicit credit constraints is both analytically more convenient and consistent with direct evidence on the terms of credit in rural Bangladesh (Maloney and Ahmed, 1988).

[10] Note that b_j denotes borrowing not 'borrowing net of lending' and thus will have a concentration at zero. The linear approximation is therefore problematic in the neighbourhood of $b_j = 0$, although the main implications are not substantially affected. The reason for setting up the problem in this way is that the data used in this study report only loans received.

where Cov and Var denote covariance and variance, respectively and $\phi_r > 0$ is the coefficient on r_v from (14). Assuming that borrowing is decreasing in the interest rate ($\delta_b > 0$), this equation indicates that when there is variation in the cost of borrowing ($\text{Var}(r_j) > 0$), there will be a negative correlation between borrowing and residual growth if those facing higher interest rates would borrow less than average at the market rate ($\text{Cov}[B_j(\bar{r}), r_j] < 0$) and the sign is indeterminant otherwise. While *net* of credit demand (as measured by $B_j(\bar{r})$) higher interest rates will be associated with lower borrowing, a positive covariance between borrowing and the interest rate may obtain if those facing higher interest rates also have high credit demand.

A second interesting model is one in which credit markets are segmented by village. This model, which is a credit-market analog to the perfect village insurance model of Townsend (1994), assumes that credit markets clear at the village level but that there may be substantial village-level variation in the equilibrating interest rate. The basic idea is that an adverse village shock and thus a high demand for credit in some villages will push up the interest rate in these villages relative to the average rate. In this case, instead of being determined by characteristics of a particular household, the cost of borrowing is determined by the supply and demand for credit in the village as a whole. Equating the per-household average supply of credit in village v, $S_v(r)$, to the per-household average demand in that village, $\bar{B}_v(r) = \Sigma_j B_j(r)/N_v$, where N_v is the number of households in the village, carrying out a linear approximation around the regional interest rate and solving yields $r_v = [\bar{B}_v(\bar{r}) - S_v(\bar{r})]/(\delta_b + \delta_s)$, where $\bar{B}_v(\bar{r})$ and $S_v(\bar{r})$ are the average borrowing and credit supply at the regional interest rate and $\delta_s = (\partial S_v/\partial r)(\bar{r})$. The covariation between *average* borrowing and residual growth is

$$\text{Cov}(\bar{b}_v, u_{ji1t}) = \frac{\phi_r}{(\delta_b + \delta_s)^2}[\delta_s \text{Var}(\bar{b}_v) + (\delta_b - \delta_s)\text{Cov}(\bar{b}_v, S_v) - \delta_b \text{Var}(S_v)].$$

$$(17)$$

Thus if the variation in the supply of credit is sufficiently small relative to the variation in credit demand at the regional interest rate then higher levels of borrowing will be associated with higher interest rates in a village. Two other testable implications follow from this model of segmented credit markets. First, household borrowing should not be correlated with the village interest rate net of village average borrowing; a test of this implication establishes whether there is within-village variation in the cost of borrowing. Second, if there is no independent (of $\bar{B}_j(\bar{r})$) variation in the per-household supply of credit ($S_v(\bar{r})$) at the regional interest rate and there is no new village-level shock between periods 0 and t, residual growth among children in the same village should not be correlated net of village average borrowing.[11] This latter implication is of

---

[11] The first implication follows from the fact that the village interest rate depends only on village aggregate demand and supply for credit, not on the demand for credit from a particular household. The second implication follows by noting that if there is no new village-level information, the only source of covariance

interest because it addresses the possibility that the same attributes of a village that determine credit demand (e.g. the severity of a recent shock) also determine the availability of credit.

II. DATA

In the autumn of 1988, Bangladesh experienced some of the worst floods in recent memory. Three major rivers that crisscross the country experienced peak levels at approximately the same time and inundated 60% of the land area of Bangladesh during the first week of September. There was severe damage in many parts of the country, particularly in areas where river embankments broke. In many areas more than 50% of the autumn crop was destroyed. Although the prices of grain were not excessively high (in part because of successful harvests in other parts of the country and in part because of sales from government stockpiles), there is evidence of a substantial decrease in the agricultural wage (10–30%) in some areas because of a loss of opportunities for work in harvesting and transplanting. Also in the immediate post-flood period there was a rapid rise in diarrhoeal disease that can be attributed in part to the contamination of water supplies.[12]

One of the hardest hit areas was Sirajganj in which the International Centre for Diarrhoeal Disease Research in Bangladesh (ICDDRB) has been registering vital events and carrying out special studies on a 10% sample of households since 1982. To aid in flood assessment, a questionnaire was incorporated into the regular rounds of the ongoing system. During the first round, running from 15 October 1988 to 14 January 1989, data on damage during the flood, asset losses and sales, grain stocks, and borrowing were collected from 1,698 sample households. Weight data and diarrhoeal disease measures were collected from children aged 6–36 months in the study household during this and a subsequent round (15 January–14 April). After restricting the sample to one child per household, weight and diarrhoeal disease data from both rounds were available for a total of 1,118 children in 74 villages.[13] Data on child weight were linked to regional weekly data on rice prices collected as part of the flood assessment. Because approximately 80% of calories in Bangladesh are provided by rice (Ahmad et al. 1977), this single price is a useful measure of variation in the cost of consumption.

Table 1 provides means and standard deviations for the variables used in the

---

in residual growth between two households in the same village is the fact that they share the same interest rate. If in addition the average village supply and demand for credit at the regional interest rate are perfectly correlated then to a first-order approximation r_v is perfectly correlated with the average level of borrowing in the village. Thus net of average borrowing, residual growth will be uncorrelated for the two households.

[12] This discussion of the flood is drawn largely from Foster (1989).
[13] Only 6 children were lost to follow up as a result of mortality between rounds. Figures from another part of rural Bangladesh indicate that the child mortality rate over the relevant period ranged between 20 and 30 per 1,000 person years (Phillips et al., 1993). Given that each child was observed for approximately 13 weeks, a mortality rate of 0·025 implies that one should have expected 7·03 deaths. While these deaths may be selective with respect to access to credit the numbers are too small to have greatly affected the results (or to attempt a selection correction). It should be noted that this level of mortality is similar to the levels observed in other years when floods were less severe.

Table 1

Means and Standard Deviations

	Children in landowning households ($N = 656$)		Children in landless households ($N = 462$)	
	Mean*	S.D.	Mean	S.D.
Weight growth†	1·658	6·261	1·851	6·399
Weight†	−34·421	13·941	−37·473	14·436
Age (months)	24·333	8·077	23·370	8·107
Male	0·530	0·499	0·515	0·500
Diarrhoeal disease‡	0·285	0·451	0·274	0·447
Rice price (Tk/Kg)	12·561	0·487	12·585	0·485
Interval between rounds (days)	90·481	6·180	91·566	8·226
Some borrowing	0·462	0·499	0·640	0·480
Amount borrowed given some borrowing (× 10³ Tk)	1·029	0·809	0·715	0·628

* All means except for weight growth and interval are from the first round of the survey.
† Weight and growth are standardised for age and sex by taking 100 times the log of the ratio of a child's weight to the corresponding NCHS standard.
‡ Diarrhoeal disease refers to proportion of days in previous two-week period.

analysis that follows. The sample has been divided into two groups. The first group consists of 656 children in households owning at least 10 decimals of land ('landowning households') while the second group consists of 462 children in households owning less than ten decimals ('landless households'). This latter group consists largely of households with no land in which the primary occupation of the household head was as a casual agricultural worker.

The measure of weight used is one hundred times the log of the child's actual weight divided by the NCHS (1977) standard weight for children of the same age and sex. Thus the mean of − 34·4 for the landowning households indicates that the children were roughly 34·4 % smaller in terms of weight than a healthy child in the developed world. Children from the landless households were smaller, but not substantially so. Weight growth refers to the difference in standardised weight between the two rounds of the survey. The positive sign of the weight-growth averages indicates that children in this population grew faster in percentage terms than dictated by the NCHS standard, suggesting that some of the adverse effects of the flood on child weight were compensated by relatively rapid growth over the subsequent three-month period.

A disaggregated picture of weight growth is provided by Fig. 1, which plots the change in standardised weight by the week of the initial observation. There is a general decline in growth over time, suggesting that the weights of children in the immediate post-flood period were especially low and therefore that children weighed in this period grew faster than those first interviewed at the end of the first round. It is also apparent that the growth patterns of children in the two sub-populations were roughly similar: they exhibit similar trends and, to some extent, similar fluctuations around the trend. While Fig. 1 shows that there was variation in the growth patterns of children following the flood,
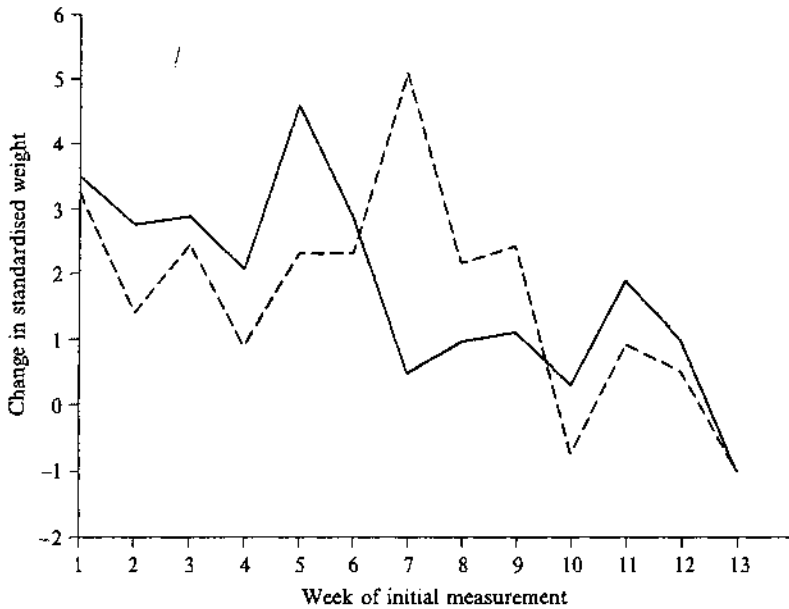
Fig. 1. Change in standardised weight by week of first measurement for children by landholding status. ———, Landowning households; ———, landless households.

it does not in itself say anything about resource availability or credit markets. The problem is that other factors might lead to this pattern of growth including fluctuations in illness and prices.

One particularly striking feature of Table 1 is the high proportion of children from households that reported borrowing in the post-flood period for consumption purposes. In particular, 46·2 % of the landowning households and 64·0 % of the landless households took out a loan. The average amount borrowed by those who did borrow was 1,029 Thaka (about US $40) and 715 Thaka for the landowning and landless households, respectively. The high proportion of households obtaining loans in this survey suggests that credit markets played an important role as a response to the flood and that even individuals with few assets were not 'rationed out' of the credit market, although they may well have borrowed less than they wished and/or paid a high rate of interest.

III. RESULTS

The principal results of this paper are obtained from random-effects (by village) instrumental variables estimates of equation (14) augmented by two variables, household and village average borrowing,

$$\Delta_{t-1} w_{ji1} \approx \phi_0 + \phi_t(t_j - 1) + \phi_a \Delta_{t-1} a_{ji0} + \phi_z \Delta_{t-1} z_{ji0} \tag{18}$$
$$+ \phi_p \Delta_{t-1} \ln(p_0) + \phi_{\hat{p}} \Delta_{t-1} \hat{p}_0 + \phi_b b_j + \phi_{\bar{b}} \bar{b}_v + \epsilon_{ji1t}.$$

Since crop damage could be assessed by the time of the first round of the survey and prices followed a standard seasonal pattern, rice prices at time $t-1$ and t

were assumed to be known as of period o and thus treated as exogenous. By contrast, since illness in period $t-1$ may have been affected by (or been an important component of) shocks experienced by the household between periods o and t and thus be correlated with ϵ_{jt1t}, the change in illness from time o to time $t-1$ was treated as endogenous; first period illness was used as an instrument.

One additional empirical issue deserves some discussion. The fact that village average borrowing is included as a regressor in equation (18) raises the possibility of measurement error bias because the average borrowing in surveyed households is a noisy measure of the *true* average borrowing in the village. Thus in addition to using standard random-effects instrumental variables methods to estimate equation (18), a maximum likelihood procedure that controls for measurement error by treating the true village average of borrowing as a latent variable was used. The procedure fits the theoretical covariance matrix $(\Omega(\omega))$ given the model and its parameters (ω) to the actual covariance matrix of the data Σ under the assumption that the variables are drawn from a joint normal distribution.[14] The theoretical covariance matrix was derived by substituting a latent variable, $\bar{b}_v^*$, for the sample village average borrowing, $\bar{b}_{v}$, in equation (18), and combining the resulting equation with a measurement equation relating household borrowing to the latent variable, $b_j = \bar{b}_v^* + e_{bj}$ for each household in the village. A number of additional covariance restrictions consistent with the interpretation of the latent variable as village average borrowing were also imposed.[15] The hypothesis that the ϵ_{jt1t} were uncorrelated across households in the same village was tested.

The coefficient estimates for equation (18) are given in Table 2. Three pairs of results are presented, with separate coefficient estimates for landed and landless households in each pair. The first two pairs of estimates consist of instrumental variables estimates with village-level random effects and were estimated separately for landed and landless households (although the average borrowing in each case was measured from both groups). The third pair is derived from the latent-variable model and is jointly estimated.

Of primary interest are the coefficients related to borrowing in the three different specifications; the other coefficients will be discussed below. Recall

[14] The procedure generates consistent parameter estimates and standard errors regardless of the distributional assumptions and is fully efficient under the assumption that the variables are generated from a multivariate normal distribution (Bentler and Dijkstra, 1985). Since the program used for this component of the analysis requires the use of a balanced design, children were randomly assigned by village to groups of four children, with two children from landless and two from landed households in each group. Incomplete groups of four were discarded, thus resulting in a reduction in sample size.

[15] The additional restrictions imposed on the theoretical covariance matrix are as follows: (1) $\bar{b}_v^*$ was assumed to be correlated with each of the other regressors in equation (18) but not with the residual ϵ_{jt1t}; (2) initial illness and each regressor except illness change were assumed to be uncorrelated with ϵ_{jt1t} but were allowed to be correlated with e_{bj}; (3) the illness change was assumed to be correlated with both residuals; (4) the errors ϵ_{jt1t} and e_{bj} were constrained to be uncorrelated with each other; and (5) the e_{bj} were assumed uncorrelated across households in the same village.

Intuition for the procedure may be gained by considering the case in which all the ϕ coefficients in equation (18) except those associated with the borrowing variables are zero. Then using the above conditions for any two households j and j' in the same village, $\text{Cov}(b_j, b_{j'}) = \text{Var}(\bar{b}_v^*)$, $\text{Cov}(\Delta_{t-1}w_{jt_1}, b_{j'}) = (\phi_b + \phi_6)\text{Var}(\bar{b}_v^*)$, and $\text{Cov}(\Delta_{t-1}w_{jt_1}, b_j) = \phi_b\text{Var}(b_j) + \phi_6\text{Var}(\bar{b}_v^*)$. Setting these covariances equal to their corresponding sample moments yields three equations that, along with the sample variance of b_j, may be solved for the three unknowns, ϕ_b, ϕ_6, and $\text{Var}(\bar{b}_v^*)$.

Table 2

Estimates of Linear Approximation to Euler Equation for Landless and Land-Owning Households

(Dependent variable: change in standardised weight.)

	IV Random effects		IV Random effects		ML Estimates*	
	Landed (N = 656)	Landless (N = 462)	Landed (N = 656)	Landless (N = 462)	Landed (N = 328)	Landless (N = 328)
ΔDiarrhoeal disease† (prop.)	−0·912 (1·788)‡	−1·960 (2·521)	−0·916 (1·782)	−1·832 (2·371)	−1·696 (2·524)	−2·336 (2·783)
ΔLog rice price (×10⁻¹)	−0·621 (1·707)	−0·976 (2·287)	−0·619 (1·692)	−1·037 (2·443)	−0·648 (1·204)	−1·588 (3·136)
ΔRice price growth (×10³)	1·474 (3·800)	0·380 (0·836)	1·476 (3·775)	0·282 (0·623)	1·194 (2·702)	0·533 (1·050)
Interval between rounds (days)	−0·066 (1·707)	0·066 (1·418)	−0·066 (1·284)	0·063 (1·360)	0·042 (0·490)	0·194 (2·619)
First round age (months)	0·003 (0·106)	0·045 (1·243)	0·003 (0·107)	0·040 (1·100)	0·004 (0·426)	0·011 (2·710)
Male	−0·013 (0·028)	0·284 (0·484)	−0·014 (0·028)	0·350 (0·599)	−0·579 (0·822)	0·409 (0·569)
Borrowing (×10³ Tk)	−0·250 (0·775)	−0·673 (1·392)	−0·243 (0·686)	−1·061 (2·073)	0·485 (0·121)	−1·418 (2·455)
Average borrowing in village (×10³ Tk)			−0·040 (0·043)	2·792 (2·205)	−2·173 (0·814)	4·864 (1·730)
Variance of average borrowing						
Residual covariance§					0·042 (1·964)	
Joint significance of regressors	F₇,₆₄₈ = 4·14 p = 0·000	F₇,₄₅₄ = 3·18 p = 0·003	F₈,₆₄₇ = 3·62 p = 0·000	F₈,₄₆₁ = 3·36 p = 0·001		
Goodness of fit					χ²₃ = 3·639 p = 0·303	χ²₁₅₄ = 165·26 p = 0·253

* ML-estimates for landless and landed households are estimated jointly.
† Endogenous variable, instrumented using first-round diarrhoeal disease.
‡ Absolute values of asymptotic t-ratios in parentheses; t-ratios for ML estimates are computed from a robust covariance matrix.
§ Likelihood ratio test for covariance of residual growth net of borrowing variables.

that under the assumption that every household faces the same cost of borrowing, neither own nor village borrowing should be correlated with residual growth. Thus when these variables are included as regressors in equation (18) they should have zero coefficients. The first pair of estimates, which includes only household borrowing, suggests that this is indeed the case: there appears to be no evidence for variation in the cost of borrowing across households for either landed or landless households.

The coefficients for the second and third pairs of estimates, which control for average borrowing, tell quite a different story. The evidence suggests that although the cost of borrowing did not vary across landed households, in landless households it varied systematically with both household and village average borrowing, with higher borrowing by a particular household net of village borrowing being associated with lower subsequent child growth and higher borrowing in the village as a whole being associated with higher subsequent child growth.

By comparing these signs on household and average borrowing with the theoretical covariances presented in equations (16) and (17) it may be seen that the former relationship is consistent with the notion that there is substantial intra-village variation in the cost of borrowing, with those households facing a high cost of borrowing choosing to borrow less; the latter suggests that interest rates were higher as a whole in villages with an especially high demand for credit.[16] These results suggest that for landless households credit markets are segmented, but that within each village there is additional variation in the cost of borrowing across landless households. With respect to the landed households there is no evidence of either market segmentation by village or variation in the cost of borrowing within the village. Apparently, although better-off households can get access to credit at the regional rate of interest or have other mechanisms (such as inter-household transfers or storage) to smooth consumption, these opportunities are not transmitted through the village credit market to the landless households.

In light of these results it is not surprising that estimates of equation (18) that included only information on household level borrowing proved misleading. Since individual and village average borrowing are correlated (the correlation coefficient is 0·31) and these two measures have opposite effects on residual growth, the omission of average borrowing from equation (18) raises the coefficient on individual borrowing toward zero. More intuitively, assuming there was a strong village-level component to the impact of the flood, the households that are likely to have had to accept the biggest decline in weight,

---

[16] Although these coefficients are indicative of the underlying covariances between residual growth and borrowing, it should be recognised that as regression coefficients they will be influenced by the extent to which the borrowing variables are correlated with the other regressors. The advantage of carrying out the analysis in this way rather than estimating (14), computing residual growth and then correlating it with the borrowing variables directly is that in the absence of perfect credit markets estimates of equation (14) that do not account for interest-rate variation will yield inconsistent parameter estimates. To the extent that the borrowing variables absorb the variation in the cost of borrowing, this potential problem is no longer an issue when the borrowing variables are included as regressors.

and thus show the biggest residual growth, are those in a hard-hit village that did not borrow because they faced unfavourable terms of credit. In order to distinguish these households from others that did not borrow because they lived in a village that was not strongly affected by the flood one must control for the magnitude of the flood impact; this can be done at least in part by controlling for the average level of borrowing in the village.

A comparison of the estimates for the IV random effects and the ML estimates suggests that the coefficient on average borrowing for the IV random effects specification is biased to zero as expected given the sampling error associated with the measure of village average borrowing. While the coefficients on average borrowing increase in magnitude for children from both types of households, only the coefficient for the landless households is significant at the 10 % level, although the level of significance drops somewhat compared with the random-effects specification. This drop results at least in part from the fact that the ML estimator made use of lower sample sizes (see footnote 14).[17]

Finally, it should be noted that these borrowing measures are of some importance in explaining variation in growth patterns. Using the ML specification, a one standard deviation increase in own borrowing by landless households (608 Thaka) for a given level of village borrowing is associated with a 0·86 point increase in standardised growth; for a given level of household borrowing a similar increase in village average borrowing is associated with a 3·0 increase in standardised growth. These figures can be compared with the standard deviation in standardised growth for the landless households of 6·399.

While the primary interest of this study is in the relationship between borrowing and subsequent growth, examination of the other estimated coefficients is instructive. Consistent with the model, diarrhoeal disease appears to raise significantly the rental price associated with weight, thus lowering weight. The point estimates suggest that a child that has been continually sick for the previous two-week period should be one to two percentage points smaller than an otherwise equivalent well child. It should be emphasised that this coefficient does not represent the effect of illness on weight in the sense of the production function (equation 3) as it is *gross* of nutritional allocations to the child. If parents respond to the weight loss of a sick child by providing additional consumption then this coefficient would underestimate the effect of illness on weight in the production function sense. There are some differences between the landless and landed households, with the landless households showing a greater impact of diarrhoeal disease on weight, perhaps reflecting differences in the effect of illness on metabolism (i.e. through f_{w1}) or risk aversion (γ) by economic strata or perhaps of the severity of illness or access to health care.

The coefficients associated with the rice prices are also consistent with the

---

[17] The ML estimates reported here were constructed assuming that, net of household average borrowing, residual growth was not correlated across households in the same village. Table 2 also shows the results of a likelihood ratio test of this hypothesis, which was not rejected ($p = 0.303$). This result indicates that although the impact of the flood may have had a strong village component, shocks in the post-flood period were not strongly correlated across households in the same village and village-level variation in the cost of borrowing is adequately captured with the aggregate borrowing measure.

model[18] although the coefficients on rice prices for the landed households and on price growth for the landless households are not significant at conventional levels. Weight is highest in periods when the price of rice is low but rising. As discussed above, the latter result is expected because when prices are rising, given that increased consumption today will raise weight today as well as in future periods, one is given an added incentive to consume today. Note that the body remains an attractive mechanism for transferring resources across periods even though it provides a lower rate of return than other storage mechanisms (such as lending) because consumption benefits are realised immediately rather than deferred as would be the case if money were invested or grain was stored.

The coefficients on age and sex are of little direct interest; indeed with only one exception, the estimated coefficients are insignificant. It should be noted, however, that (1) the dependent variable weight growth has been standardised for sex and age, and (2) age and sex effects only enter equation (18) to the extent that they change over time (i.e. they may be thought of as being interacted with round, age or duration). Thus the significant positive coefficient on age for landless households in the ML specification indicates that older children grew more between the two rounds than did younger children. Since the log of the rental price is linear in the log of f_{et} (equation 6), one explanation is that $\ln(f_e)$ is a convex function of age so that there is less decline in $\ln(f_e)$ over the period of study for older than for younger children.

The coefficient on sex is somewhat more interesting in that it has been suggested that boys in rural South Asia are less likely to suffer during periods of scarcity than are girls (Behrman and Deoalikar, 1990; Razzaque *et al.* 1990). In the context of the model this effect might arise if there were physiological differences in the production function for boys and girls that differentially altered their respective rental prices over the period of study, as might be the case, for example, if the effect of calories on standardised weight changed differentially with age for boys and girls. More plausibly, there may be differences in the extent of risk aversion with respect to boys and girls (i.e. $\gamma_m > \gamma_f$) so that parents smooth the weight of male children more completely. The absence of a significant sex effect suggests this is unlikely to be the case. Indeed, a test that the data for boys and girls could be pooled was not rejected ($p = 0.260$ and $p = 0.988$ for landed and landless households, respectively); through not significantly different, the point estimates for landed households are consistent with the hypothesis that risk aversion is greater for boys although the effect is in the opposite direction for the landless households.

A final issue relates to the simplifying assumptions made in constructing the linearised Euler equation (14). Of particular concern in this regard is the assumption that the rate of depreciation is not influenced by body size ($f_{wwt} = 0$) because one might expect that 'catch-up growth' will produce a

---

[18] The prices are incorporated in nominal terms. An anonymous referee has correctly pointed out that given that x_{jt} is being used as a numeraire, prices should be deflated using a CPI or other similar index computed on an annual basis (monthly CPIs would incorporate rice-price variation). Because prices enter equation (18) in logs and rates of change, parameters other than the constant term are not affected by inflation that is constant over the relevant period.

correlation between levels of borrowing and subsequent growth. The argument is that even in the absence of credit market imperfections there will tend to be a correlation between borrowing and weight in the immediate post-flood period. If this correlation is positive[19] and if, as a result of catch-up growth, children that weigh less in the immediate post-flood period tend to grow more over the subsequent period, then a spurious negative correlation between borrowing and growth could result.

This concern may be addressed. First, the weight production function (equation 3) embodies a measure of biological catch-up growth (assuming $f_{wt} < 1$) even when the rate of depreciation is constant: for a given level of consumption and illness, growth is a downward sloping linear function of body size with a slope of $f_{wt} - 1$. Thus, the restriction $f_{wwt} = 0$ does not rule out a simple form of catch-up growth. Second, even if a more complex form of catch-up growth were present and weight and borrowing were positively correlated, it is not clear why one should expect to see opposite effects on growth of own village average borrowing. Indeed, a simple regression of initial weight on household and village average borrowing for the landless households yields positive but insignificant coefficients on both variables.[20] This result makes it seem unlikely that the relationship between weight and the borrowing variables is responsible for the observed significant coefficients obtained from the Euler equation estimates.

Third, it is not obvious that plausible forms of catch-up growth will result in a negative covariance between weight and subsequent growth. While *given consumption* low-weight children will grow faster than high-weight children, an implication of the model is that consumption will be importantly influenced by the extent of catch-up growth; catch-up growth may thus have quite the opposite effect on the relationship between weight and growth. Assume, for the sake of argument, that time $t-1$ is a period when prices are low and rising and time 0 is a period when prices are high and falling, implying that $w_t > w_1$. Implicitly differentiating equation (13) yields:

$$\frac{d\Delta_{t-1} w_1}{dw_1} = \frac{\dfrac{p_{t-1}(1+\hat{p}_{t-1})f_{wwt}}{\pi_t} + \dfrac{p_0(1+\hat{p}_0)f_{ww1}}{\pi_1}}{-\gamma + \dfrac{p_{t-1}(1+\hat{p}_{t-1})f_{wwt}}{\pi_t}}$$

$$= \frac{p_0 p_{t-1} f_{ww1}[R(\hat{p}_0 - \hat{p}_{t-1}) + (1+\hat{p}_0)(1+\hat{p}_{t-1})(f_{w0} - f_{wt})] - p_t(f_{wwt} - f_{ww1})\pi_1}{\pi_1(-\gamma\pi_t + p_{t+1}f_{wwt})},$$

(19)

where the denominator must be negative to ensure that equation (13) characterises an interior maximum. While little is known for certain about the shape of the weight production function, one plausible model is that catch-up growth only becomes important at low levels of weight.[21] The idea is that at

[19] For landless labourers in these data the correlation is positive ($\rho = 0.02$) but insignificant ($p = 0.662$).

[20] The regression equation is $w_{ft1} = 8.29 + 0.053 b_j + 0.231 \bar{b}_j$; the p-value for the joint test of significance is 0.700.

[21] This specification was suggested by an anonymous referee.

intermediate levels of weight, given consumption, initial weight has little effect on growth (i.e. $f_{wt} \approx 1$) but at low levels of weight, growth is quite responsive to the level of weight ($f_{wt} < 1$). Assuming in addition that growth is non-increasing in weight for high-weight individuals, this model implies $f_{wwt} > 0$ and $f_{wwwt} < 0$ and thus, using equation (19), that low-weight children grow *less* than average ($d\Delta_{t-1} w_1/dw_1 > 0$). Intuition for this surprising result may be gained by noting that if body size has a negative impact on growth then fewer resources are required to maintain a child at a low weight than at an intermediate weight, giving households less of an incentive to increase body sizes during surplus periods. Given the above conditions on the weight production function this effect is stronger for poor households than for better-off households and thus poor households will exhibit lower weight variability. More generally if cross-sectional and intertemporal weight variation is small, equation (19) implies that catch-up growth effects will be of second order regardless of their sign. In view of this and the previous arguments it seems unlikely that the main results of this paper may be attributed to catch-up growth.

It should be noted, however, that even if catch-up growth is not primarily responsible for the observed relationship between borrowing and residual weight growth, the costs of any reductions in body size resulting from credit market imperfections will be diminished by the relatively rapid recovery that can be expected during periods of surplus if catch-up growth is important. Thus even if catch-up growth does not importantly affect the conclusion that credit market imperfections are present, it may well play an important role in the evaluation of the welfare costs of these market imperfections.

IV. CONCLUSIONS

This paper has attempted to characterise the role of credit markets in smoothing fluctuations in the weights of young children following a severe economic shock and has provided both methodological and substantive insights. The key methodological contributions of this paper involve showing how data on anthropometry can be used to study intertemporal resource allocation decisions in general and credit market structure in particular.

The principal substantive conclusions have to do with the effectiveness of existing mechanisms in rural Bangladesh during periods of extreme scarcity such as those caused by the flood of 1988. The analysis suggests that existing mechanisms were partially effective in reducing the impact of the flood on child weight in the better-off households. Both landless and landowning households made substantial use of credit to meet consumption needs during the post-flood period. However, evidence also suggests that the costs of borrowing varied across villages and economic strata, and that, as a result, children in the landless households were especially vulnerable to the conditions created by the flood.

Because the high cost of transferring resources between periods appears to be an important contributor to fluctuations in child growth in the poorest

households, small-scale credit programmes targeting these households may provide significant benefits in terms of reduced fluctuations in child growth. Moreover, since these fluctuations are symptomatic of a more general problem, it is likely that benefits will extend into other aspects of household welfare. A household that finds it necessary to reduce food consumption during the slack season is also likely to find its economic activities curtailed by the high cost of credit during certain periods of the year. By implication, longitudinal analysis of fluctuations in child growth may provide an important mechanism for evaluating the success of credit and savings interventions that target poor households.

University of Pennsylvania

Date of receipt of final typescript: August 1994

REFERENCES

Ahmad, K. U., Huda, Mhd. N. and Nath, P. C. (1977). *Nutrition Survey of Rural Bangladesh 1975–76*. Dhaka: Institute of Nutrition and Food Science.

Behrman, J. R. and Deoalikar, A. B. (1988). 'Health and nutrition.' In *Handbook of Development Economics, Volume 1* (ed. H. Chenery and T. N. Srinivasan). Amsterdam: North Holland.

Behrman, J. R. and Deoalikar, A. B. (1990). 'The intrahousehold demand for nutrients in rural south India: individual estimates, fixed effects and permanent income.' *Journal of Human Resources*, vol. 25:4, pp. 665–96.

Bentler, P. M. and Dijkstra, T. (1985). 'Efficient estimation via linearization in structural models.' In *Multivariate Analysis VI* (ed. P. R. Krishaiah). Amsterdam: North Holland.

Dasgupta, Partha (1994). *An Inquiry into Well-Being and Destitution*. New York: Oxford University Press.

Deaton, A. and Muellbauer, J. (1980). *Economics and Consumer Behavior*. Cambridge: Cambridge University Press.

Foster, S. O. (1989). 'Flood evaluation', manuscript.

Grossman, M. (1972). *The Demand for Health*. NBER Occasional Paper 119.

Hayashi, F. (1988). 'Tests for liquidity constraints: a critical survey.' In *Advances in Econometrics*, Fifth World Congress, volume II (ed. Bewley Truman), pp. 91–120. New York: Cambridge University Press.

Mace, B. J. (1991). 'Full insurance in the presence of aggregate uncertainty.' *Journal of Political Economy*, vol. 99(5), pp. 928–56.

Maloney, C. and Ahmed, A. B. Sharfuddin (1988). *Rural Savings and Credit in Bangladesh*. Dhaka: University Press Limited.

Miron, J. (1986). 'Seasonal fluctuations and the life cycle–permanent income model of consumption.' *Journal of Political Economy*, vol. 94(6), pp. 1258–79.

Morduch, J. (1990). 'Risk, production, and saving: evidence from Indian households.' Harvard University (draft).

Morduch, J. (1991). 'Consumption smoothing across space: tests for village-level responses to risk.' Harvard University (draft).

National Center for Health Statistics (NCHS) (1977). 'National Center for Health Statistics growth curves for children's birth–18 years, United States.' In *Vital and Health Statistics, Series II*, Data from the National Health Survey no. (PHS) 78-1650. Washington D.C.: NCHS, US Dept of Health, Education and Welfare.

Paxson, C. H. (1993). 'Consumption and income seasonality in Thailand.' *Journal of Political Economy*, vol. 101(1), pp. 39–72.

Phillips, J. F., LeGrand, T. K., Koenig, M. A. and Chakraborty, J. (1993). 'The effects of a maternal and child health – family planning project on infant and child mortality in Matlab, Bangladesh.' Manuscript.

Prader, A., Tanner, J. M. and von Harnack, G. A. (1963). 'Catch-up growth following illness or starvation: an example of developmental canalization in man.' *Journal of Pediatrics*, vol. 62(5), pp. 646–59.

Razzaque, A., Alam, N., Wai, L. and Foster, A. (1990). 'Sustained effects of the 1974–5 famine on infant and child mortality in a rural area of Bangladesh.' *Population Studies*, vol. 44, pp. 145–54.

Rosenzweig, M. R. and Wolpin, K. I. (1993). 'Credit market constraints, consumption smoothing and the accumulation of durable production assets in low-income countries: investments in bullocks in India.' *Journal of Political Economy*, vol. 101(2), pp. 223–44.

Strauss, J. and Thomas, D. (1994). 'Human resources: empirical modeling of household and family decisions.' Forthcoming in *Handbook of Development Economics, vol. 3* (ed. T. N. Srinivasan and J. R. Behrman). Amsterdam: North Holland.

Townsend, R. M. (1994). 'Risk and insurance in village India.' *Econometrica*, vol. 62(3), pp. 539–92.

Udry, C. (1993). 'Risk and insurance in a rural credit market: an empirical investigation in Northern Nigeria.' *Review of Economic Studies*, forthcoming.

Zeldes, S. P. (1989). 'Consumption and liquidity constraints: an empirical investigation.' *Journal of Political Economy*, vol. 92(2), pp. 305–46.