Dedicated

to

My Beloved Parents

and

Dear sister Rajeswari

THREE ESSAYS ON THE ECONOMICS OF HOUSEHOLD BEHAVIOUR IN DEVELOPING COUNTRIES

By

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ABSTRACT

The first two Essays in this thesis deal with the issue of intra-household allocation of resources among children in India. In the first Essay, we present an analysis of gender patterns in consumption within the household, utilizing a unique panel of data on rural households. We find that female children get fewer resources than male children, as reported in the literature, by estimating Engel curves for various goods. We then hypothesize that this may be due to a wealth-effect associated with female children, since in India parents spend a considerable amount of resources on the marriages of their daughters. One more female child in the household increases the marginal utility of wealth in this context, since female children reduce life-time wealth. Invoking the assumption used in modern theories of life-cycle consumption that households seek to equalize the marginal utility of wealth over time, and utilizing the panel nature of our data, we model the (marginal utility of) wealth-effect as an unobserved household-specific fixed effect that stays constant over time. We then estimate our Engel curves with controls for the unobserved fixed effect to find that the bias in favour of male children that we observe in our levels equations vanishes in the fixed-effects version. This result supports our prediction that the bias against female children that we observe in the data is due mainly to the wealth-effect (or high marriage costs of female children).

In Essay 2, we formalize the ideas presented in Essay 1 with a simple three-period model of intra-household allocation. We allow for the possibility that parents may have preferences towards male children, as an alternative to the wealth-effect motive outlined above. The model yields many intuitive and testable predictions on changes in household consumption around the birth of children. Based on the same data used in the first Essay, we find that for the wealthy households in our sample the wealth-effect motive dominates parental preferences. These households reduce their total expenditures soon after a female birth, in order to save for the anticipated marriage costs in the future. Our analysis of the data from a marriage survey for the same households shows that the savings estimates that our results suggest match up with the marriage costs for female children in these wealthy households. Our results for the poorer households in the sample weakly support the parental preferences hypothesis.

The last, self-contained, Essay presents a theory of urban-rural remittances in developing countries. The framework here is similar to one in the literature on the economics of the family: the interaction between the rural family and the (self-interested) migrant is formalized as a simple game. We show that migrants remit only if remittances are used in augmenting the family bequests. It is also shown that they remit only if their incomes fall within a certain interval, given the rural incomes: intuitively, rich and poor migrants do not remit because their behaviour is conditioned by parental bequests. Our comparative static predictions show that remittances are non-monotonically related to the migrant's and rural incomes, and the family's initial stock of bequests.

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ESSAY 1

Gender-Bias in Intrahousehold Allocation: The Importance of Household Fixed Effects

1. Introduction

The allocation of resources within the household has become an important research issue in recent years. Any analysis of the distribution of income across households could present a wrong picture if there are inequalities in the distribution of resources within households[1]. There is considerable evidence that resources are not allocated randomly within households, and that the distribution of resources, pecuniary as well as non-pecuniary, is unequal within the family. Such an unequal distribution of goods usually takes the form of a bias against females or children, especially in some poor countries.

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1. Haddad and Kanbur (1990) discuss the implications of intra-household inequality for inter-household inequality. They present evidence that the neglect of the former leads to an underestimation of the latter.

There is a vast literature on the existence of gender-bias in different parts of the world, including Africa, Asia, and Latin America. In India, for example, mortality rates and other anthropometric outcomes indicate that there is a bias against girls in the intra-household allocation of food (Bardhan (1984), Behrman (1988), Das Gupta (1984), Deaton (1987, 1989), S.Subramanian and Deaton (1991), Harriss (1990), Rosenzweig and Schultz (1982), Sen (1984), Sen and Sengupta (1983)).[2]

While the evaluation of the standard of living of a household as a unit can be done on the basis of household-level data, the measurement of the welfare of each individual within a household poses a difficult problem since household surveys do not usually provide any information on the consumption of each individual. Further it is problematic to assign a particular level of consumption to each individual since many commodities are consumed jointly within the household. In the case of food, there are many nutrition surveys[3] that collect individual data based on 24-hour recall information. Such surveys, however, do not collect data on other goods at an individual level. Almost all the studies on gender-bias in intra-household allocation are based on nutrition surveys;

2. In the Indian case, North-South distinction seems to be important in explaining gender bias in intra-household allocation of food. See Harriss (1990).

3. The Indian data set used in this study also has a nutrition survey (see Behrman (1988)). Pitt, Rosenzweig and Hassan (1990) utilize a nutrition survey from Bangladesh to look at intra-household allocation of resources.

only a few studies[4] look at household level consumption expenditure data to examine the presence, or absence, of inequalities within the household.

The goals in this essay are two-fold. First, to determine the pattern of intra-household allocation by looking only at household level consumption data. Second, to look for a rationale, within the framework of the modern approach to intertemporal allocation, as to why parents may discriminate between male and female children in the intra-household allocation of resources, in some countries or settings. For this purpose, we use a unique panel of consumption data from India, collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) as a part of its Village Level Studies (VLS) programme.

Our approach is to estimate several Engel curves to test for the effects of gender on consumption patterns. In a typical Engel curve relationship, total household expenditure is held constant. Under this method, it is possible to test for the impact of gender only on the composition of demand. For example, if we take two households with the same total outlay to spend, then only the composition of demand can

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4. Deaton (1987, 1989), Haddad and Hoddinott (1991), and S.Subramaniam and Deaton (1991) use household level consumption data to look at gender patterns in intra-household allocation.

change with the gender-composition of the household (since total expenditure, or outlay, is held constant, spending less on one good means more expenditure on some other good). Therefore we estimate equations in which total household income is included as a major explanatory variable instead of total household expenditures. This could capture any gender-bias in intra-household allocation that comes from parental consumption and saving behaviour following the birth of a child. For example, if the child born is a girl, then parents may start a life-cycle savings plan in order to meet marriage expenses[5] at a later date. In such cases, the presence of an additional girl in the household may lead to a reduction in total household expenditure (conditional on total household income) and also to a reduction in its major component, food expenditure.

The cross-section Engel curve equations with household income as the main explanatory variable indicate that male children receive more resources than female children in the case of food, with the result more pronounced for young male children. These cross-section equations are useful only for determining the pattern of intra-household allocation. In order to model parental behaviour, as outlined above, pertaining to the intertemporal allocation of resources within the household, we control

5. See Miller (1980) for some anthropological evidence on marriage payment practices among propertied and unpropertied classes in India. Here again, considerable regional (and to a certain extent, caste) differences are present. In Essay 2, we present evidence on marriage costs for the households in our sample in the data used here.

for household specific fixed effects utilizing the panel nature of the data. The bias in favour of male children, which is indicated by the cross-section results, vanishes when household fixed effects are controlled.

We do not derive the estimation equations in this Essay: they are standard consumption equations with control for demographics, income and other factors. The dependent variable is the logarithm of expenditures in all the equations. Deaton (1981) estimates similar equations for determining gender patterns in allocation within the household. In order to explain the gender effects (of children) on consumption, we invoke the assumption used in modern theories of life-cycle consumption that households attempt to keep marginal utility of wealth constant when they allocate their resources over time. As we elaborate on this below, if female children cost more than male children (in the form of higher marriage costs due to dowries) then the birth of female children will have the same effect as a wealth shock. The birth of a female child in this context will increase the parental marginal utility of wealth. This will have an effect on current consumption for households with predominantly more female children, since they will embark on a new consumption-savings plan in order to meet the future marriage related expenditures (in their attempt to keep the marginal utility of wealth constant over time).

Our first step in this essay is to estimate the Engel curves for the whole data set, without taking into account the panel nature of the data with repeated observations on the same households. This is done for comparing our results with the current results in the literature. Then, in order to incorporate the marginal utility rationale given above, we exploit the panel nature of the data by estimating fixed effects equations, treating the household marginal utility of wealth as the unobserved household-specific fixed effect. Such an estimation controls for the unobserved marginal utility and gives us unbiased estimates for the demographic variables of interest.

In Essay 2, we formalize the ideas presented in this Essay by introducing a simple, three-period model of intra-household allocation of resources. We derive predictions for testing two competing hypotheses pertaining to intra-household allocation: one, that parents may have bias in favour of male children, so they may allocate more resources to them; the alternative, that parents do not have any bias, but they are simply responding to the wealth-effect associated with a female birth, by changing their consumption-saving profile. Our results in here show that parental behaviour can be explained by the wealth-effect hypothesis, for those households with high marriage costs.

The format of this Essay is as follows: in Section 2, we present a review of the related literature. Here we also present the general idea behind the estimation of

Engel curves for looking at gender patterns in consumption, apart from offering a brief review of some nutrition-based studies of the problem. Section 3 presents an outline of the structure of the estimating equations and the marginal utility hypothesis.

In Section 4, we provide a general background for panel data analysis, with two examples to illustrate the fixed effects approach. In Section 5, we discuss the sampling considerations for the ICRISAT panel and the characteristics of the study regions. Section 6 presents the estimation results, and Section 7 summarizes the findings in this Essay.

2. A Review of Related Literature

Existing studies of the intra-household allocation of goods use models in which the allocation is determined in one of the following four ways: (i) parents allocate resources based on the differential labour market returns to boys and girls - Rosenzweig and Schultz (1982), Sen and Sengupta (1983); (ii) parents allocate resources according to their own utility, which depends on the well-being of their children - an approach due to Behrman, Pollak and Taubman (1982), Behrman (1988), papers by Deaton (1981, 1987, 1989) and S.Subramanian and Deaton (1991), that are based on the demand theory approach could also be categorized under this; (iii) households allocate resources based on the productivity of individual members - Pitt, Rosenzweig and Hassan (1990); (iv) resources are allocated according to the relative bargaining power of the family members - Haddad and Hoddinott (1991) and Thomas (1990). This approach in this Essay belongs to (i) above, in that parents allocate resources to male and female children in a pure investment sense.

We first focus on the demand theory approach that is utilized in the papers by Deaton (1981, 1987, 1989), S.Subramanian and Deaton (1991), Haddad and Hoddinott (1991) for analyzing the problem of intra-household allocation of resources. Given the data limitations that we outlined above in the introduction, conventional demand theory provides us a tool: the equivalence scale procedure is a convenient mechanism with which we can compare expenditure patterns across households and link particular patterns of consumption with the demographic composition of the households. The equivalence scale measure gives the amount by which total household outlay must be increased in order to compensate a household for its size relative to some reference household. For example, if we take the reference household to contain two adults and no children, and if it costs twice as much to maintain a family of two adults and three children, the scale for the second family would have a value of 2. Or, even simpler, it gives us the ratio of purchasing power needed by two households with different composition to reach the same standard of living.

In the equivalence scale method due to Engel, the scale depends on the share of the budget spent on food. The equivalence scale for a household with children is obtained on the basis of the outlay, X_c, at which its foodshare is the same as that of a reference household without children, with a reference budget X_r. Then the ratio X_c/X_r is the Engel equivalence scale. This method implies[6] an utility function of the form:

$$U = u(q_1/m,\ q_2/m) \tag{1}$$

6. Deaton and Muellbauer (1980) and Muellbauer (1987) present the general ideas.

where q_1 is food, q_2 is an index of non-food and the deflator, m, increases with household size. The deflator m, not being a mere headcount, allows for economies of scale or for lesser needs of children. A second method for constructing equivalence scales is due to Rothbarth[7]. This method is based on the idea that expenditure on goods exclusively consumed by adults can serve as an indicator of welfare. In this method, we divide the goods into two categories, q_A, goods consumed only by adults, and q_B, all the other goods. Households with different numbers of children are at the same level of welfare if their expenditures on goods not consumed by children are the same. Thus the equivalence scale is the ratio (X_c/X_r) of outlays at which the adult goods' consumption is equalized.

Based on the second equivalence scale procedure, Deaton (1987) derives an outlay equivalent ratio (using household level consumption data), which is defined as the addition to the total outlay that would generate the same change in the expenditure on a particular good as would a change in the number of persons in a particular demographic category within the household, say one more female child in the 0-4 age group changing the expenditure on adult clothing. To derive the outlay equivalent ratio,

7. Deaton and Muellbauer (1980) provide a detailed review of this and the other equivalence scale procedures. Browning (1992) presents a review of the various different approaches to the measurement of costs of children and household welfare.

we can start with the Engel curve for good i :

$$(p_i q_i)^h = g_i(x^h, a^h, z^h) \tag{2}$$

where

$p_i q_i$ - expenditure on good i

x - total household outlay

a - a vector of demographic characteristics

z - a vector of other characteristics

h - index for the household.

Let n stand for the household size, and n_k for the number of people of type k in the household. The ratio

$$\frac{d(p_i q_i)/dn_k}{d(p_i q_i)/dx} \tag{3}$$

provides a measure of the income (or outlay) equivalent of marginal changes in demographic characteristics, since it is the total derivative of outlay with respect to n_k, with expenditure on good i fixed. If we express this measure as a ratio of total outlay per capita,

$$\pi_{ik} = \frac{d(p_i q_i)/dn_k}{d(p_i q_i)/dx}\frac{n}{x} \tag{4}$$

this measure can provide useful information about intra-household allocation[8]. For example, if good i is an adult good and k is a child category, then the π ratio must be negative. This effect is similar to an income effect, because resources are diverted away from adult goods to goods consumed by children upon the arrival of an additional child, as would be the case of a reduction in household income.

More formally, under demographic separability, we can write the demand functions for adult goods as

$$(p_i q_i)^h = g_i\{\phi(x, a_c, a_a), a_a\} \tag{5}$$

The 'a' subscript stands for adults and 'c' stands for children. The adult component, a_a, can influence expenditures on adult goods generally, but the children component, a_c, is restricted to operate through the funtion ϕ, which reflects the "real" resources available taking into consideration the size and composition of the household.

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8. We provide only the intuitive ideas underlying this approach. Deaton, Ruiz-Castillo and Thomas (1989) derive the outlay equivalent ratios from an optimizing model.

The above formulation of the demand for adult goods implies that the π ratios will be the same for all adult goods and for any demographic category in a_c[9]. That is, if good i is an adult good and k is a child category, then the equality of the π-ratios for all the adult goods (for the particular category k) comes from the fact that the presence of an additional child must exert only income effects on the demand for the good. Hence the derivative $d(p_i q_i)/dn_k$ is proportional to the derivative $d(p_i q_i)/dx$, and the π-ratios are independent of i for any given child category k. This ratio, then, will be negative for the a_c category, since children are expected to have a negative impact on adult goods expenditures. For any adult good and any individual in a_a, this ratio will be positive, since adults increase consumption of adult goods.

These π-ratios provide a convenient measure for the magnitude of the income effect of children on adult goods expenditures. If there is any gender (or age) bias in the allocation of resources against girls, π-ratios will be more negative for boys than for girls: the reduction in the expenditures on q_A goods will be greater following an increase in the number of male children than following an increase in the number of female children if there is any intra-household bias in favour of male children. Deaton (1987, 1989) computes these ratios for all adult goods and for all demographic categories

9. See Deaton, Ruiz-Castillo and Thomas (1989).

and finds that the ratios are equal for male and female children, but that prime age males get a higher share of adult goods, relative to women and older adults. S.Subramanian and Deaton (1991) present evidence, based on the π-ratio (for young children) for expenditure on tobacco is higher for males than females in India indicating that there is a pro-male bias.

By now it will be clear that this procedure is suitable only when demographic separability is satisfied. If we take a good like food, which is consumed by both children and adults, there are two offsetting effects on the π ratios: one is the positive effect, as the household size increases, the demand for food also increases, hence the ratio is greater than zero; but, since there is less available now with an increase in size, there will be a negative effect also. It is hard to decompose the total effect into its income and substitution components. Deaton (1987, 1989) and Subramanian and Deaton (1991) find that there is no sex-bias in the allocation of food.

In this Essay, our estimating equations are similar to the Engel curve equations that Deaton (1981) estimates for data from Sri Lanka. We do not estimate any budget share equations. But in Essay 2, our theoretical model, under the male bias regime (we also allow for the alternative that differential allocation of resources may be in response to the high marriage costs of female children) yields the same outcome as in the demographic-separability approach due to Deaton, Ruiz-Castillo and Thomas (1989). In our life-cycle allocation model, parents reduce adult expenditures more in response to a male birth than to a female birth, under the male bias regime.

We now turn to studies that are based on nutrition data. Studies here fall in one of the four categories mentioned at the beginning of this section. Rosenzweig and Schultz (1984) provide some evidence in support of the view that parents may not have any gender preferences, but they make their investment decisions on the basis of market signals, for example gender differential in expected returns to their investments in male and female children. They explore the possibility that economic behaviour may determine mortality differentials between male and female children. Their study, using rural Indian household and census level data, takes child survival differentials as the outcome of parental investments in children and they find that the female-male survival differentials depend on expected labour market returns to the investments in children as adults. Their evidence suggests that female children receive a larger share of household resources when women's expected employment opportunities are high.

Thomas (1990) finds that child survival differentials depend very much on who controls income within the household. Using Brazilian data, he shows that the effect in reducing the female-male survival differentials of maternal unearned income is about twenty times larger than that of paternal unearned income. These results provide some indication that public policies designed to improve labour market opportunities for women and public income transfers to women may reduce gender differences in the allocation of resources.

Behrman's (1988) generalized version of the Behrman, Pollak and Taubman(1982) model can accommodate both parental preferences and an investment based allocation of resources. In this model, parents are assumed to have a utility funtion defined over a separable subutility function (U) and some other outcomes (Z). The function U is defined over I expected health related outcomes for each of the J children:

$$U = U(H_{11},...,H_{IJ}),\ i=1,...,I \text{ and } j=1,...,J$$

Behrman specifies a CES from for the function U, in order to model explicitly the degree of parental egalitarianism towards their children:

$$U = (\Sigma\Sigma\, a_{ij} H_{ij}^{c})^{1/c} \qquad (6)$$

The parameter c captures parental inequality aversion. This model contains the Rosenzweig-Schultz pure investment case as a sub-class when $c \rightarrow 1$. Parents value all child health related outcomes equally, independent of the distribution of these outcomes. This is like the basic Becker-model: human capital investments are made without any concern for distribution among the siblings. $c \rightarrow \infty$ is the case of infinite inequality aversion, where parents value only the improved health of the worst-off child. The a_{ij} parameters are the parental weights on each child's health related outcomes. For example, equal concern is the case in which all a_{ij} are equal for a given i. If $a_{ib} > a_{ig}$, then there is unequal concern favouring boys. He also specifies a quasi Cobb-Douglas form for the health related outcome production funtions (i.e., H_{ij}'s as functions of nutrient intakes). The application of utility maximization conditions gives a set of relations between nutrition investments and health related outcomes.

Behrman applies this model to the data used in this Essay: he utilizes the nutrition survey conducted as a part of the ICRISAT panel data collection process. The model is estimated separately for the lean and surplus (in terms of food availability) seasons to account for seasonality. Two important results emerge: in terms of parental inequality aversion, the pure investment argument is rejected: c is estimated to be 0.47. There is some evidence for parental gender preferences in the lean season: parents weigh an identical health-related outcome for male children 5% more favourably than that for female children. But parental behaviour is compensatory in the surplus season, since c is estimated to be -1.74.

Behrman and Deolalikar (1990) come to similar conclusions by estimating price elasticities of demand for nutrients, using the ICRISAT nutrition survey data. There is some evidence for differential responses of male and female nutrient intakes to changes in food prices. Estimated price elasticities of nutrient intakes are significantly lower for females than for males. These lower (and negative) values indicate that females will disproportionately bear the burden of higher prices during lean seasons or in drought conditions. They also control for community, household, and individual fixed effects.

Pitt, Rosenzweig and Hassan (1990) present a model of intra-household allocation that is based on the efficiency wage hypothesis. The idea is that if the possibility of employment, or the wage rate conditional on employment, depends on the worker's health status, a poor family may maximize its returns if food and other inputs are distributed unequally towards those who can turn it into higher incomes. So households allocate food according to the intensity of work effort exerted by each individual. They present evidence that individuals, in some demographic categories who participate in effort-intensive, high wage labour market activities (prime age males in their data from rural Bangladesh) on average receive higher allocations of food than others in the household (females, children and other males). This is another hypothesis which links economic behaviour with intra-household allocation.

3. *Model and Estimation Procedure*

Modern theories of intertemporal allocation assume that individuals attempt to keep their marginal utility of expenditures constant[10] over time. This assumption could offer an intuitive and plausible explanation for parental economic behaviour in allocating resources over time, as children come into and leave the household[11]. Parents may favour male children over female children in some social and cultural settings, India for example, because of several factors: economic contributions made by female children may be considerably less than that made by male children to the household, or returns to investments in girls may be considerably lower than for boys.

In many countries, labour market opportunities are limited for women[12]. Yet another important factor could be marriage-related financial commitments that daughters impose on their parents without any tangible returns. In such contexts parents

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10. See Browning, Deaton and Irish (1985). See also Browning (1992) for a general review.

11. In Essay 2, a simple three-period model is developed to analyze intra-household allocation of resources over time, as the demographic composition of the household changes.

12. Differential returns in the labour market, as reviewed in Section 2, seem to play a crucial role in explaining male-female children survival differentials [see Rozensweig and Schultz (1982)].

may optimally allocate the limited resources available, based on a cost-benefit calculation. Or, to put it differently, parents may view daughters as a drain on their wealth. If that is the case, a preponderance of female children will take the form of a wealth-effect: girls will increase parental marginal utility of lifetime wealth, because they may potentially reduce their parents' wealth as a result of the above factors. Then, in a utility maximizing framework, parents may be induced to reduce household expenditures following the birth of a female child, because it acts like a wealth shock. They may allocate more resources to boys (because, marginal utility is low) and fewer to girls, since they want to keep their marginal utility of expenditures constant over time.

To analyze the relationship between the gender composition and consumption patterns of households, we start from the general equation for an Engel curve

$$C_{ht} = f(Y_{ht}, a_{ht}, Z_h, \alpha_h, u_{ht}) \tag{7}$$

where C_{ht} is (log of) household consumption expenditure at time t, Y_{ht} is (log of) total household income, a_{ht} is a vector of household demographic composition and age variables, Z_h is a vector of time-invariant control variables, u_{ht} is the standard error term, and α_h is an unobserved household-specific fixed effect.

If households are assumed to keep marginal utility constant, the specification above shows an elegant way to formalize the process of intra-household allocation. The household fixed effect, α_h, can be visualized as the unobserved marginal utility of household expenditures. Let the stream of marginal utilities over time (from Period 1 to Period T) of household h be given by:

$$\alpha_{h,1},\alpha_{h,2},...,\alpha_{h,t-1},\alpha_{h,t},\alpha_{h,t+1},...,\alpha_{h,T}$$

The constant marginal utility assumption states that each period's marginal utility will be equal to some fixed α_h. Then if there is a change in the gender composition of children in household h at time t the marginal utilities can be ranked as follows:

(1) No wealth-shock: $\alpha_{h,t+1} = \alpha_{h,t-1}$;

(2) Wealth-shock: if the household has one more girl, then $\alpha_{h,t+1} > \alpha_{h,t-1}$; if the household has one more boy,then $\alpha_{h,t+1} < \alpha_{h,t-1}$.

Under such a specification, without controlling for the household specific fixed effect (α_h), one would expect to see differential gender effects on household consumption expenditures. The unobserved fixed effect biases the demographic coefficients of interest. However, once the unobserved effect is controlled for, there should not be any differences in parental allocative behaviour towards male and female children.

In order to test the above hypothesis, we estimate a levels-version and a fixed-effects version of equation (7). To be more specific, we estimate equations of the following form:

$$C_{ht} = \beta_o + \beta_M M_{ht} + \beta_F F_{ht} + \beta_Y Y_{ht} + \beta_z Z_h + u_{ht} \quad (8)$$

where C_{ht} is the log of consumption expenditure, M_{ht} and F_{ht} are the numbers of males and females in three age groups (adults, young and old children), and Y_{ht} is the log of household income. If there is pro-male bias in the intra-household allocation of resources, then we would expect to find $\beta_M > \beta_F$, that males are associated with higher consumption than females (particularly for children)[13]. We find that there is evidence for such a bias for the rural Indian sample used. However, as I have pointed out above (the marginal utility argument) this result may not necessarily indicate that boys are getting more resources, but instead that households with predominantly more girls are "poorer" and must adjust their consumption patterns over the life-cycle accordingly.

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13. Deaton (1981) estimates the same type of Engel curves for Sri Lankan data and finds that there is no evidence of any pro-male bias in his sample. In Deaton (1987), $\beta_M > \beta_F$ for prime age males and females.

Thus the finding that the coefficients for males and females are unequal is a consequence of an omitted wealth effect that is correlated with the gender structure of the household. We use the within-estimator approach[14] to control for the unobserved (fixed) wealth-effect in the Engel curves. In the fixed effects[15] version, one can no longer reject the equality of the gender coefficients, suggesting that the levels-version result favouring males is a consequence of the unobserved wealth (or the marginal utility of wealth) effect. Both the levels and the fixed effects estimates are obtained using ordinary least squares, and the random effects estimates, which are not presented, are obtained using generalized least squares.

14. In the next section, we provide a brief review of the estimation issues involved in the analysis panel data. Hsiao (1986) provides a good analysis of panel data estimation methods.

15. It should be pointed out, as an anonymous referee has suggested, that the fixed effects estimators may difference out both the transitory and permanent responses of the households to the changing gender composition. We are particularly interested if female children get fewer resources than male children, when both male and female children are present in the household. Thus, as far as children are concerned, in our model transitory and permanent responses are the same since households keep their total spending at the reduced level until the female children leave the household at marriage.

4. A Brief Review of Panel Data Estimation Methods

In this section, some econometric issues are discussed and an outline of the techniques that are useful in analysing panel data is also presented. We provide two examples in order to illustrate the application of the methods to the problem considered in this Essay.

The most important advantage of pooling cross-section and time-series data is the ability such a pooling offers us in the form of controlling for individual-specific fixed effects, effects that are specific to each cross-sectional unit. Let us consider a specific model:

$$Y_{it} = X_{it}\,\beta + Z_i\,\gamma + \alpha_i + u_{it}, \quad i = 1,\ldots,N; \quad t = 1,\ldots,T \tag{9}$$

where X and Z are 1 x k and 1 x g vectors of time varying and time invariant exogenous variables. The disturbance term u_{it} is assumed to be independently identically distributed with mean zero and variance σ_u^2. The other variable on the right hand side, α_i, is a latent individual effect and it is assumed to be a time-invariant random variable distributed independently across the cross-sectional units with variance σ_α^2.

The primary concern in the estimation of the above equation is the potential correlation of the individual specific effect with the variables in X and Z. If there is such correlation, least squares estimates of the coefficients of the above equation will be biased and inconsistent. However, if we have repeated observations for a group of individuals, as in a panel, we can control for the unobservable individual specific effect by either first-differencing or taking deviations of the data from means.

We can write the above equation in a vector form as:

$$Y_i = e\alpha_i + \beta X_i + \gamma Z_i + u_i \tag{10}$$

where Y_i is a Tx1 vector

$e' = (1,1,...,1)$, a 1xT vector

X_i and Z_i are KxT matrices

u_i is a Tx1 vector

To control for the latent effect α, we can multiply equation (10) by a Tx1 idempotent transformation matrix, given by

$$Q = I_T - (ee')/T$$

so that we have

$$QY_i = Qe\alpha_i + Q\beta X_i + Q\gamma Z_i + Qe_i$$
$$= Q\beta X_i + Qe_i \tag{11}$$

The multiplication by the Q matrix transforms data into deviations from their individual means. Equation (3) is now controlled for the individual effect α, but a disadvantage of this method is that we will not be able to estimate the effects of the time invariant variables contained in the Z matrix.

The estimates that we obtain from this procedure are known as the "fixed effects" estimates. This model is called the analysis-of-covariance model or the least-squares dummy variable model(LSDV). The estimates are also known as "within-group" estimates, because in forming the estimator we utilize only the variation within each group.

Two examples of the fixed-effects approach:

MaCurdy's (1981) paper on life-cycle labour supply under certainty is a good example of this approach. The reduced form labour supply equation in his model is given by:

$$\ln N_i(t) = F_i + bt + \delta \ln W_i(t) + u_i(t)$$

where N is labour supply, t is experience and W is the wage rate. The intercept term F_i represents a time-invariant individual specific component. F_i contains the worker's (unobserved) marginal utility of wealth as one of its components. The marginal utility of initial wealth, which stands as a summary measure of a worker's lifetime potential wages and asset income, is assumed to stay constant through time but to vary across workers. It is clear that the wage/earnings term is correlated with the unobserved marginal utility wealth, but the problem here is that there is no suitable instrument for W_i. But if we have panel data, we can difference out the F component. MaCurdy uses the PSID data and estimates the equation by first differencing it and thus controlling for the unobservable individual specific effect.

As the second example, we can consider the estimation of a simple production function relationship. Suppose we have data on some agricultural output for several farms for several years. We estimate an equation in which the dependent variable is the output, and the explanatory variables are all the relevant inputs. However, in addition, a relevant explanatory variable is also the quality of soil, which is an unobserved farm-specific factor. The covariance model can control for this unobserved input and thus we can obtain consistent and unbiased estimates of the production function.

For our analysis, we utilize the fixed-effects procedure to obtain consistent estimates of the Engel curve relationship. In this case, the unobservable effect is household-specific. We have data for nine years for each household, so we can model the household specific effect as staying constant through time but varying across households. We estimate equations of the form:

$$Y_{ht} = \alpha_h + \beta X_{ht} + U_{ht}$$

where the h subscript stands for household and α_h component is the household-specific effect which we do not observe. We can characterize this effect as representing the marginal utility of expenditures of households. That is, if we assume that parents allocate expenditures intertemporally among their children so as to keep the marginal utility of expenditures constant, we can model the relationship as given above. We can control for this unobserved effect by utilizing the panel nature of our data and the fixed effects method.

In the above model, α, the individual specific variable, is treated as a fixed effect. But, in the "random-effects" or error-components model, we treat α as a random variable, rather than as a fixed effect, because it does not seem reasonable to treat one unobservable variable(α) as fixed but another unobservable variable (U_i's, the disturbance term) as random. In this model, the residual in the regression equation, V_{it}, consists of two components:

$$V_{it} = \alpha_i + U_{it}$$

If we follow this assumption, we will be able to estimate the effects of the time-invariant variables also. It is not always easy to decide if the effects should be fixed or random. The problem with the Random Effects model is that if the cross-sectional characteristic is correlated with the included explanatory variables, then the resulting estimates are biased and inconsistent. On the other hand, the problem with the Fixed Effects model is the loss of efficiency since we increase the number of parameters to be estimated. But, we can estimate the model in both ways and do a specification test (due to Hausman) to see if the fixed effects estimates are significantly different from the random effects estimates. The null hypothesis for this test is that there is no correlation between the cross-sectional characteristic and the included explanatory variables, against the alternative that they are correlated. Under the null, the Random Effects estimates should not be very different from the Fixed Effects estimates.

In our analysis below, we estimate both the Random Effects (which is a GLS model, with N by T observations, taking into account that each household is observed T times) and the Fixed Effects models. Then we do the Hausman tests to compare the two sets of estimates, and show that they are different in our case.

5. ***Data, Sampling Considerations and Characteristics of the ICRISAT Study Regions in India***

The regional focus of the present study is on the Southeastern and South-Central parts of India, most parts of which are classified as Semi-Arid Tropical (SAT) regions. In agroclimatological terms, SAT includes any tropical region where rainfall exceeds potential evaporation four to six months of the year. Much of peninsular India is semi-arid tropical in nature, and so are large parts of the state of Andhra Pradesh and Maharashtra (in which the panel villages are located). SAT India has not derived much of the benefits of green revolution in wheat and rice that was instrumental in the agricultural development of much of South Asia. The type of agriculture practiced is mainly dryland (or unirrigated) agriculture, so rainfall uncertainty is a major hurdle in the production process.

With the main objective of understanding the dynamics of agricultural development and the economics of production relations in SAT India, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)[16] initiated the process of studying the agricultural conditions in three contrasting regions in 1975. The study

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16. Walker and Ryan (1990) provide more background information about the study regions and ICRISAT's other projects. They also offer a compilation of the various different studies that were conducted using ICRISAT's data sets.

regions (or districts) were chosen on the basis of cropping, soil and climatic criteria: two of these districts, Akola and Sholapur, are in Maharashtra and the third district, Mahbubnagar, is in Andhra Pradesh (see Map). All the villages in these three dryland SAT regions depend very much on rainfall for agricultural operations. Farmers decide about their planting operations based on past record and expected onset of monsoon. In Mahbubnagar and Sholapur rainfall is not assured, but in Akola rainfall is more certain. The first two regions are technologically stagnant, but Akola has experienced some technical change in dryland agriculture. The distribution of land ownership is more equal in Sholapur and Akola than in Mahbubnagar. In terms of village-level infrasturucture, there is not much difference among the villages in the study regions: they all have similar facilities and a well-functioning auction system in the regulated market for the sale of agricultural products. Caste hierarchy is clearly defined in all the villages, and the system is rigid in some of the villages in the three regions.

Data and Sampling Considerations:

The sample of households in the panel (the Village Level Studies data set - VLS) was selected in three stages: first, some smaller administrative units, known as talukas, within the districts were chosen on the basis of some secondary data; second, two representative villages were chosen from each district; and third, a random sample of

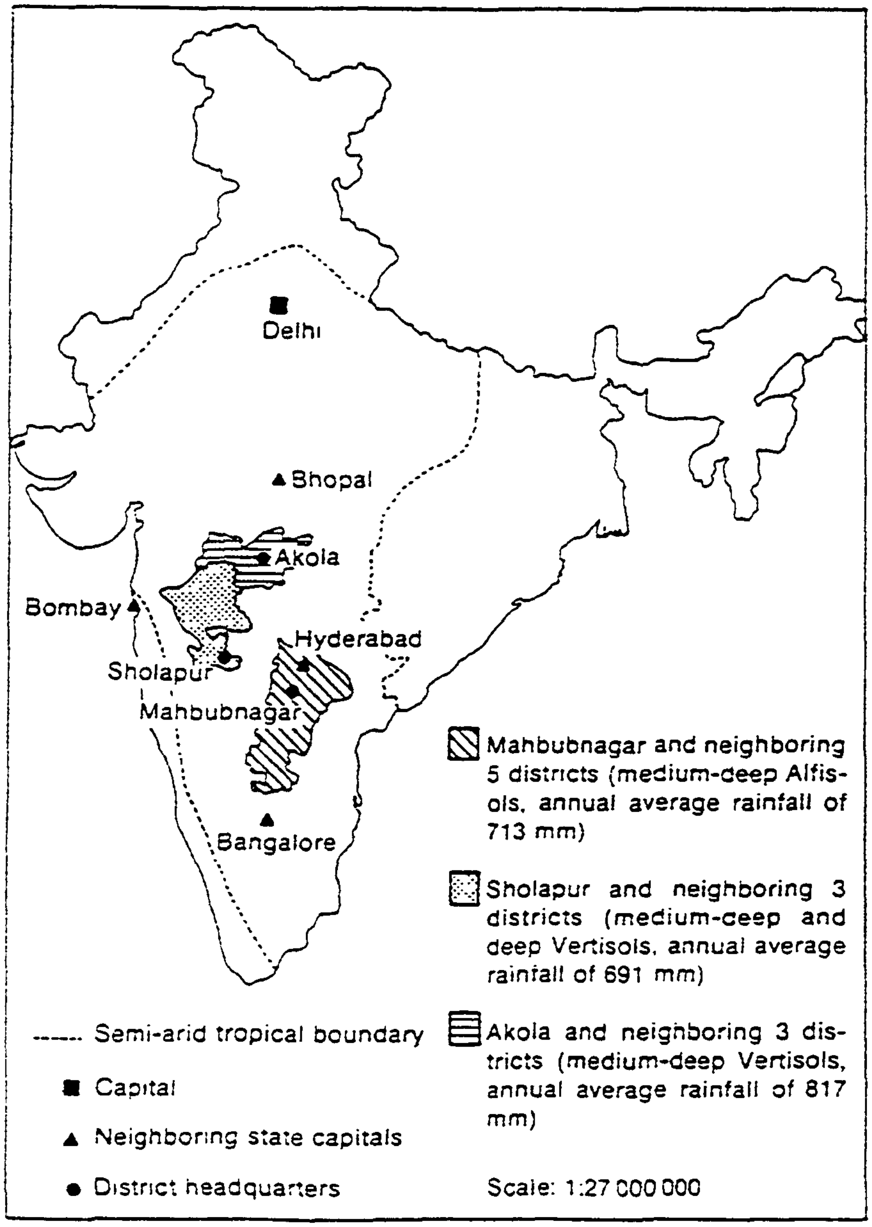

Figure Location of India's semi-arid tropics and the three study regions in 1975

SOURCE: Walker and Ryan (1990)

agricultural households was chosen from the villages. ICRISAT surveyed every household in each village in early 1975, and based on this survey, a sample of forty agricultural households was selected from each village. Within each village, a sample of thirty cultivator and ten landless labour households (with less than 0.2 hectares of land) was drawn. The cultivator-households were stratified into three groups on the basis of operated landholdings: small households were those with 0.2 - 2.0 hectares of operated land, medium households were from 1.2 - 3.2 hectares and large farmers were defined as holding more than 3.2 hectares of land.

Detailed household-level data were collected in only one village within each district. Thus, we have data for three villages for ten years: the villages are referred to as follows - Aurepalle (in Mahbubnagar) is Village 1, Shirapur (in Sholapur) is Village 3, and Kanzara (in Akola) is Village 5. Of the original sample of 120 households, 16 emigrated from the villages during the sample period - most of these are labour households who left the villages for employment in urban areas. The VLS panel thus contains data on 104 continuous households for a period of ten years from 1975-84. The panel has three data bases[17]: a village base, with data on village level prices, rainfall and other general information; a household data base, with data on assets, income, food and

17. See Walker and Ryan (1990).

non-food (non-durable) consumption, investment, and labour supply; and a plot data base, with data on cropping patterns, input utilization and other details. Data on household transactions were collected at three-to-four-week intervals and other data on landholdings, credit and debt standings of the households and household composition were collected once at the beginning of each year. In addition, many special purpose surveys were also conducted during the study period: a nutrition and health survey was carried out for two years from 1976-78, a survey of retrospective land market transactions and human fertility in 1980, a retrospective family history survey in 1984, a survey on common property management in 1984, a retrospective survey on inheritances in 1984 and a retrospective survey on marriages in 1984. In Essay 2, we use the retrospective survey on marriages, in addition to the consumption data in the panel.

In this Essay, we utilize the household data base in the VLS data set. Household data on food expenditures were collected for all the years during 1975-84, but non-food expenditure data were not collected in detail in 1976 or after 1981. Therefore, in order to maintain consistency, since we look at the impact of demographic variables on the components of total expenditures, we use the data for food and total consumption expenditures for the period 1976-81. In addition, out of the 104 continuous households in the panel, we drop 5 from our analysis: two households are single person households, and in 3 households many children were living outside the village during the panel period.

The VLS data are considered to be of reliable quality. The panel and some of the special purpose surveys have been used by a number of authors to study an array of problems pertaining to the village economy: Rosenzweig (1988) on consumption smoothing, Atkeson and Ogaki (1991) on intertemporal substitution in consumption, Bhargava and Ravallion (1991) on permanent income hypothesis, Rosenzweig and Wolpin (1993) on production relations, Morduch (1990, 1991) on risk-sharing, consumption smoothing and saving, and Townsend (1991) on risk and insurance. Some of the nutritional studies are reviewed in Section 2 in this Essay.

6. *Analysis of Estimation Results*

In this section, we first start with presenting some descriptive statistics for the ICRISAT data. We then discuss briefly the different methods that have been followed in the literature for parametrising the effects of children in the estimation equations. The next part of the section is devoted for analysing and discussing the estimation results.

Table 1 presents some descriptive statistics for the variables used in estimation. I use the food price index to deflate nominal food expenditures and the general price index to obtain real income and real total expenditures. The share of food in total expenditure is around 70% for all the three villages. The 6-year standard deviation in household food expenditures is proportionately less than that in household incomes. Household mean incomes show considerable fluctuations over the sample period, given that both crop revenues and (agricultural) labour earnings both fluctuate depending on the monsoon conditions in the regions. The average household size is 6, and the average total number of children (age 0-15) is 2.5. Female children, on average, are about 1 year younger than male children in these households.

6.1 A Note on Parametrising the Effects of Children in the Estimation Equations:

In studying the effect of children on household consumption behaviour, one of the most important issues is the way in which such demographic effects are specified in the estimating equations. We have a number of different characteristics that are important - the number of children, their ages and, the most important in our study, their sex. In the literature[18], many combinations of these characteristics have been used in specifying the ways in which children affect household welfare.

A starting point is to include only the number of children, regardless of their age (or sex). This variable does not allow for any economies of scale in the Engel curves. A second approach would be to put in many dummy variables, for the presence of one child, or two children etc, with the objective of allowing for some non-linearity in the impact of children on household outlays. The ways in which the children variables enter the Engel curves will affect the household equivalence scales significantly. Browning (1992) discusses the possible candidates and their merits. Banks and Johnson (1993) show that the Engel food-share scales vary from 1.11 to 1.85, depending on which children variable they use, in their British Family Expenditure Survey data set.

18. Browning (1992) provides a review of a number of empirical studies that deal with this issue in different ways. Banks and Johnson (1993) look at the various possible ways of including the children variables.

In the present study, we look at two age-bands, 0-4 and 5-15, and include the numbers of male and female children separately in these age bands. We also include the mean ages of male and female children, and the square root of the mean ages (to allow for some non-linearity) in order to smooth out the discrete break between the two age groups. We also present the results with just the numbers of male and female children, without any age break.

6.2 Analysis of Estimation Results:

In this sub-section, results from the estimation of equation (8) are presented. In this equation, apart from the numbers of children in the two age bands, their mean ages and square-root of mean ages, we include the numbers of adult (age > 15) males and females separately. These variables account for the changing gender and age composition within the households over time. Household income in period t is another important control variable that is included. The vector Z_h contains a number of village (2 - Villages Kanzara and Shirapur are included), household caste (low and medium castes are included and high caste is dropped) and time (1981 is dropped) dummy variables.

Table 2 presents the estimation results for 4 equations. I first analyse the levels-version results: in equation (2.1) there are four children groups and equation (2.2) is a restricted version of (2.1). The most important thing to note in these two equations is the significant positive effect for all the male groups. Female children in the age group 0-4 do not have any significant effect on food expenditures in (2.1), and in (2.2) when female children are aggregated, they do not have any effect. Table 4 presents the F-test results for equality of gender effects in the levels and fixed effects equations for food expenditures. In (2.1) there is a significant difference between male and female children in the 0-4 group [F(1,568)=4.10, p=0.041], but not for the 5-15 age group. However, the overall difference is significant in (2.2) [F(1,570)=3.40, p=0.064]. This result may support Behrman's (1988) finding based on the ICRISAT nutrition survey[19] that female children on average get less nutrients than boys (during lean seasons). But one must always be cautious in interpreting the result obtained here: it does not imply directly that girls get fewer nutrients than boys, but it does reveal that girls do not have any significant effect on food expenditures.

19. As discussed in Section 2, Behrman and Deolalikar (1990) find that females have lower price elasticities of demand for nutrients than males in the ICRISAT nutrition survey data.

In both the equations, the difference between adult males and adult females is strongly significant. Most of the other variables are significant in (2.1) and (2.2): the income elasticity is around 0.29 (a 10% increase in income leads to a 2.9% increase in food expenditures). Of the age variables, both the male children age variables are significant. The village dummies are also significant. In Essay 2, we look at the interaction between household wealth (as measured by land holdings) and the effect of children on consumption in detail. There we show that gender differences are more pronounced for the medium and large landed households than for the other two categories, in terms of the wealth-effect motivation that we present here.

In the first two columns of Table 2, there is no control for the unobserved household fixed effect, α_h, which is characterized as the parents' marginal utility of wealth. Columns 3 and 4 of Table 2 present the fixed effects estimates which control for the fixed effects by estimating the model in deviation form (or, the within-estimator approach). In equations (2.3) and (2.4), no male children group has any significant effect on food consumption, with the only significant effect being that of female children in the 5-15 group. The F-test results presented in Table 4 show that there is no difference between male and female children, with controls for fixed effects: the bias in favour of male children, which is present in the levels equations, vanishes with control for the unobserved household fixed effect. If the household fixed effect is not controlled for, one would conclude, as in most of the literature, that parents have a pro-male bias in the intra-household allocation of food. But the results here clearly suggest that, with appropriate controls for the wealth-adjustments that parents make, there is no gender-bias in the intra-household allocation of food over and above the impact of such an intertemporal adjustment. There is no significant difference between adult male and female groups. The male age coefficients are significant and income is still significant; however, the effects of the time-invariant variables cannot be observed in the fixed-effects version.

In order to test the hypothesis that parents may be forced to reduce total household expenditures (hence, food expenditures), we have estimated the above equations with total expenditure as the dependent variable. The estimation results are presented in Table 3 and the F-test results are presented in Table 5. There seems to be some support for this hypothesis, at least for young children. Male children significantly increase total expenditures whereas female children do not have any effect and there is a significant difference between them [$F(1,568)=3.54$, $p=0.057$]. However in the case of older children, female children significantly increase expenditures but male children do not have any effect. The income elasticity here is around 0.30, and many of the fixed variables are significant. As in the case of the food expenditure equations, the results change in this case also when we control for fixed effects. In equation (3.3), both the adult variables are significant and so is the female children (5-15) group. Young male children are no longer significantly different from young female children, with control for fixed effects.

Next, we present some test statistics for comparing across the OLS, random effects (GLS) and the fixed effects models, in Tables 6 and 7. The F-test results presented in the first row in Table 6 clearly favour the hypothesis that the household fixed effects are highly significant in both food and total expenditure equations. These results were obtained by estimating the four equations with 98 household dummies. The second row presents the results to test for the hypothesis that there are no error components (random effects vs no effects): these are also highly significant. The random effects estimator is a GLS estimator which accounts for the fact that the households are observed 5 times during the program. The OLS results (which treat the data in a cross-section framework, ignoring the panel feature) are presented here for purposes of comparison with the cross-section results available in the literature which suggest that there is a pro-male bias in intra-household allocation.

In Table 7, I have presented the Hausman test statistics to compare the fixed effects and the random effects results. The theoretical ideas behind this test are presented in Section 4 above. Here, the null hypothesis is that the cross-sectional (household specific fixed effect) characteristic is not correlated with the included explanatory variables, against the alternative that they are correlated. If the null hypothesis is accepted (equality of Random and Fixed effects coefficients), then it would indicate that the unobserved cross-sectional characteristic does not bias the other coefficients. The Hausman test values, presented for the demographic variables (children) of interest, however, clearly demonstrate that the fixed effects estimates are significanlty different from the levels estimates for both food and total expenditures. Thus the null hypothesis of no correlation is rejected in favour of the alternative. The fixed effects-controlled estimates presented above indicate that there is no bias in the allocation of resources within the household, as against the levels estimates which do show that there is a pro-male bias in favour of young male children. Thus, over and above the unobserved fixed effect, we do not find any evidence of gender differentials for children in the data. Our marginal utility argument presented in Section 3 above would suggest that our cross-sectional results ($\beta_M > \beta_F$) may not necessarily mean that boys are getting more resources, but instead that households with more female children are poorer and must reduce their consumption over the life-cycle.

7. Summary and Conclusion

In this Essay, we examine the issue of gender-bias in intra-household allocation of resources from the perspective of the modern theories of intertemporal allocation. The empirical analysis is based on a panel of household level consumption data from India. Several Engel curve relationships are estimated, with household income as the first explanatory variable, to determine gender patterns in consumption. The levels-version results of this paper are in line with the findings in the literature that parents favour boys over girls in allocation of resources[20].

Based on the assumption that households seek to equalize the marginal utility of expenditures when they allocate resources, we model the parental marginal utility of wealth as the unobserved household-specific fixed effect that stays constant over time. If parents optimally allocate resources over the life-cycle, then they would reduce consumption expenditure (and increase savings) following the birth of a female child because female children increase the marginal utility of wealth. The fixed effects estimation results, based on this rationale, indicate that, once the unobserved

20. Bardhan (1984), S.Subramanian and Deaton (1991), Harriss (1990), Sen and Sengupta (1983) present evidence for intra-household disparities in food allocation in India.

household fixed effect is controlled there is no evidence of any significant gender-bias in the intrahousehold allocation of food and other resources. These results point out that the bias against female children in the intra-household allocation of resources derives entirely from the presence of the unobserved fixed effect.

The wealth-effect hypothesis proposed here and the results we obtain have important welfare implications. The results suggest that households with disproportionately more female children have lower consumption than households with more male children. To the extent that female children contribute in the form of earnings to the household pool of income, one would expect the impact of the wealth-effect on household consumption to be lower. Miller (1980) and Harriss (1990) provide some anthropological evidence that in some parts of India, dowries and marriage costs are significantly lower than other parts: for example, in the Northern parts of India, the prevalence of dowry is much higher than in the South among the unpropertied[21] groups, due to the poor labour market opportunities for women in the North. In some Southern parts of the country where wet-irrigation is practised with more earnings opportunities for women, there is a system of reverse-dowry or bride-price in existence.

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21. There is evidence that propertied groups spend a substantial amount on dowry and marriage costs throughout the country. See Miller (1980). In Essay 2, we provide a review of the anthropological evidence related to this aspect, and we also analyze the ICRISAT marriage survey data to look at dowry and marriage costs for our sample households.

Dowry, then, can be seen as a price to pay for compensating the lower earnings of women. Any policy that aims at improving the labour market opportunities for women would have the effect of lowering this price, which in turn should lead to changes at the household level. This policy implication is in line with a related finding in the literature that an increase in the earnings of women in the labour market leads to better survival chances for female children (Rosenzweig and Schultz (1982)).

In this Essay, the marginal utility of wealth argument was used to motivate the wealth-effect idea that expected future expenditures would reduce the current consumption of households with more female children. Our first step was to estimate the cross-section Engel curves to determine the gender patterns in consumption. We then suggested that the observed gender patterns may be due to the wealth-effect that is associated with female children. Our next step is to formalize this argument with a structural model, in order to derive specific predictions within an optimizing framework. In Essay 2, we provide such a framework and we also consider an alternative to the wealth-effect hypothesis: that differential allocation may be due to parental preferences in favour of male children. In terms of estimation as well, we take the approach in this Essay a step further, by estimating the changes in consumption around a birth in order to get more precise estimates of consumption responses due to wealth-effect or parental preferences.

Table 1 : Descriptive Statistics for ICRISAT Households, 1976-81[a]

Variables	Median	SD
Food Expenditure	3166.00	1523.00
Log of Food Expenditure	7.95	0.46
Total Expenditure	4617.00	2346.00
Log of Total Expenditure	8.32	0.47
Total Household Income	6188.33	5754.93
Number of adult males	1.77	0.98
Number of adult females	1.75	0.96
Number of male children, 0-4	0.39	0.67
Number of female children, 0-4	0.30	0.56
Number of male children, 5-15	0.99	0.92
Number of female children, 5-15	0.79	0.89
Household size	5.99	2.78
Mean age of male children	5.98	4.69
Mean age of female children	5.09	4.89

a. Number of observations:594; all expenditure values are in 1983 rupees.

Notes:

(1) Food also includes edible oils and fats. Non-food expenditures include: narcotics, tea, coffee, tobacco, pan, alcohol, clothing, tailoring expenses, chappals and footwear, medicines, cosmetics, soap and barber services, travel and entertainment, electricity, water charges, cooking fuel, labour expenses for domestic work and other expenses.

(2) Total household income is the sum of: net trade income, net crop income, net livestock income, net land rent, salary and wage incomes.

Table 2 : Food Expenditure Equations - Levels and Fixed Effects Estimates for ICRISAT Data:1976-81 (Dependent Variable - Log of real food expenditure)[a,b]

Variables	2.1 Levels	2.2 Levels	2.3 F.Effects	2.4 F.Effects
Males (>15)	0.112 (0.014)	0.110 (0.014)	0.084 (0.031)	0.084 (0.030)
Females (>15)	0.041 (0.015)	0.041 (0.015)	0.087 (0.024)	0.085 (0.023)
Males (0-4)	0.085 (0.023)	--	0.035 (0.026)	--
Females (0-4)	0.015 (0.028)	--	0.027 (0.032)	--
Males (5-15)	0.052 (0.019)	--	0.037 (0.030)	--
Females (5-15)	0.049 (0.019)	--	0.066 (0.031)	--
Males (0-15)	--	0.067 (0.015)	--	0.029 (0.020)
Females (0-15)	--	0.027 (0.016)	--	0.041 (0.025)
Log real income	0.295 (0.019)	0.297 (0.019)	0.163 (0.023)	0.163 (0.023)
Mean age of Male Children	0.032 (0.012)	0.028 (0.011)	0.030 (0.016)	0.028 (0.015)
Sqrt (Mean age of Male Children)	-0.089 (0.044)	-0.083 (0.041)	-0.103 (0.061)	-0.091 (0.060)
Mean age of Female Children	0.001 (0.012)	0.005 (0.011)	0.022 (0.017)	0.026 (0.016)
Sqrt (Mean age of Female Children)	-0.011 (0.044)	-0.013 (0.040)	-0.087 (0.063)	-0.087 (0.062)

Variables	2.1 Levels	2.2 Levels	2.3 F.Effects	2.4 F.Effects
Intercept	4.901 (0.157)	4.881 (0.155)	--	--
R-squared	0.677	0.676	0.193	0.192
Sample Size	594	594	594	594

a. Standard errors in parantheses; b. All the other time-invariant controls are reported in Table 8.

Table 3 : Total Expenditure Equations - Levels and Fixed Effects Estimates for ICRISAT Data:1976-81 (Dependent Variable - Log of real total expenditure)[a,b]

Variables	3.1 Levels	3.2 Levels	3.3 F.Effects	3.4 F.Effects
Males (>15)	0.092 (0.014)	0.093 (0.014)	0.064 (0.030)	0.069 (0.029)
Females (>15)	0.051 (0.015)	0.049 (0.015)	0.093 (0.023)	0.091 (0.022)
Males (0-4)	0.084 (0.024)	--	0.034 (0.025)	--
Females (0-4)	0.018 (0.028)	--	0.024 (0.031)	--
Males (5-15)	0.021 (0.019)	--	0.001 (0.029)	--
Females (5-15)	0.061 (0.019)	--	0.055 (0.030)	--
Males (0-15)	--	0.046 (0.015)	--	0.011 (0.019)

Variables	3.1 Levels	3.2 Levels	3.3 F.Effects	3.4 F.Effects
Females (0-15)	--	0.033 (0.016)	--	0.035 (0.024)
Log real income	0.304 (0.019)	0.302 (0.019)	0.137 (0.022)	0.134 (0.022)
Mean age of Male Children	0.024 (0.012)	0.015 (0.011)	0.021 (0.015)	0.013 (0.014)
Sqrt (Mean age of Male Children)	-0.052 (0.044)	-0.033 (0.041)	-0.063 (0.059)	-0.039 (0.057)
Mean age of Female Children	0.006 (0.012)	0.009 (0.011)	0.013 (0.016)	0.018 (0.016)
Sqrt (Mean age of Female Children)	-0.036 (0.044)	-0.034 (0.040)	-0.051 (0.061)	-0.055 (0.059)
Intercept	5.215 (0.157)	5.229 (0.156)	--	--
R-squared	0.698	0.694	0.166	0.164
Sample Size	589	589	589	589

a. Standard errors in parentheses; b. All the other time-invariant controls are reported in Table 8.

Table 4 : F-test Results for Gender Equality in Food Expenditure Equations[a]

Variable	2.1 Levels	2.2 Levels	2.3 F.Effects	2.4 F.Effects
Adults	8.800 (0.003)	8.390 (0.004)	0.000 (0.913)	0.000 (0.937)
Children,0-4	4.100 (0.041)	--	0.040 (0.827)	--
Children,5-15	0.010 (0.899)	--	0.038 (0.547)	--
All Children	2.080 (0.125)	3.360 (0.064)	0.370 (0.689)	0.110 (0.734)
Adults and Children	4.200 (0.006)	5.810 (0.003)	0.260 (0.857)	0.060 (0.943)

Table 5 : F-test Results for Gender Equality in Total Expenditure Equations[a]

Variable	3.1 Levels	3.2 Levels	3.3 F.Effects	3.4 F.Effects
Adults	3.010 (0.079)	3.420 (0.062)	0.390 (0.541)	0.250 (0.626)
Children,0-4	3.540 (0.057)	--	0.060 (0.795)	--
Children,5-15	2.290 (0.126)	--	1.410 (0.233)	--
All Children	3.460 (0.032)	0.380 (0.548)	1.230 (0.294)	0.490 (0.493)
Adults and Children	3.460 (0.016)	1.880 (0.153)	0.840 (0.476)	0.300 (0.744)

a. Numbers in parentheses are p-values in both the tables.

Table 6 : Tests for the Significance of Random and Fixed Effects in Food and Total Expenditure Equations[a]

Type	2.1 (Food)	2.2 (Food)	3.1 (Total)	3.2 (Total)
Fixed vs No Effects (F - tests)	F(98,479) 3.33	F(98,481) 3.42	F(98,479) 4.99	F(98,481) 5.20
Random vs No Effects (Lagrange Multiplier test)	93.14 (0.00)	92.48 (0.00)	118.75 (0.00)	124.68 (0.00)

a. Figures in parentheses are p-values.

Table 7 : Hausman Test Results for Gender Coefficients (Fixed versus Random Effects) in Food and Total Expenditure Equations[a]

Variable	2.3 (Food)	2.4 (Food)	3.3 (Total)	3.4 (Total)
Children,0-4 : Chi-sq(2)	13.251 (0.001)	--	21.894 (0.000)	--
All Children : Chi-sq(4)	13.402 (0.009)	--	22.184 (0.000)	--
Children,0-15: Chi-sq(2)	--	12.083 (0.002)	--	18.660 (0.000)

a. Figures in parentheses are p-values.

Table 8 : Food and Total Expenditure Equations - Levels Estimates for Time Invariant Control Variables[a]

Variables	2.1 Food Exp	2.2 Food Exp	3.1 Tot.Exp	3.2 Tot.Exp
Dummy (Village 3)[b]	0.292 (0.028)	0.295 (0.028)	0.360 (0.028)	0.361 (0.029)
Dummy (Village 5)	0.131 (0.029)	0.140 (0.029)	0.250 (0.029)	0.262 (0.029)
Dummy (1976)[c]	0.009 (0.039)	0.010 (0.039)	-0.011 (0.039)	-0.009 (0.040)
Dummy (1977)	-0.025 (0.039)	-0.023 (0.039)	-0.100 (0.039)	-0.098 (0.039)
Dummy (1978)	-0.014 (0.038)	-0.011 (0.039)	-0.071 (0.039)	-0.069 (0.039)
Dummy (1979)	0.152 (0.039)	0.155 (0.038)	0.010 (0.039)	0.104 (0.039)
Dummy (1980)	0.186 (0.039)	0.188 (0.038)	0.127 (0.038)	0.129 (0.038)
Low Caste Dummy[d]	-0.022 (0.035)	-0.027 (0.034)	-0.070 (0.035)	-0.081 (0.035)
Medium Caste Dummy	-0.017 (0.029)	-0.014 (0.029)	-0.045 (0.028)	-0.045 (0.029)

a. Standard errors in parentheses; b.Village 1 is dropped;c.Year 1981 is dropped;d.High caste is dropped.

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ESSAY 2

Gender Bias in India : Parental Preferences or Marriage Costs?

1. Introduction

How resources are allocated within the household is an intriguing question. In recent years there has been an increased emphasis on theoretical as well as empirical research to look at this problem. A closely related and important issue is the intra-household distribution of welfare, particularly in many developing countries where there is evidence that females, especially children, receive fewer resources than males (see Bardhan (1984), Deaton (1989), Harriss (1990), Sen and Sengupta (1983), Subramaniam (1993), Subramanian and Deaton (1991)). Theoretically, it poses an interesting problem because the various approaches to the issue have very different implications for household behaviour. The traditional approach has been to treat the household as a single person: this is the so called 'unitary' approach. Non-unitary intra-household models yield some implications for observable behaviour that would not been seen in unitary models of resource allocation. For example, who receives (how much) income has an effect on (observable) demands in non-unitary models (see Thomas (1991), Bourguignon et al

(1992), Bourguignon and Chiappori (1992)). Our interest in this paper is to look at the allocation of resources among children in a developing country context.

Allocation of resources within the household may be done on the basis of pure parental preferences, or there may be some economic motivation governing the process. Under the former, parents allocate more resources to male children because they have a preference towards them (intra-household gender bias). This type of son preference is common in many societies because of cultural, religious or social factors. The most important reason suggested for son preference is old age security. In a number of developing countries, particularly in rural areas, the joint family system is still in existence and usually female children leave their parents' households after marriage whereas male children stay with their parents. Also, several anthropological studies suggest that parents may prefer sons because only male children can perform certain religious rites in the household (see the papers quoted in Harriss (1990)).

On the other hand, there may be some pure economic rationale behind the process of allocation of resources within the household. Market opportunities are limited for women in many developing countries. In India, in particular, economic opportunities for women in rural areas depend on ecological factors and production relations. Culture and religion also have a significant role to play as determinants of outside opportunities for women. In such cases, allocation of resources may be based on the (differential) returns in the form of earnings of males and females. Rosenzweig and Schultz (1982) test this hypothesis and provide evidence that expected employment opportunities for women have a positive impact on survival chances for female children.

Another important economic motivation for differential resource allocation in a number of developing countries could be the higher costs of raising female children. Especially in the Indian subcontinent parents spend a substantial amount of resources, in addition to the usual costs of raising children, to marry their daughters off. The practice of giving dowry (or a transfer at the time of marriage from the bride's family to the groom's family) has been in existence in India and other Asian countries for centuries. Monetary and non-monetary transactions related to the marriage of female children often amount to a significant portion of a household's assets. There is evidence that the real value of dowry payments and marriage costs has been on the rise in India over the last seven decades.[1]

1. See Rao (1993). There are many reasons given for the increase in marriage related payments, which we look at in Section 4 below. Rao's paper uses, in addition to the same data set used in this paper, Indian census data for the study regions from the 1920s. This trend has been observed in many other South Asian countries also.

We make a clear distinction between a bias in favour of having male children and a bias in favour of male children if both male and female children are present in the household. It is the latter we focus on, although the former may lead to the latter: less care is taken of female children since they are less valued. Our basic premise in this paper is that if households spend a significant amount on female children at the time of their marriage, and if male children do not impose any such "burden" (it is not just that parents do not have to pay any price like dowry for males, but they may also bring resources into the household at the time of their marriage[2]), then this difference in the costs of raising male and female children is bound to affect the allocation of resources. Gender composition of the household will then be of importance in the allocation of resources. In a life-cycle context, observing the sex of a child at birth (or, equivalently, a change in the gender composition) may have an immediate impact on household consumption and savings behaviour: the birth of a female child has the same effect as a negative shock on lifetime household wealth. To be specific, households with more female children will reduce their current expenditures and increase their savings to pay for the dowry and other marriage related expenses at some point in the future.

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2. It should be noted, however, that the practice of reverse-dowry or bride-price is also in existence in some countries. This practice is followed in some parts of India (see Miller (1980)).

The problem of household resource allocation in this context provides a perfect setting for a natural experiment to study the allocation of resources over the life-cycle. We develop a simple three period model in Section 2 that captures the essence of this natural experiment provided by the sex of a new born child. The model allows for pure bias (or within-household bias), which takes the form of parents spending more resources on male children, and differential resource allocation due to the higher marriage costs of female children. The basic predictions of the model come naturally from the assumption that individuals attempt to keep their marginal utility constant when they allocate resources over the life-cycle (see, for example, Browning, Deaton and Irish (1985)). We show that the predictions for the two competing hypotheses (within-household bias versus marriage costs) differ based on the type of goods. The predictions are the same for changes in total household consumption (X_{t+1} - X_{t-1}, where X denotes total expenditures and t is the birth year, and our two other approximations of the changes in consumption around a birth, which are explained below) following the birth of a girl: under both regimes, total expenditure is lower after a female birth, relative to a male birth. But they are opposite for changes in the consumption of adult-specific goods around a birth: under the wealth-effect regime, these expenditures are lower after a female birth, while under the within-bias regime they are higher following a female birth.

In Section 4 we test the predictions of the model in order to infer whether all the difference between male and female children is a pure wealth-effect, so that the difference should vanish when wealth is controlled for, or it is due to pure parental preferences. For this purpose, we use annual household level consumption data from the ICRISAT-VLS (International Crops Research Institute for the Semi-Arid Tropics - Village Level Studies) data set for the period 1975-84. These data follow 120 households over the sample period. In addition to the two year changes in consumption (X_{t+1} - X_{t-1}), we develop two other procedures for differencing consumption to increase the precision of our estimates. We use the birth-dates of children to construct two other approximate consumption-difference variables that are sensitive to changes in consumption soon after a birth.

We also calculate approximate adult-expenditures on food, based on some estimates of bias costs (as we explain in Section 3.2 below), and test the predictions of our model for this category, given that food is the major item in the household budgets of the rural households in our sample. All our estimation equations are controlled for geographic and time effects (village-year effects in our case) that may affect household consumption, past fertility (by putting in the stock of children) and household income: given our small sample size, we follow a parsimonious approach to control the village-year effects. It is outlined in detail in Section 3.4 below.

To give a flavour of the results, despite the relatively small number of births (94 total births during 1975-84) in the sample we find significant and robust evidence in favour of the marriage costs hypothesis and against pure bias. We also look at two different categories of households based on their wealth holdings (as measured by the size of land holdings), since there is plenty of evidence in the anthropological literature that marriage costs are positively correlated with wealth-levels. The results for the wealthy households in our sample strongly support the marriage costs hypothesis.

Our findings also have implications for the wider debate on the validity of the life-cycle model. If our conclusions on the effects of a female birth on household consumption are correct, then it seems that households make adjustments in current consumption to meet committments that are at least fourteen to fifteen years[3] away. This sort of behaviour is, of course, exactly that posited by the life-cycle model of consumption.

The Essay is organized as follows: in Section 2 we present the model and derive the predictions to test the competing hypotheses. We also review the

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3. The mean age at marriage for females in the ICRISAT data is around 15 years; but Indian census data for the region show that the mean age has increased from 15.5 to 19.8 years (see Rao (1993)).

results from the related literature in light of the predictions of our model in this section. Section 3 starts with a brief description of the sample, then we present our method for constructing the unobserved adult-food expenditure variable, followed by a discussion of the summary statistics for the expenditure variables. Here we also present some descriptive regression results to give an idea of the effect of children on household composition. In Section 3.4 we discuss the issues pertaining to the econometric implementation of our model: here we present the method which is used in constructing the village-year control variable. We also present all the estimation equations here. In Section 3.5, we discuss the two other approximations for the dependent variable in our estimation equations that we use in addition to the two-year difference in consumption around a birth, which we use as the starting point.

In Section 4 we present an analysis of our estimation results: here, for all the three approximations, we analyze the raw data first with the help of box-plots to look at consumption changes around a birth, followed by an analysis of the estimation results with controls for the other variables. Section 5 provides review of related anthropological evidence on marriage payment practices in India and a brief analysis of the data contained in a retrospective survey on marriages conducted by ICRISAT. In Section 6 we offer a summary and conclude the Essay with some implications of our results.

2 Model and Review of Results in the Literature

2.1 Model

In this section we present the elements of our model and derive the predictions for the competing hypotheses of marriage costs and within-household gender bias. At the end of the section, we compare the predictions of our model with the results available in the literature.

In Essay 1, we categorized the existing studies of the intra-household allocation of goods into four different groups. We present them here for reference: (i) models in which parents allocate resources according to their own utility, which depends on the well-being of their children (see Behrman (1988)); this may account for pure parental preference, as outlined above and in Essay 1, as well; (ii) models in which parents allocate resources based on the differential labour market returns to boys and girls (see Rosenzweig and Schultz (1982)); (iii) models in which households allocate resources based on the productivity of individual members (see Pitt, Rosenzweig and Hassan (1990)); (iv) models in which resources are allocated according to the relative bargaining power of the family members (see McElroy and Horney (1981), Sen (1984) and Thomas (1990)).

The simple model that we present here combines features of (i), the parental preference approach, and (ii), the pure returns (or the wealth-effect in our case) based approach. We assume a three period structure: the household starts with a fixed wealth (W) in period 1; there is a single birth at the end of period 1, and the child leaves the household at the beginning of period 3 at which point any marriage costs are paid. We also assume that the sex of the child is known only at the time of birth, and that is the only feature of uncertainty in the model.

We model parental preferences (or within household bias) towards male children by attaching a higher weight to the utility of male children than to the utility of female children in the parental life-time utility functions[4] (a weight of 1 if the child is a girl, a weight > 1 if it is a boy). Under the within-bias regime, this implies that parents spend more (bias costs) on male children than female children. Wealth-effect takes the form of an additional expenditure E (marriage costs, including dowry and other marriage expenses) for girls, over and above the usual costs of raising children. The key assumption that we invoke here is the one used in modern theories of inter-temporal allocation: that households attempt to equalize the marginal utility of wealth over time when they allocate resources over the life-cycle. The notations in the model are presented below.

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4. Browning and Subramaniam (1994) discuss the theoretical considerations and other possibilities for modelling parental preferences in this context.

We use the following notations in the model:

W - *Initial wealth of the household*

s - *sex of the child; s = g if girl, s = b if boy*

X_t^s - *Total household expenditure at time t in the event of s =*

C_t^s - *Expenditure on adult goods at time t in the event of s = g,b*

K^s - *Cost of (raising) children - paid in period 2*

E - *Marriage costs (if s = g) - paid in period 3*

The household incurs a total expenditure of X_i in period i, for i=1,2 and 3. Based on the constant marginal utility assumption, the consumption profile of the household after the birth depends on the sex of the child:

$$(X_1,\ X_2^g,\ X_3^g)\ \text{if } s = g \ ; \quad (X_1,\ X_2^b,\ X_3^b)\ \text{if } s = b$$

We assume, to make the analysis simple, that parents agree on the allocation of resources within the household, noting however that there is evidence in the literature against such a unified decision-making process for allocation of resources between male and female children (see Thomas (1990)). He shows that incomes under the control of mother and father affect the allocation of resources for children differently. It is also assumed that utility is additively separable over time as well as over adults' and children's consumption. We set the real rate of interest to zero in what follows and assume normality for all the components of total consumption.

Lifetime (parental) utility functions are written as

$$U(C_1) + U(C_2^s) + \delta\phi(K^s) + U(C_3^s), \quad s = b,g$$
$$\text{subject to } C_3^s = W - C_2^s - K^s - \mu E \tag{1}$$
$$\text{where } \mu=1 \text{ if } s=g, \text{and } \mu=0 \text{ if } s=b$$

As outlined in the introduction, we focus on two cases: Case 1 - marriage costs regime, here E > 0 and δ = 1 for both s = b and s = g; Case 2 - within-household bias regime, here E = 0 and δ > 1 for s = b and δ = 1 for s = g.

Case 1: Only Marriage Costs (E > 0, δ = 1)

In this case, the preferences and the budget constraints are

$$U(C_1) + U(C_2^s) + \phi(K^s) + U(C_3^s), \text{ for } s = b,g$$
$$s.t: C_3^s = W - E - C_2^s - K^s = W - E - X_2^s \tag{2}$$
$$\text{where } E > 0 \text{ if } s=g, \ E = 0 \text{ if } s=b$$

The following proposition states the result for this case:

Proposition 1: If marriage costs are positive ($E > 0$) and if parents care equally about male and female children ($\delta = 1$), then

$$(C_2^b > C_2^g) \text{ and } (X_2^b > X_2^g)$$

Proof: The first order conditions for the problem stated in (2) are:

for s = b

$$U'(C_2^b) = U'(W - C_2^b - K^b)$$
$$2C_2^b = W - K^b \qquad (3a)$$

$$\phi'(K^b) = U'(W - C_2^b - K^b) \qquad (3b)$$

for s = g

$$U'(C_2^g) = U'(W - E - C_2^g - K^g)$$
$$2C_2^g = W - E - K^g \qquad (4a)$$

$$\phi'(K^g) = U'(W-E-C_2^g-K^g) \tag{4b}$$

From (3a) and (4a) we have:

$$2\,(C_2^b - C_2^g) + (K^b - K^g) = E \tag{5}$$

Since E > 0, from (5) it follows that either $(C_2^g > C_2^g)$ or $(K^b > K^g)$ or both.

We also have:

$$\begin{aligned}
(K^b > K^g) &\Leftrightarrow \phi'(K^b) < \phi'(K^g) \\
&\Leftrightarrow U'(W-C_2^b-K^b) < U'(W-E-C_2^g-K^g) \\
&\qquad \textit{from (3b) and (4b)} \\
&\Leftrightarrow U'(C_2^b) < U'(C_2^g) \\
&\qquad \textit{from (3a) and (4a)} \\
&\Leftrightarrow C_2^b > C_2^g
\end{aligned} \tag{6}$$

Thus we have both $(K^b > K^g)$ and $(C_2^b > C_2^g)$. Hence

$$(X_2^b - X_2^g) > 0, \; or \; (C_2^b + K^b) > (C_2^g + K^g) \tag{7}$$

Q.E.D.

<u>Case 2</u>: <u>**Only Within-household Bias (E = 0, δ > 1 if s = b, δ = 1 if s = g)**</u>

In this case, the preferences and the budget constraints are

$$\begin{gathered} U(C_1) + U(C_2^b) + \delta\phi(K^b) + U(C_3^b) \\ s.t.\; C_3^b = W - C_2^b - K^b \\ \\ U(C_1) + U(C_2^g) + \phi(K^g) + U(C_3^g) \\ s.t.\; C_3^g = W - C_2^g - K^g \end{gathered} \tag{8}$$

The following proposition states the result for this case:

<u>Proposition 2</u>: If parents care more about male children than female children (δ > 1 for male children, and δ = 1 for female children) and if marriage costs are zero, then

$$(C_2^b < C_2^g) \; and \; (X_2^b > X_2^g)$$

Proof: The first order conditions stated for the problem in (8) are:

for s= b

$$U'(C_2^b) = U'(W - C_2^b - K^b)$$
$$2C_2^b = W - K^b \tag{9a}$$

$$\delta\phi'(K^b) = U(W - C_2^b - K^b) \tag{9b}$$

for s = g

$$U'(C_2^g) = U'(W - C_2^g - K^g)$$
$$2C_2^g = W - K^g \tag{10a}$$

$$\phi'(K^g) = U'(W - C_2^g - K^g) \tag{10b}$$

From (9a) and (10a) we have:

$$2(C_2^b - C_2^g) = (K^g - K^b) \tag{11}$$

From the first-order conditions, we have:

$$\begin{aligned}(K^g \geq K^b) &\Leftrightarrow \phi'(K^g) \leq \phi'(K^b)\\ &\Leftrightarrow \phi'(K^g) < \delta\phi'(K^b), \textit{ since } \delta > 1\\ &\Leftrightarrow U'(C_2^g) < U'(C_2^b) \textit{ from } (9b) \; \& \; (10b)\\ &\Leftrightarrow C_2^g > C_2^b\end{aligned} \tag{12}$$

Thus ($K^g \geq K^b$) implies $(C_2^b - C_2^g) < 0$ which contradicts (11), hence

$K^g < K^b$.

It follows then that, $C_2^b < C_2^g$ from (11). We also have

$$\begin{aligned}(X_2^b - X_2^g) &= (C_2^b + K^b) - (C_2^g + K^g)\\ &= (C_2^g - C_2^b), \textit{ from } (9a) \textit{ and } (10a)\\ &> 0\end{aligned} \tag{13}$$

Q.E.D.

The above propositions state and show that the birth of a female child (in Period 2) reduces total household expenditures under both marriage cost and within-bias regimes (either $E > 0$ or $\delta > 1$). The marginal utility argument presented above provides the utility underpinning for this outcome. Though intuitively simple, since bias costs on male children increase total household expenditures in Period 2 and future marriage costs for female children reduce current (Period 2) total household expenditures, this result does not allow us to differentiate between the two regimes. But the rankings we obtain in the propositions for adult goods do provide different predictions: in the marriage costs regime, parents reduce total household expenditures following the birth of a female child, and they reduce the expenditures on adult goods as well (with normality assumption for the components of total expenditure); in the within-bias regime, parents reduce their expenditure on adult goods in order to meet the increased child costs (or bias costs in this case) following the birth of a male child.

The above predictions are summarized in the following tables.

Table 1 : Total Expenditures

$$X_2^g - X_2^b$$

E and δ	δ = 1	δ > 1
E = 0	0	Negative
E > 0	Negative	Negative

Table 2 : Expenditures on Adult-goods

$$C_2^g - C_2^b$$

E and δ	δ = 1	δ > 1
E = 0	0	Positive
E > 0	Negative	Positive or Negative

As stated in the tables, if the difference between expenditures on adult goods is positive, then the dominant motive for differential resource allocation is within-household bias. On the other hand, if the difference is negative then the dominant motive is marriage costs. Deaton (1989) obtains the same theoretical result for the within-household bias regime (Case 2, but he does not look at marriage costs) based on household outlay equivalent ratios.

2.2 A Brief Review of Previous Results

In this section we present a brief review of the results in the literature in light of our framework presented above, which allows for both pure bias (B) as well as wealth-effect (E) in intra-household allocation of resources. The evidence that there is gender bias, based on cross-section data, has been presented in the following forms: (a) Household consumption expenditures are lower with one more female child than with one more male child (Subramaniam (1993) provides evidence in favour of this by estimating Engel curves for consumption, with demographic variables; there is a vast amount of anthropological and other indirect evidence in the literature - Harriss (1990), Miller (1980), Sen and Sengupta (1983)); (b) Adult-specific expenditures are lower with one more male child than with one more female child (Deaton (1989), Deaton (1990), S.Subramanian and Deaton (1992)) - this has been interpreted as evidence of bias, since parents reduce expenditures on adult-specific goods in order to increase spending on children-specific goods for male children; (c) Nutrition intakes are higher for male children (Bardhan (1984), Behrman(1988), Das Gupta (1984), Harriss (1990), Sen (1984), Sen and Sengupta (1983)).

In terms of our framework, (i) $E > 0$ and $\delta = 1$ (only wealth-effect and no within-household bias) is consistent with (a), but not (b) and (c); (ii) $E = 0$ and $\delta > 1$, with $\delta = 1$ for girls (only within-household bias and no wealth-effect) is consistent with (a), (b) and (c); (iii) $E > 0$ and $\delta > 1$ (both within-household bias and marriage costs) is consistent with all of them or only with (a), depending on whether bias dominates marriage costs or marriage costs dominate bias.

Based on the same panel data used in this paper, we show in Essay 1 that the cross-sectional result of lower consumption associated with female children no longer holds when household fixed effects are controlled for. Here, there is no difference between the marginal effects of male and female children on the change in household consumption over time (C_t - C_{t-1}). This result is not strictly compatible with the cross-section result referred to in (a) above, since births are not accounted for in the fixed-effects estimates. It is, however, consistent with (i), (ii) as well as (iii), as the theoretical predictions presented above show. If the unobserved marginal utility is controlled for, as in the fixed-effects method, then there should not be any difference in consumption (whether due to within-bias or wealth-effect). Behrman and Deolalikar (1990) also find that, using ICRISAT nutrition data, there is no support for any consumption difference between males and females with controls for individual fixed effects. In this paper, we focus on the change in consumption at the time of birth by looking at $C_{t+1} - C_{t-1}$, where t is the birth year. We also look two other, more precise, ways of differencing consumption based on the date of birth information we have in the data. In the context of life-cycle allocation of resources, these changes at birth indicate that households will follow the new consumption profile at least in the medium term.

3. Data, Econometric Implementation and Results

3.1 Description of Data

We utilize the same data used in Essay 1, the ICRISAT-VLS (International Crops Research Institute for the Semi-Arid Tropics - Village Level Studies) panel data set in this Essay as well. We provide a brief review of the main features of the data set here for reference: these data are from a household survey initiated by ICRISAT in 1975 in three benchmark villages representative of India's semi-arid tropical regions. The data set contains information on consumption, income, production and household demographics for 120 households from the three villages in three distinct agroclimatic regions for 10 years (from 1975 to 1984). These villages, two in the state of Maharashtra and one in the state of Andhra Pradesh, are in the Central and South-Central parts of India.

Within each village, a random sample of thirty cultivator - ten each of small, medium and large landholding[5] households - and ten landless households was drawn for the panel. There was a resident investigator, who collected all the data and who as well functioned as a participant-observer, in each village. In addition, ICRISAT

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5. More details are presented in Essay 1.

also conducted a retrospective survey on inheritance, dowry and marriage related transfers in 1984, apart from a number of other special surveys[6]. We use the data on household consumption, income and demographics - for a period of the whole ten years (1975-84) for food consumption, and for six years (1976-81)[7] for total consumption, since consumption data were not collected in detail in 1975 or after 1981. We focus on the consumption patterns for the households which have had at least one birth during the sample period. Of the 120 households in the three villages, we have continuous data only for 104 households. We use the data for 97 of these houeseholds, after dropping single person households, households without any children and joint-family households with multiple births in any given year.

The data on the demographic compositions of ICRISAT households are considered to be very reliable, since the resident investigator in each village were required to record all the changes in household composition in each household during the sample period. These data were collected on an annual basis at the beginning of the year, but we also

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6. See Essay 1. Also, see Walker and Ryan (1990) for a compendium of the studies based on these data sets.

7. In this Essay, since we focus on consumption changes around births in the households, our sample is quite small. Therefore, when we look at food consumption we use the longer data set, and for non-food and total expenditures data we confine ourselves to the period 1976-81. In Essay 1, we used the data for all the years (with and without births) for all the households.

have information as to when in a given year, approximately, a change in household composition (for example, a birth) took place. Other changes in age and gender profile (for example, through new marriages) were also recorded as and when they took place. We use the annual data on consumption[8], and correspondingly annual data on household incomes[9]. All the consumption and income figures were deflated with village-level price indices (with 1983 as base year).

3.2 Type of Goods

In order to test the predictions of our model, we use the sum of household food and non-food consumption expenditures (see note (5) below) for the total household consumption variable, X_i. In the ICRISAT data, we observe only total household level consumption, and not consumption by adults and children separately. We do have household expenditures on a few adult-only-goods such as narcotics and alcohol (in the

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8. Food consumption includes also edible oils and fats. Non-food expenditures include: narcotics, tea, coffee, tobacco, pan, alcohol, clothing, tailoring expenses, chappals and footwear, medicines, cosmetics, soap and barber service, travel and entertainment, electricity, water charges, cooking fuel, labour expenses for domestic work, and other miscellaneous expenses.

9. Total household income is the sum of: net trade income, net crop income, net livestock income, net land rent, salary and wage incomes. We do not include transfer income because for most households a major fraction of transfer incomes comes from marriage-related transfers.

data, expenditure on these two adult goods is added to the household consumption of tea and coffee). However, the mean budget share of this category in total expenditures is small (at around 4 per cent), with a number of zeros if we take the whole sample period 1975-84. We use the total expenditure on these four goods, confining ourselves to the data for 1976-81, to test the predictions regarding adult goods in the model.

For the ICRISAT households in the poor rural regions of India, food is the single most important item in the household budget. The mean budget share of food in total expenditures is about 70 per cent, with the share being 68 per cent even for the largest landholding households. Given the substantially high budget share of food, there is reason to believe that households will make adjustments in food consumption as well following the birth of children when they re-allocate the available resources. For this reason, and due to the low budget share of non-food adult goods, we look at the rankings for total household food expenditure and obtain an estimate of adult food expenditures, which we calculate from total household food consumption with allowance for possible bias (and child) costs.

Total household consumption expenditure for Period 2 is:

$$X^s = X_f^s + X_n^s = C_f^s + C_n^s + K_f^s + K_n^s, \; for \; s = b,g \tag{14}$$

where

X_i^s = *Total household expenditures on* i = *f(food), n(non-food),*
C_i^s = *Adult expenditures on* i = *f,n*
K_i^s = *Child costs on* i = *f,n*

From the rankings for adult-goods expenditures in Table 2, assuming normality of the components (food and non-food) of adult-goods consumption, we have $C_f^b > C_f^g$ under the marriage costs regime (since $C^b > C^g$) and $C_f^b < C_f^g$ under the within-household bias regime (since $C^b < C^g$). These rankings imply the following for the marriage costs regime

$$(C_f^b + K_f^b) > (C_f^g + K_f^g) \quad \text{or } X_f^b > X_f^g, \text{ since } K_f^b > K_f^g \text{ from (5)} \tag{15}$$

and for the within-household bias regime

$$(C_f^b + K_f^b) \gtrless (C_f^g + K_f^g) \quad \text{or } X_f^b \gtrless X_f^g, \text{ since } K_f^b > K_f^g \text{ from (12)} \tag{16}$$

In other words, (15) and (16) state that the prediction for Case 1 (wealth-effect) may not be different from that for Case 2 (within household bias): if the difference $(X_f^g - X_f^b)$ is positive, then within-household bias is the dominant motive, but if it is negative, then either of the motives may hold.

The following table summarizes the predictions:

Table 3 : Total Household Food Expenditures

$(X_f^g - X_f^b)$

E and δ	$\delta = 1$	$\delta > 1$
E = 0	0	Positive or Negative
E > 0	Negative	Positive or Negative

Our next step is to obtain an estimate of adult expenditures on food (not observed in the data) from total household food expenditure, with an allowance for costs of children (including bias costs, both of which are not observed in the data) that the household may incur in favour of male children. From (5) and (12) it follows that

$K^b \geq K^g$ under Case 1 $K^b > K^g$ under Case 2. Let the relationship between the costs of male and female children be given by

$$K_i^b = K_i^g + B_i, \quad B_i \geq 0, \, for \; i = f,n \tag{17}$$

where B_i is the bias component of child costs: parents spend B_i over and above what they spend for a female child on a male child (under Case 2, $B_i > 0$). We can write the adult expenditures on food as

$$\begin{aligned} C_f^b &= X_f^b - K_f^g - B_f \\ C_f^g &= X_f^g - K_f^g \end{aligned} \tag{18}$$

The following table summarizes the rankings for the adult food expenditure variables in (16), based on the predictions presented in Table 2.

Table 4 : Adult Food Expenditures

$$(X_f^g - (X_f^b - B_f))$$

E and δ	δ = 1	δ > 1
E = 0	0	Positive
E > 0	Negative	Negative or Positive

As stated above, we do not observe how much adults spend on food for themselves (defined in (17)) and how much of an additional amount they spend on male children (the bias component of the costs of children (B_i)) in the ICRISAT data. In order to obtain an estimate for the adult food expenditures, we use some plausible values for the unobserved bias cost of food (B_f). There is evidence in the literature that female children get 4 per cent fewer resources in nutrient allocation, at least in the lean season, in the ICRISAT villages (see Behrman (1988)). Based on this, we use an estimate of 100-150 Rupees as bias costs for new-born children (since we look at consumption differences around birth) to obtain an estimate for adult expenditures on food. This estimate is based on mean food expenditures in the ICRISAT villages for all the households. It suggests that parents spend 100 to 150 rupees a year more on food for male infants over and above what they spend on female children. It should be noted that there may be bias in the form of higher non-food expenditures as well (for example, higher health-care expenditures for new-born male children) over and above higher food allocation. The costs of children will be, then, $(K_f + K_n)$ for households with one more female child, and $(K_f + K_n + B_f + B_n)$ for households with one more male child. The predictions presented in Tables 2 and 4 allow us to look at the changes in parental expenditures on food as well as non-food for themselves following the birth of children.

3.3 Consumption and Household Composition

Table 5 provides some descriptive statistics on household consumption (food, adult goods - narcotics etc, and total) and income, based on the size of landholdings. It includes all the households in the sample (those with and without any births during 1975-84). It should be noted that the averages presented in the table also include the changes in consumption following the birth of children. As noted above, households in all the categories spend a substantial portion of their budgets on food consumption, with the mean share being 70 per cent. Non-food and total expenditure data are, as mentioned above, for a shorter period (1976-81). In Table 6, we present some simple descriptive regression results on food consumption and household composition for all the ICRISAT households. In these equations we include only the numbers of adults and children, and there is no control for any other variables that might affect household consumption. The marginal effect of the children variables varies across the equations. For the landless and small-holder households young children have a significant effect on food expenditures, while for the other two categories there is no such effect in these cross-section equations.

Table 5 : Mean Consumption and Income for ICRISAT Households[a]

Type of Households	Food Expenditure	Narcotics etc Expenditure (adult good)[c]	Total Expenditure[c]	Income
Landless (21)[b]	2282 (1242)	206 (139)	3645 (2107)	3566 (4094)
Small (27)	2557 (995)	262 (155)	4160 (1566)	4888 (2827)
Medium (26)	2618 (1226)	234 (165)	4404 (1659)	5151 (3042)
Large (23)	3514 (1766)	287 (212)	5898 (2896)	11419 (8666)
All (97)	2740 (1395)	249 (172)	4526 (2237)	6221 (5899)

(a. Values are in 1983 rupees; standard deviations are in parantheses; b. Number of households in each category; c. Food data for 1975-84, Non-food data for 1976-81)

Table 6 : Food Consumption and Household Composition: ICRISAT Households

(Dependent variable: Food expenditures in 1983 rupees; standard errors in brackets)

Type of Households	No.of Adults-2	No.of Children (0-4)	No.of Children (5-15)	Intercept	R-square (No.of Obs)
Landless	449.7 (47)	220.8 (88.1)	212.5 (54.8)	1267.8 (134)	0.3695 (210)
Small	280.0 (42)	-142.3 (71.5)	136.2 (48.8)	2069.0 (111)	0.1598 (270)
Medium	345.9 (41)	49.0 (82)	250.2 (46.7)	1598.7 (119)	0.3184 (260)
Large	471.0 (61)	126.1 (108)	147.6 (65.5)	2302.1 (189)	0.2579 (230)
All	411.7 (25)	32.5 (46.4)	203.2 (28.6)	1767.6 (72.4)	0.2727 (970)

3.4 Econometric Implementation

For estimating the model and testing the various predictions, we use the data for all the households which had at least one birth during the sample period (1975-84 for food consumption and 1976-81 for total and adult goods consumption). The dependent variables in all our estimation equations, as explained below, involve two year differencing of expenditures. As a result, we do not utilize the births in the first or the last years (1975 or 1976, 1984 or 1981) in the survey. In total, there are 94 births in the sample during 1976-83 of which 58 are males and 36 are females. The corresponding numbers for 1977-80 are 27 males and 14 females. The cell sizes for each individual category of households (based on landholding) are quite small, particularly during 1977-80.

Given such small sample sizes, we test the predictions separately for the labour and small households in one group, and medium and large households in another. We provide a justification for such a grouping in Section 4 below: medium and large households spend a considerably higher fraction of their incomes on marriages of female children than the labour and small households. Also, labour and small households seem to have similar adjustments in consumption following the birth of children as do medium and large households in the data. We use the whole panel of data, for all the households with or without any births, for constructing our control variables in the estimation equations.

Our basic equation involves regressing the consumption difference, $(C_{t+1} - C_{t-1})$, around the birth of children on male and female birth dummies, where t is the birth year. We estimate equations of the form

$$\Delta C = \beta_0 + \beta_1 D \tag{19}$$

where the left-hand side variable is $(C_{t+1} - C_{t-1})$, D = 1 if the newborn child is a girl and D = -1 if it is a boy. Then the coefficient β_1 gives an estimate of the difference between consumption responses following female and male births, without controlling for any other effects that may influence household consumption. The descriptive statistics presented in Table 6 above indicate a high variance for the consumption variables, suggesting that village and time effects do have an impact on household consumption for all the categories. The most obvious way to control for these temporal and spatial effects is to include village and time dummies in the regression equations. This, however, would involve a significant loss in the degrees of freedom given our small sample sizes.

There is reason to believe that in village economies, such as the semi-arid areas in our sample, where most of the households are dependent upon agriculture, there will be a high correlation across household incomes within a village. If incomes are correlated, then household consumption should also exhibit such a correlation across the individual units[10]. We exploit this feature to control for the village by year effects in a parsimonious way in our consumption equations. We compute medians for the household consumption differences for each village and for each year, and include these as a control variable in our equations. For this purpose, the consumption differences ($C_{t+1} - C_{t-1}$) are computed for each household in each village. Then we drop all the households which had at least one birth (for which we estimate the consumption responses) before computing the within-village-year median of these consumption differences. Thus, for example, if household 1 in Village 1 had a birth in year 1976, then on the right hand side of the equation the control variable will be the median of the consumption differences for all the no-birth households in Village 1 in year 1976. The consumption equations are of the form given in (19):

$$\Delta C = \beta_0 + \beta_1 D + \beta_2 (\overline{\Delta C}) \tag{20}$$

where $\overline{\Delta C}$ is village-by-year median consumption

10. Townsend (1991) provides evidence that household incomes and consumption co-move within all the three ICRISAT villages.

It should be noted that this new median consumption variable (without including the birth household) should be completely orthogonal to D in the population. In order to ensure the orthogonality of D and median consumption, we next estimate the above equation replacing the median variable with its estimated residual. Theoretically, including the residual should not affect the coefficient of interest, β_1. Theory also predicts that it will improve the fit of the equation and reduce the standard error of the estimate of β_1.

$$\Delta C = \beta_0 + \beta_1 D + \beta_3(\overline{\Delta C_R}) \quad \text{where } \overline{\Delta C_R} \text{ is the predicted residual} \tag{21}$$

As additional control variables we include the stock of male and female children, or the number of male and female children (in the age group 0-15) in period t-1, in order to account for the possibility that birth (and the sex of the child) is endogenous to the existing gender composition of children within the household:

$$\Delta C = \beta_0 + \beta_1 D + \beta_3 \overline{\Delta C_R} + \beta_4 M_{t-1} + \beta_5 F_{t-1} \tag{22}$$

where M_{t-1} and F_{t-1} are the numbers of male and female children, respectively, in period t-1.

In addition, we also control for household income by including the difference in income around a birth, analogous to the dependent variable.

$$\Delta C = \beta_0 + \beta_1 D + \beta_3 \overline{\Delta C_R} + \beta_4 M_{t-1} + \beta_5 F_{t-1} + \beta_6 (\Delta Y) \qquad (23)$$

3.5 Two Additional Approximations for ΔC

In the ICRISAT survey, we have only annual consumption data (aggregated from monthly consumption figures). Our dependent variable (C_{t+1} - C_{t-1}) is, therefore, based on the expenditures in the years before and after the birth. But households may have more immediate adjustments in their consumption following a birth, within the birth-year which will be reflected in C_t, whereas the two year difference measure is not sensitive to such immediate changes in consumption.

To be more specific, let α be a continuous variable that takes a value in the interval $0 \leq \alpha \leq 1$. Let α denote the point in year t at which a birth takes place: if the birth is at the beginning of t, α will be close to 0 and if it is towards the end of the period, α will be close to 1. Using this variable, we can define an α-weighted consumption difference variable as follows:

$$\Delta C = \alpha(C_{t+1} - C_t) + (1-\alpha)(C_t - C_{t-1}) \tag{24}$$

This definition is flexible in the sense that if (i) $\alpha = 0$, then $\Delta C = C_t - C_{t-1}$ which is more appropriate if the birth is at the beginning of t, and (ii) $\alpha = 1$, then $\Delta C = C_{t+1} - C_t$ which is more appropriate if the birth is at the end of t, than the two year difference $(C_{t+1} - C_{t-1})$. For other values of α, the corresponding difference can be calculated using (23).

In the ICRISAT-VLS survey, as we pointed out at the beginning of this section, the village resident investigators recorded any change in the household composition as soon as such a change took place in the households. Thus, in the data we have information on all compositional changes due to birth, death, or addition of new members through marriage etc. The investigators also recorded approximate dates on which these changes were reported. Given that the investigators stayed in the villages and developed a close rapport with the respondents whom they met frequently, the recorded-dates[11] can be used as reliable (approximate) dates of birth for our purposes in this Essay. Using the date of birth information, we calculate α for each birth in our sample and obtain the α-weighted consumption difference (equation (24)), which we call α-Approximation I. We estimate the five equations, (19) to (23), are with this new dependent variable in our analysis. The median consumption variable, to control for the village-year effects, is calculated using the α-definition: here, for each household, based on its α for male or female birth, we calculate the value of the village-year median consumption variable.

It is useful to formalize the above arguments with an illustrative figure, which presents the consumption sequences around a birth clearly. In Figure 1, $\underline{C}$ denotes consumption before the birth, which occurs at α in year t, and $\overline{C}$ stands for consumption soon after the birth. The difference $(\overline{C} - \underline{C})$ would be the most ideal measure of the change in household consumption around a birth. But $\underline{C}$ and $\overline{C}$ are unobservable in the data, since we have only annual level consumption. However, we can approximately

11. Household composition details were collected at the beginning of each survey year in the data. If there were any changes in the composition during the year, these appear along with the recorded dates. For example, if a household member migrated out, it was recorded with the date on which he/she left, and if the person happened to move back in the same year, he/she would have three records in the Household file (one at the beginning of the year, one each for the out and in moves).

measure (with errors) these unobservable consumption variables from the observed annual consumption data that we have in the panel.

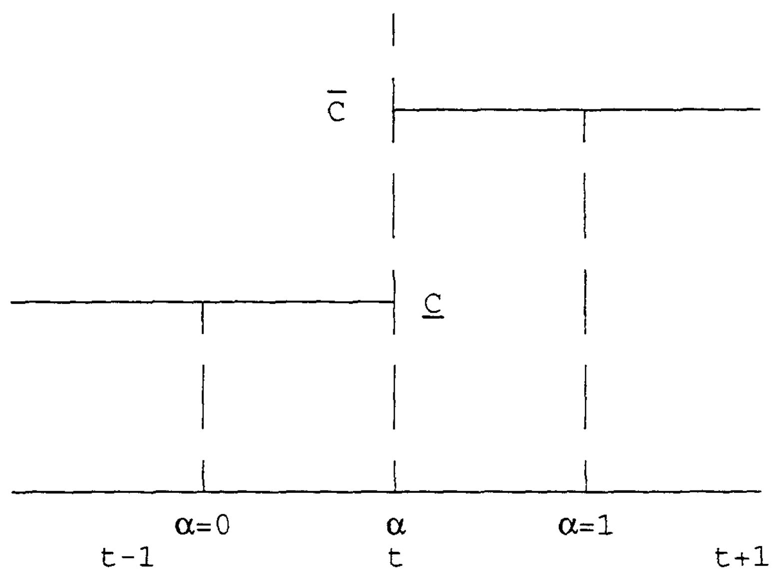

Figure 1 : Consumption Around a Birth

Let the relationships between observed consumption and the unobserved variables be as follows:

$$C_{t-1} = \underline{C} + \epsilon_{t-1}$$

$$C_{t+1} = \overline{C} + \epsilon_{t+1} \tag{25}$$

$$C_t = \alpha\underline{C} + (1-\alpha)\overline{C} + \epsilon_t$$

where ϵ_t, ϵ_{t-1} and ϵ_{t+1} are measurement errors associated with the corresponding observed consumption variables.

The first approximation (two year difference) provides a crude way of estimating the change in consumption, and the second method provides a more flexible approximation based on the date of birth variable α. We now propose a third alternative, even more flexible, approximation for the dependent variable in the estimation equations by utilizing the relationships in (25) and the second approximation in (24). For this purpose, let ΔC be defined as follows:

$$\Delta C = K_1 C_{t+1} + K_2 C_t - (K_1 + K_2) C_{t-1} \tag{26}$$

where K_1 and K_2 are some functions of the date of birth variable α. In our first approximation, $K_1 = 1$ and $K_2 = 0$ since we do not utilize the date of birth information. In our second approximation (α-Approximation I) which also takes the general form given in (26), $K_1 = \alpha$ and $K_2 = (1 - 2\alpha)$.

The next step, in obtaining the functional relationships for K_1 and K_2, involves substituting the relationships given in (25) into the variables in equation (26):

$$\Delta C = K_1(\overline{C} + \epsilon_{t+1}) + K_2(\alpha \underline{C} + (1-\alpha)\overline{C} + \epsilon_t) - (K_1 + K_2)(\underline{C} + \epsilon_{t-1}) \qquad (27)$$

collecting terms

$$\Delta C = (K_1 + (1-\alpha)K_2)(\overline{C} - \underline{C}) + K_1\epsilon_{t+1} + K_2\epsilon_t - (K_1 + K_2)\epsilon_{t-1} \qquad (28)$$

then

$$\Delta C = \frac{\Delta C}{K_1 + (1-\alpha)K_2} = (\overline{C} - \underline{C}) + Error \qquad (29)$$

The left-hand side expression in (29) gives us an approximation of the true difference $(\overline{C} - \underline{C})$ in consumption around a birth. Utilizing the general functional form given in (26) and the resulting equation in (29), we have the following:

$$K_1 = \frac{K_1}{K_1 + (1-\alpha)K_2}, \quad K_2 = \frac{K_2}{K_1 + (1-\alpha)K_2}$$

$$\textit{then, } K_1 = 1 - (1-\alpha)K_2$$

Substituting the above value for K_1 into (26):

$$\Delta C = (1 - (1-\alpha)K_2)C_{t+1} + K_2 C_t - (1+\alpha K_2)C_{t-1} \tag{30}$$

In order to solve for K_2, we utilize the conditions

$$\textit{(i) if } \alpha = 0, \textit{ then } K_2 = 1 \textit{ for } \Delta C = C_t - C_{t-1}$$

$$\textit{(ii) if } \alpha = 1, \textit{ then } K_2 = -1 \textit{ for } \Delta C = C_{t+1} - C_t$$

which must be satisfied by any flexible approximation. From (i) and (ii) it can be easily seen that the only functional form for K_2 that satisfies both the conditions is the linear relationship, $K_2 = 1 - 2\alpha$. Thus, our third approximation (which we call α-Approximation II) is given by:

$$\Delta C = [1 - (1-\alpha)(1-2\alpha)]C_{t+1} + (1-2\alpha)C_t - [1+\alpha(1-2\alpha)]C_{t-1} \qquad (31)$$

It can be easily seen that at the extreme values for α ($\alpha = 0$ or $\alpha = 1$), the above two approximations in (24) and (31) give the same values for the dependent variable in our estimation equations. It can also be seen that α-Approximation II (equation (31)) places more weight on C_{t+1} and less weight on C_{t-1} than α-Approximation I (equation (24)), for any given value of the date of birth variable α. Thus, for low values of α, α-Approximation I would provide a better approximation, and for high values of α, α-Approximation II would provide a better approximation for the difference in consumption around a birth. If α is low (birth at the beginning of t), then a relatively higher weight must be on C_t than on C_{t+1}, and similarly if α (birth towards the end of t) is high, then C_{t+1} must have a higher weight than C_t.

In our sample, the mean value for α is 0.503 (standard deviation = 0.397; for male births, the mean is 0.50 with S.D = 0.284, for female births, the mean is 0.508 with S.D = 0.321). We estimate our equations for all the three approximations. To provide an illustration:

$$\text{if } \alpha = 1/4 : \quad \begin{aligned} &\textit{Equation } (24) : \Delta C = 1/4\, C_{t+1} + 1/2\, C_t - 3/4\, C_{t-1} \\ &\textit{Equation } (31) : \Delta C = 5/8\, C_{t+1} + 1/2\, C_t - 9/8\, C_{t-1} \end{aligned}$$

$$\text{if } \alpha = 3/4 : \quad \begin{aligned} &\textit{Equation } (24) : \Delta C = 3/4\, C_{t+1} - 1/2\, C_t - 1/4\, C_{t-1} \\ &\textit{Equation } (31) : \Delta C = 9/8\, C_{t+1} - 1/2\, C_t - 5/8\, C_{t-1} \end{aligned}$$

4. Analysis of Estimation Results

We begin our analysis by looking at the raw data on consumption for the ICRISAT households, specifically at the changes in household consumption around the birth of a child. The data on household total consumption around the birth of male and female children are presented in Figures 1a to 3c for labour, small, medium and large households, in the form of Box and Whisker plots or Tukey boxes. The line in the middle of the box is for the median or 50th percentile of the data. The box extends over the inter-quartile range, from the 25th to the 75th percentiles. The whiskers, or the lines from the boxes, extend to the lower and upper adjacent values, which are defined as three-halves the inter-quartile range up to the point where there is data. We refer to the points in the data that are above the upper and below the lower adjacent values as outliers, and individually plot them.

The plots for total consumption, which present the data without any other controls, show that there are no outliers for the changes in total consumption around a birth. The y-axis variable in each figure is the corresponding change in consumption - for approximation 1, in figures 1a, 2a and 3a, it is

$$\log X_{t+1} - \log X_{t-1}$$

for approximation 2, in figures 1b, 2b and 3b, it is given by:

$$\alpha*(\log X_{t+1} - \log X_t) + (1-\alpha)*(\log X_t - \log X_{t-1})$$

and for approximation 3, in figures 1c, 2c and 3c, it is given by:

$$[1-((1-\alpha)*(1-2\alpha))]*\log X_{t+1} + (1-2\alpha)*\log X_t - [1+(\alpha*(1-2\alpha))]*\log X_{t-1}$$

They show the similarity between labour and small households for the changes around male and female births. For medium and large households (which are pooled due to the small size of the sample), household total consumption goes down around a female birth relative to the change around a male birth under all the three approximations. We observe a similar relationship for the labour households under approximation 2. Given these matching patterns in consumption changes, we pool the landless and small landholding groups, and the landed groups together for our analysis. In Section 4 below, we provide another justification based on the relative marriage costs for these households.

4.1 Estimation Results for Approximation 1

We start with the results for the medium and large households: Figures 4 to 7 present the raw data on the expenditure categories for medium and large households (the figure for total consumption is presented here again for comparison). Tables 8 to 11 present the estimation results. There are no outliers for the total expenditure category in the data. Table 8 presents the estimation results for total household expenditures: the coefficient on the gender variable (D) is negative, as predicted by the theory, since parents reduce total household expenditures by about 15 per cent following the birth of a girl. However, as we discussed above, this reduction could be either due to within-household bias in favour of male children or wealth-effect. The standard error of this (negative) coefficient declines slightly when we control for the village-year effects (by including the village-year median consumption for the no-birth households) in column 3 of Table 8. The important thing to note here, as we discussed above, is that the coefficient of the D variable does not change when we include the residuals. We find that the size of the reduction in total expenditures increases to around 20 per cent (t-value of 1.8) when we include the other control variables (stock of children and income).

The estimation results for total household food consumption are presented in Table 9, with the box-plots for the raw data in Figure 5, for the medium and large households. As can be seen from the figure, there is an outlier in the data which is individually plotted. The first column in the table provides the estimates with the outlier in the data: there is a significant reduction in household food consumption following the birth of a girl. We remove this outlier in the second column, and the reduction in expenditures becomes sharper. With the village-year control variable, the standard error of this coefficient declines slightly, with households reducing their total food expenditures by about 18 per cent following a female birth, relative to a male birth. Here again the other three control variables do not have any significant effect, though they alter the coefficient estimate for the birth-difference dummy slightly. In column 6 we see that the reduction in food expenditures is around 20 per cent for these households.

The next three figures and tables provide the results for adult goods expenditures for medium and large households: Figures 6a and 6b show that parents do reduce expenditures on food for themselves. There is also an outlier in both the figures. Table 10a presents the results for adult food expenditures with $\tilde{B}_f = 100$ - with the outlier in, there is a 11.7 per cent reduction in adult expenditures on food; column 2 presents the estimates with the outlier removed, there is a significant fall in adult expenditures (16.7 per cent in columns 2 and 4). The last two columns do not show any significance for the children-stock and income variables, with a reduction of about

19 per cent in adult-food expenditures. In Table 10b, the bias costs are increased to 150 rupees ($\tilde{B}_f$ = 150). As one would expect from our definitions of adult-food expenditures, the reduction in expenditures following the birth of a girl is lower with an increase in the bias costs - parents reduce their own food expenditures by about 16 per cent, and with the inclusion of the other controls, the reduction is around 18 per cent. There is no qualitative change in the other results.

The raw data on narcotics expenditures are presented in Figure 7: the box-plots suggest that, without any other controls, parents reduce the expenditures on this category of adult goods following the birth of both male and female children, but they reduce it more if the new born is a girl. This indicates that wealth-effect is the dominant motive, but we do not find any significant effects in the data when we include the other control variables (Table 11). Expenditures fall by about 10 per cent, but this outcome is not significant as presented in column 3 of the table.

Overall, however, our results support the marriage costs hypothesis for the medium and large households: these households behave as though there is a shock on their life-time wealth following the birth of a girl. For household food and adult food expenditures, we find that there is a sizeable and significant reduction in expenditures.

But we find that there is only a weak reduction in the expenditures on narcotics. They reduce total household expenditures by about 20 per cent following a female birth.

We now turn to the estimation results for labour and small households; the raw data are presented in Figures 8 to 11 and Tables 12 to 15 provide the estimation results. The box-plots for total household expenditures show that there is no support for the predictions of the model as presented in Table 1 for total expenditures. The results presented in Table 12 show that household total expenditures increase following the birth of a girl. However, we find that there is a reduction in household total food expenditures following a female birth. Figure 11 presents the raw data on narcotics etc (adult goods) for these households. We find that these households reduce their expenditures on narcotics following the birth of a boy, but increase the expenditures following the birth of a girl. The net increase, which is not significant, in expenditures on this adult-goods category is about 27 per cent following the birth of a girl. But there is no such increase in the estimated adult food expenditures for these households, as the results reported in Tables 14a and 14b show. The signs of the birth difference coefficients for narcotics equations do line up with the within-household bias motive, but these results (for both food and non-food adult goods) do not provide any conclusive evidence in favour of or against our competing hypotheses.

Thus, in terms of the predictions of our model, our results for the landless and small ICRISAT households do not provide support for either of the predictions. The outcome that the propertied households behave as if there is a negative wealth-effect is concomitant with the anthropological evidence we present in the next section. The available evidence points out that wealthy households in rural India follow the practice of giving dowry, whereas unpropertied groups generally do not[12]. Our analysis of the retrospective data on marriages collected by ICRISAT also presents a similar picture. We deal with these issues in Section 5.

12. See Bardhan (1984) and Miller (1980). Miller provides evidence that the practice of giving dowry is more prevalent among the wealthy, landed groups than among the unpropertied groups in rural India.

4.2 Estimation Results for Approximation 2 (α - Approximation I)

The next set of results deals with the second approximation (or the α - approximation I) for the dependent variable in our estimation equations. Figures 12 to 15 present the raw data for this approximation for the medium and large households, and the estimation results appear in Tables 16 to 19. Qualitatively, the results here are the same as for approximation 1. Households significantly reduce their expenditures on total food (9 per cent), adult food (8 per cent and 7.7 per cent) and narcotics (18 per cent) following the birth of a girl. We present the results with and without the outliers, if any. We construct the village level median consumption (for the no-birth, out of sample households) variable using the α - definition of the dependent variable. But the total expenditure results are weaker for this approximation than for the first approximation. The other control variables (children and income) do not have any significant effect in these equations. The results we get for this approximation support the outcome under the first approximation, at least when we look at household food and adult-food expenditures, that for these propertied households wealth-effect dominates any parental preferences in intra-household allocation of resources over the life-cycle.

This approximation yields qualitatively similar results for the labour and small households as well. These results are presented in Tables 20 to 23. There is no siginificant difference in household food or adult food consumption between male and female births - these households do not have any significant changes in their consumption of food following the birth of children, as can be seen from box plots. The increase in the expenditures on narcotics is smaller in size (and insignificant) under this approximation, at about 13 per cent. Total expenditure equations still give us results that do not support the predictions of our model. Thus, as in the above analysis, we do not find any conclusive evidence in favour or against the two hypotheses. The next sub-section deals with the third approximation of the dependent variable.

4.3 Estimation Results for Approximation 3 (α - Approximation II)

The box-plots for the raw data for this approximation for the medium and large households are presented in Figures 20 to 23, and Tables 24 to 27 provide the estimation results: the same qualitative picture, as in the above two approximations, emerges here as well. Households in this category reduce their total expenditures following the birth of a girl (11 per cent), but the reduction is not significant as in the first approximation. Total household food expenditures decline by about 14.5 per cent following the birth of a girl, relative to the birth of a boy. Parents reduce their own expenditures on food significantly (Table 26b), by about 15 per cent, if the child is a girl They also reduce the expenditures on narcotics by about 20 per cent, though it is not at a significant level.

The last set of figures (Figures 24 to 27) and tables (Tables 28 to 31) present the data and results for labour and small households for this approximation. The results are, in general, similar to the first two approximations, with the exception of adult goods expenditures (on narcotics etc). We do not find any significant differences between male and female births with regard to household food or adult food expenditures. In the case of narcotics expenditures, the landless and small households increase their expenditures by about 25 per cent following the birth of a girl (column 4 in Table 31). The box plots presented in Figure 27 show the raw difference for this category of expenditures. This result supports the within-household bias motive, as outlined in our theoretical model above. It should however be noted that the inclusion of the income variable (in column 6) reduces the significance of the birth-difference coefficient. Results for total expenditures do not support the predictions of the model in this case as well for these households.

4.4 Discussion of the Results

The above results for the three approximations for the dependent variable present a consistent picture for the wealthy households, at least when we look at the household food and adult-food expenditures: the allocative behaviour of these households in the ICRISAT data can be explained by the marriage costs hypothesis of the model. We find that expenditures decline following the birth of a girl, and they increase (with the exception of narcotics consumption) following the birth of a boy under all the three approximations - see the box plots - indicating that parents reduce current consumption in order to increase their savings. The outcomes from the various estimation equations for total food and adult-food expenditures (with the control variables) support the wealth-shock hypothesis, that these households reduce current expenditures soon after the birth of a girl in order to meet the dowry and other financial commitments of the girl's marriage that is at least fourteen years away in the future. We find that total expenditures decline following the birth of a girl in all the approximations, but significantly so only in the first approximation.

Our model implies that these households reduce their total expenditures by about 20 per cent every year, under approximation 1 (and around 15 per cent under approximation 3, though it is not significant), following the birth of a female child, until she leaves the household after her marriage. This type of behaviour exactly mimics the outcome predicted by the life-cycle model of consumption: that agents adjust their current consumption in order to meet future commitments. We also provide some evidence below from the ICRISAT retrospective marriage survey, which approximately matches up the figures we get for the consumption adjustments following births with the marriage costs for these households.

Our results for labour and small households, however, provide some support for the within-household bias hypothesis. The estimation equations for adult goods - narcotics mainly, in approximation 3 - show that parents reduce expenditures following the birth of a male child, but increase them following a female birth, giving a positive coefficient for the birth dummy in our equations. The results from the total expenditure equations do not support the predictions of our model. These results suggest that we have limited support for the within-household bias motive for the labour and small households, at least when we confine ourselves to the expenditures on narcotics. S.Subramanian and Deaton (1991) report the same result for a sample of Indian households, but they do not look at the landed and landless households separately. Bardhan's (1984) review of the available anthropological and anthropometric evidence suggests that one would expect to find male children being allocated more resources relative to female children in unpropertied households, whereas in propertied households the difference may be less or non-existent. We now turn to present some anthropological evidence on dowry and marriage costs in India.

5. Other Evidence

The institution of dowry and marriage-related payments has long been in existence in India. There are many regional, caste and class variations in the practice of giving dowry and bride-price across the country. There is a rich anthropological and ethnographic literature on marriage practices and customs in India. Miller (1980) examines the hypothesis that higher marriage costs for female children lead to a differential treatment of boys and girls by parents, based on information from various rural ethnographic surveys and mortality data from the Census of India[13]. The surveys covered in her paper look at the marriage payment practices of both propertied and unpropertied groups, and for various castes within these groups, across the country. The data support the hypothesis in the sense that mortality rates for female children are higher in regions where different caste and class groups follow the practice of giving dowry and marriage related payments.

In general, marriage costs are substantially higher for the bride's family among the propertied groups throughout the country. Among the unpropertied (landless)

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13. Rosenzweig and Schultz (1982), as noted above, using an Indian household survey and census data find that increased returns to investments in female children (in the form of an increase in employment opportunities for females) have a positive impact on the survival chances of female children.

groups, there are regional variations: reciprocity or exchange of gifts, and in some cases bride-wealth, is the norm in the Southern and Eastern parts of India generally, and dowry is common in the North. The main reason, as suggested by economists, lies in the participation of females in agriculture and other economic activities. Female participation rates are lower among the landed groups than for the landless households throughout the country, and for the landless participation rates are lower in the North than in the South due in part to ecological conditions. Social anthropologists suggest hypergamy, or the custom of choosing grooms from a superior clan, which is practiced predominantly in the north as the main reason for the prevalence of dowry in that part of the country[14].

Higher marriage cost for female children was given as the main reason by the British government for the practice of female infanticide, which it legally abolished in 1870. However, even after the enactment of the Dowry Prohibition Act by the government in 1961, there has been a rise in the real value of dowry payments, and many communities have been switching from paying bride-price to the practice of giving dowry (Epstein (1973), Harriss (1990), Rao (1993a, 1993b)). Demographers suggest marriage squeeze, or more women than men in the marriageable age groups assuming that women

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14. See Srinivas (1984). There is a sound economic rationale behind hypergamy: the bride's family acquires status through the marriage and the groom's family acquires, in return, wealth in the form of dowry and gifts.

marry older men and anthropologists provide Sanskritization, or the process of lower caste groups adopting the upper-caste behaviour of paying dowry, as the main reasons for these trends in the marriage market in India.

Based on the ICRISAT retrospective survey on marriages and Indian census data for the study districts, in addition to the consumption data used in this study, Rao (1993a) finds support in favour of the marriage squeeze hypothesis without much evidence for the alternative that the changing dowry trends may be a reflection of the participation behaviour of women in labour market activities. Social pressure that female children must be married before an "acceptable" age imposes significant economic pressures on households with predominantly more female children to increase the dowry in a marriage market made competitive by marriage squeeze. Rao presents evidence that the average dowry received by a groom amounts to about sixty eight per cent of his household's assets before the marriage and that the real value of dowry payments has risen over the last seven decades. In accordance with Miller's (1980) hypothesis, given the high dowry and marriage costs in the ICRISAT regions, it should be noted that the mortality rate for female children exceeds that for male children in the sample regions (Miller (1981)).

5.1 Marriage Costs for Propertied and Unpropertied Households in ICRISAT Regions

In 1984-85, ICRISAT conducted a survey on marriage and inheritances in which households reported cash and kind transactions at the time of marriage, marriage expenses incurred by the family, year of marriage and a number of other things. This survey was conducted in all the ten semi-arid villages where ICRISAT started its initial agricultural research in 1975. The information gathered in this survey corroborates the anthropological evidence reported above that marriage costs increase with wealth. Largest landholding households incur significantly higher marriage costs in the form of higher marriage expenses and dowry given. Propertied groups in general pay higher dowries in cash and kind than the landless households. The reason for the higher costs, as suggested in the literature, may be that women in propertied households do not actively participate in labour-market activities.

In the following table we provide some descriptive statistics on marriage expenses and dowries paid for marriages of daughters of the head of the household in the three villages for which we have continuous consumption data from 1975-84. Both marriage expenses and dowry in cash for marriages after 1975 are deflated with a consumer price index (1983 as the base year, columns 4 and 5), but marriage costs for marriages during the whole period (with the first marriage reported in the early 1940s, column 3) are not deflated. We also report the dowry amount (paid in cash, converted to 1983 gold value) for the whole data set (column 2).

Table 7 : Mean Marriage Costs for ICRISAT Households[a]

Households	Cash Dowry, All years	Mar Exp, All years	Cash Dowry, After 1975 (in 1983 rupees)	Mar. Exp, After 1975 (in 1983 rupees)
Labour and Small Households	1096 (1948)	1404 (1208)	1199 (1156)	1681 (1330)
Medium and Large Households	5396 (15925)	2957 (4206)	6373 (10092)	4567 (4971)

(a. All figures are in rupees; column 2 is cash converted to 1983 gold value; columns 4 and 5 are for marriages after 1975; numbers in parantheses are standard deviations)

Large land-owning households spend approximately ten times as much as the landless labour households in getting their daughters married off. Medium and large households spend about 10940 rupees for a daughter's marriage (from columns 4 and 5 of the table). Labour and small households, on the other hand, spend about 2880 rupees on a marriage. In addition to cash dowries, wealthy-households also pay a substantial amount in kind: the value of dowry in gold is about 2300 rupees (whereas it is 141 rupees for the labour and small households), apart from the silver and livestock dowries. The wealthy households spend up to 30 per cent more than their one year's income (from the 1975-84 mean income data) on dowry and marriage costs for a girl's marriage. The labour and small households spend about 59 per cent of their one year's income on a marriage.

Given that marriage costs increase with wealth, one would expect to see more adjustments in household consumption for the larger landholding groups than for the landless and small households as soon as the birth-surprise is revealed, under the marriage-costs regime. It should also be noted that a majority of households reported meeting the costs of marriages from own savings, with sale of property coming second. In our analysis above, we have therefore estimated the consumption equations separately for these two groups of households.

For the medium and large households, we find that there is a reduction in total expenditures of about 15 to 20 per cent (Approximations 1 and 3) following the birth of a female child. The descriptive statistics in Table 5 report that the average annual total expenditure for these households is around 5150 rupees. If these households reduce their total expenditures by 15-20 per cent every year, their savings add up to about 9750-14000 rupees over 13-14 years (mean age at marriage for females is about 15 years in our data). This range of savings matches up approximately with the evidence presented above that these households spend about 11000 rupees for a girl's marriage, on dowry and other expenses. It should, however, be pointed out that our estimation results for the labour and small households do not allow a similar comparison with their marriage costs. We find that for these poorer households bias in favour of male children dominates any wealth-effect associated with a female birth, at least when we look at the adult-expenditures on narcotics.

6. *Summary and Conclusions*

In this paper we looked at an important issue pertaining to household consumption behaviour in a number of developing countries. There is evidence in the development economics literature that females, especially female children, are discriminated against in the allocation of resources within the household in many developing countries, particularly in Asia. We presented two possible, competing hypotheses that may help us in understanding the parental motives behind any such non-random distribution of resources within the household: we considered the possibility that parents may exhibit preferences towards male children in allocating resources (within-household bias), against the alternative that parents may follow a systematic allocation pattern due to the higher (marriage) costs of female children in many countries.

In India and a number of other Asian countries, the system of dowry has long been in existence. There is evidence (economic, as well as anthropological) that households spend a substantial amount of resources on the marriages of female children. If parental behaviour in the sphere of intra-household allocation is influenced by the higher (marriage) costs of female children, then one would expect to see a change in the household consumption-savings profile following the birth of female children: households would reduce their current expenditures and increase their savings in order to meet the future marriage costs. The birth of a female child, in this context, then will have the same effect as that of a negative shock on life-time household wealth.

Based on this simple, life-cycle argument, we presented a three period model that allows for both within-household bias and wealth effect (marriage costs) motives for intra-household allocation of resources. Invoking the assumption used in the modern theories of life-cycle consumption that households attempt to maintain their marginal utility of wealth constant over time, we obtained various predictions pertaining to consumption changes over time following the birth of children. It was also shown that the predictions of the model depend crucially on the category of household expenditures that we look at: predictions for total consumption differ from those for the expenditures on adult-goods.

The model we present shows that household total expenditures are lower after a female birth (relative to a male birth) under both the within-bias and the wealth-effect regimes. However, expenditures on adult goods are lower after a female birth under the wealth-effect regime, but the model yields the outcome that they are higher after a female birth (relative to a male birth) under the within-household bias regime. Thus, we need to look at components of total consumption in order to discriminate between the two competing hypothesis.

There is a simple intuition behind these predictions: under the wealth-effect regime, the marginal utility of wealth is higher following the birth of a female child (since life-time wealth is lower) - parents then reduce total expenditures, and all the component expenditures (adult and other goods), soon after a female birth (and they keep them at the reduced level until the child leaves home after marriage), in order to keep the marginal utility of wealth constant over time. The size of the reduction depends on the amount they expect to incur in the form of dowry and other marriage expenses in the future. On the other hand, under the within-household bias regime, parents reduce adult expenditures more following a male birth (relative to a female birth) in order to make room for the higher expenditures (bias costs) on male children. The model predicts a positive (net) effect on total expenditures following a male birth relative to a female birth, and this as we show is due to the bias costs of male children.

We use a unique panel of data (ICRISAT Village Level Studies survey) on rural Indian households for testing the predictions of our model. Based on the evidence in the literature that wealthy households incur much higher expenses on dowry and marriage ceromonies than poor households, we test the predictions separately for landed and landless households in our sample. Consumption patterns over time for the medium and large households in our data seem to suggest that for these households wealth-effect or marriage costs of female children dominate any within-household parental preferences towards male children. We find that these households reduce total expenditures in the range of 15 to 20 per cent following the birth of a female child. Under the structure of the model, this implies that they maintain the lower expenditures until the time of the child's marriage. The resulting savings estimates for these households are fairly comparable to the amount of resources these households spend on a daughter's marriage. Our savings figures are in the range of 9750-14000 rupees for these households over 13-14 years, and they spend on average about 11000 rupees for a daughter's marriage.

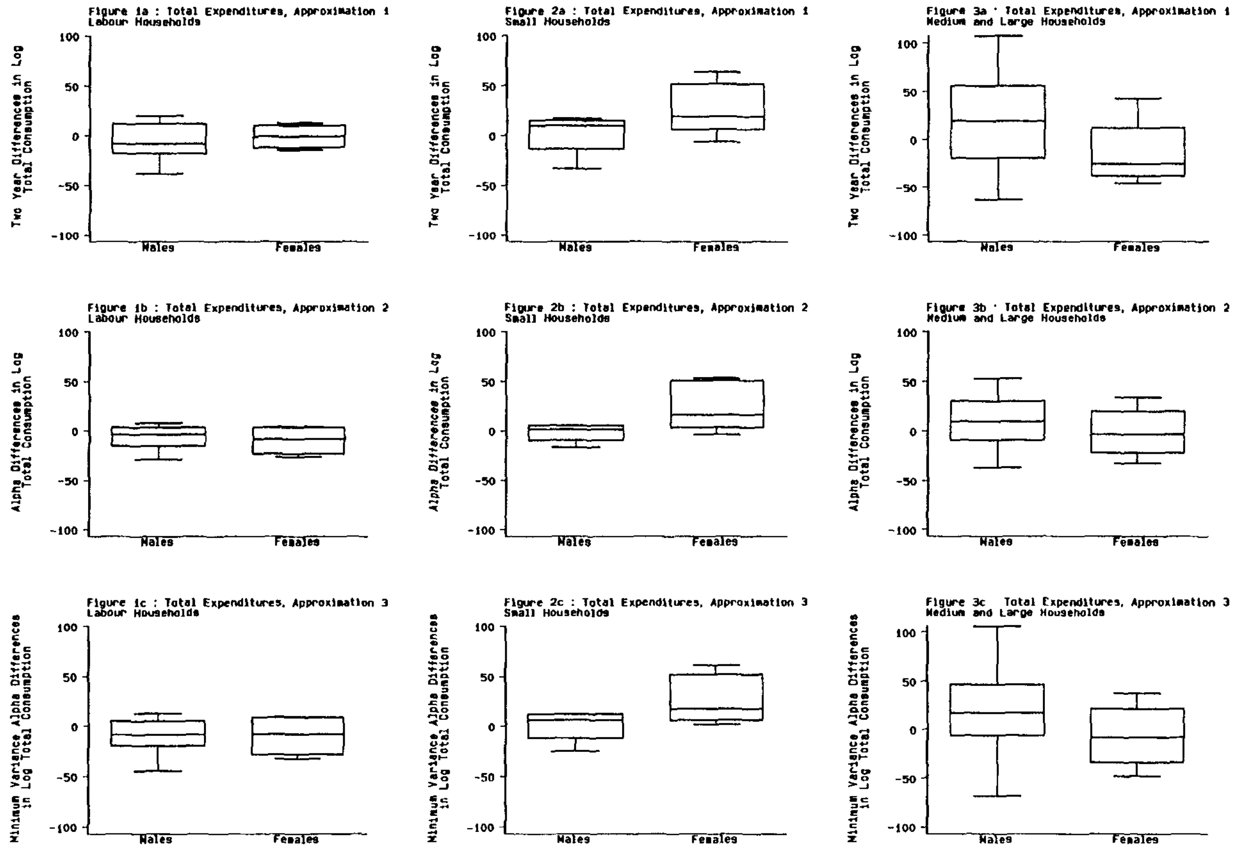
However, this outcome does not hold for the poorer households in our sample. The labour and small landed households seem to exhibit preferences towards male children in the intra-household allocation of resources. We find that these households significantly reduce their spending on narcotics following the birth of a male child, at least under one of our approximations for the dependent variable, implying that within-household bias dominates any wealth-effect associated with a female birth. These results must be interpreted with some caution, since our results for total expenditures for these households do not support the predictions of our model.

Our results also have broader implications for the debate on the validity of the life-cycle consumption model. If our conclusions regarding the wealth-effect for the landed households following a female birth are correct, then from our results it seems that households do make adjustments in their current consumption in order to meet their future commitments that are at least fifteen years away. The life-cycle model posits exactly the same kind of behaviour, that any anticipated shocks on life-time wealth are factored into the agents' consumption decisions so that consumption smooths any changes in wealth. The reduction in consumption that we observe for the medium and large households following a female birth clearly indicates that those households with predominantly more female children are poorer, over their life-times, than those with more male children.

Under the within-bias regime, we look at the possibility that parents may have preferences towards male children given that both male and female children are present in the household, as opposed to parental preferences for having male children. While the within-bias and the wealth-effect hypotheses are two distinct motives the model, it is possible that the wealth-shock associated with the high marriage costs of female children may be an important cultural factor in parental preferences regarding the sex of children in India. As the predictions of our model indicate, both motives may be present but one dominates the other. For the wealthy households we find that wealth-effect dominates within-household bias, but the reverse holds for the poorer households.

The practice of giving dowry has been in existence in centuries in India. We presented some evidence in Section 5 that there is a switch from bride price to paying dowry and that there has been a rise in the real value of dowry payments in the recent years. Only an increase in the market opportunities for women would reduce the negative effect of the wealth-shock, given that the legislative attempts have not been successful in solving this problem with its roots in the culture of the country.

Total Expenditures, By Landholding Group, All Approximations



Stata™

Raw Data for Medium and Large Households, Approximation 1

Figure 4 : Total Expenditures, Approx 1
Medium and Large Households

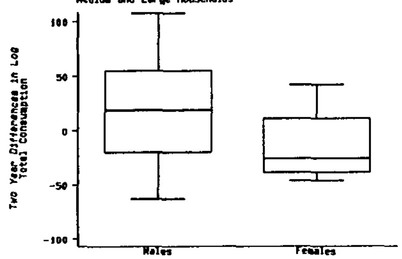


Figure 5 : Total Food Expenditures, Approx 1
Medium and Large Households

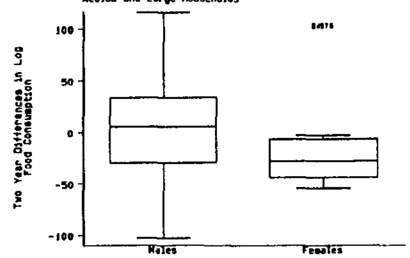


Figure 6a : Adult Food Expenditures 1, Approx 1
Medium and Large Households

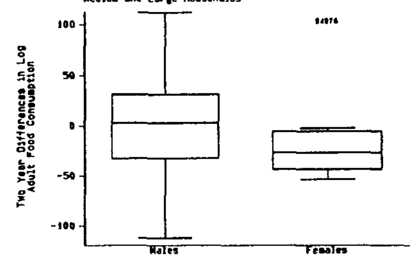


Figure 6b : Adult Food Expenditures 2, Approx 1
Medium and Large Households

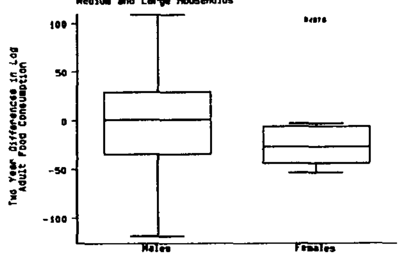
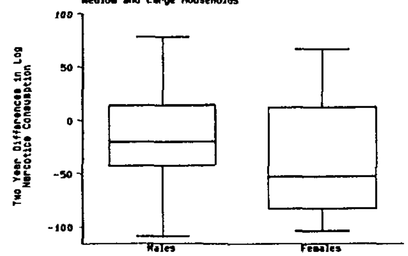
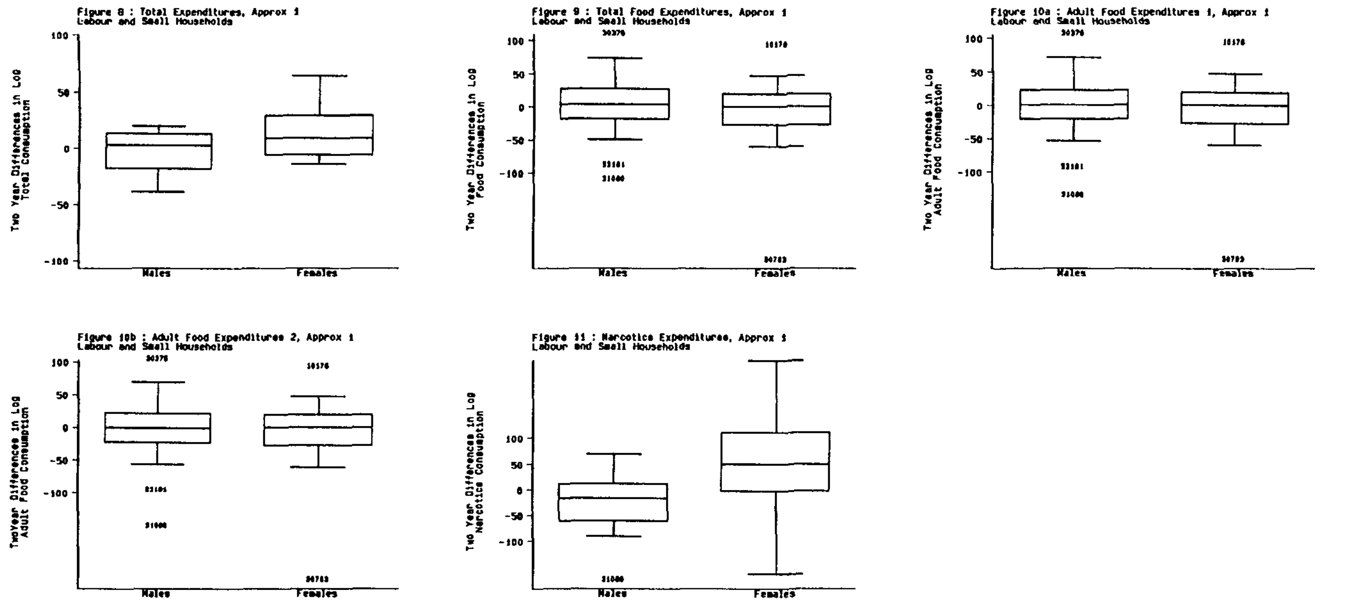


Figure 7 : Narcotics Expenditures, Approx 1
Medium and Large Households



Raw Data for Labour and Small Households, Approximation 1



Raw Data for Medium and Large Households, Approximation 2

Figure 12 . Total Expenditures, Approx 2
Medium and Large Households

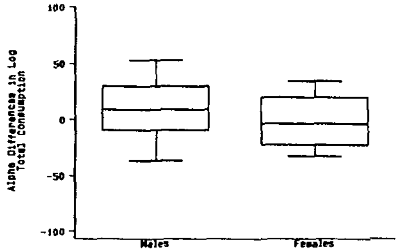


Figure 13 : Total Food Expenditures, Approx 2
Medium and Large Households

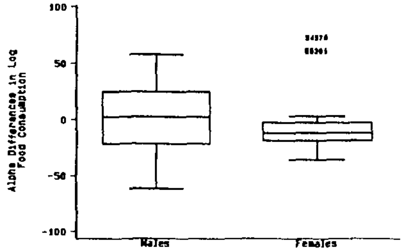


Figure 14a : Adult Food Expenditures 1, Approx 2
Medium and Large Households

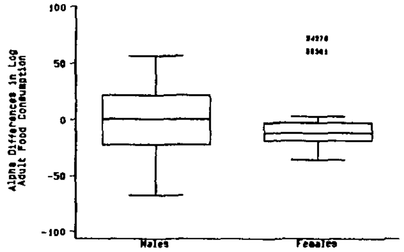


Figure 14b : Adult Food Expenditures 2, Approx 2
Medium and Large Households

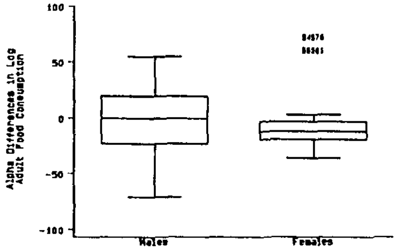
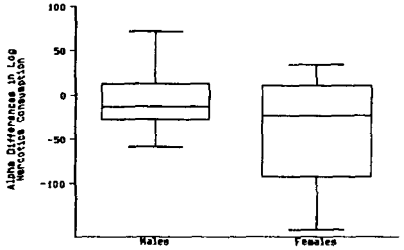


Figure 15 Narcotics Expenditures, Approx 2
Medium and Large Households



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Raw Data for Labour and Small Households, Approximation 2

Figure 16 Total Expenditures, Approx 2
Labour and Small Households

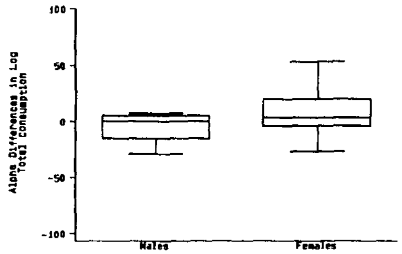


Figure 17 · Total Food Expenditures, Approx 2
Labour and Small Households

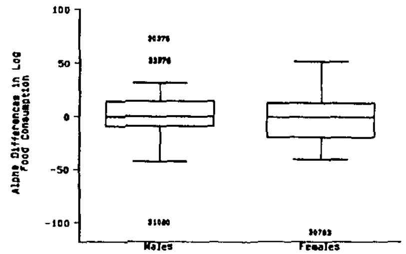


Figure 18a : Adult Food Expenditures 1, Approx 2
Labour and Small Households

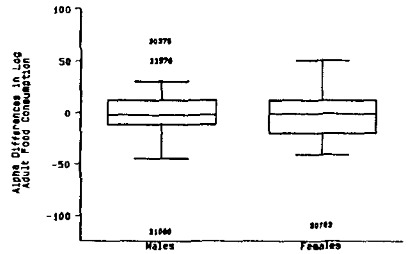


Figure 18b : Adult Food Expenditures 2, Approx 2
Labour and Small Households

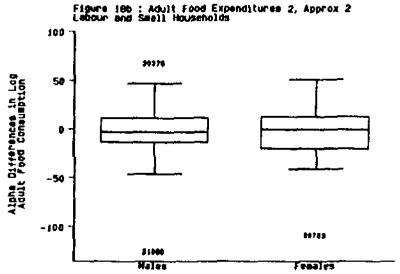
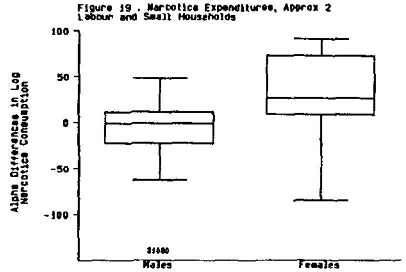


Figure 19 . Narcotics Expenditures, Approx 2
Labour and Small Households



Raw Data for Medium and Large Households, Approximation 3

Figure 20 . Total Expenditures, Approx 3
Medium and Large Households

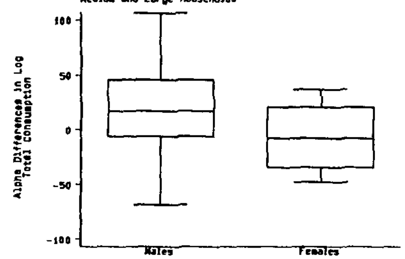


Figure 21 Total Food Expenditures, Approx 3
Medium and Large Households

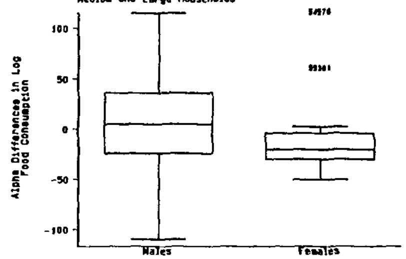


Figure 22a . Adult Food Expenditures 1, Approx 3
Medium and Large Households

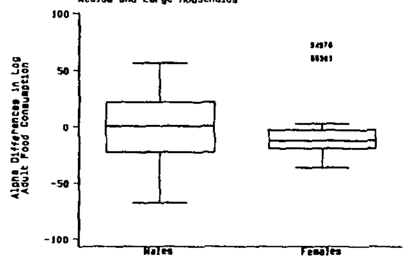


Figure 22b : Adult Food Expenditures 2, Approx 3
Medium and Large Households

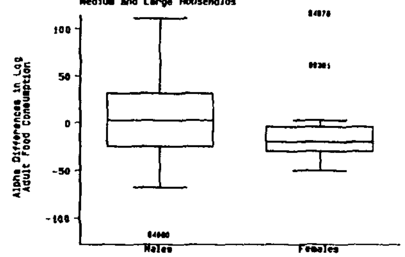
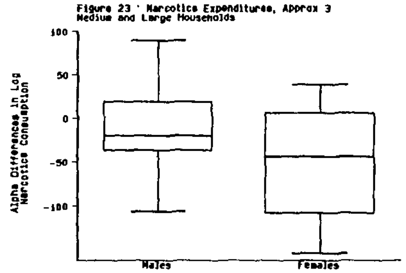


Figure 23 ' Narcotics Expenditures, Approx 3
Medium and Large Households



Raw Data for Labour and Small Households, Approximation 3

Figure 24 . Total Expenditures, Approx 3
Labour and Small Households

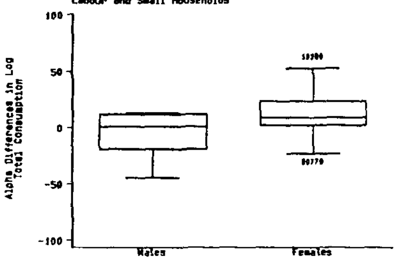


Figure 25 Total Food Expenditures, Approx 3
Labour and Small Households

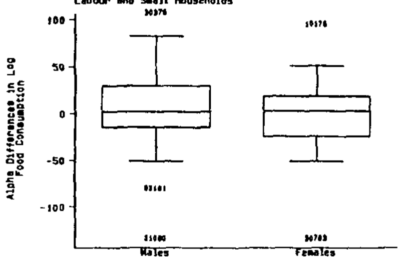


Figure 26a . Adult Food Expenditures 1, Approx 3
Labour and Small Households

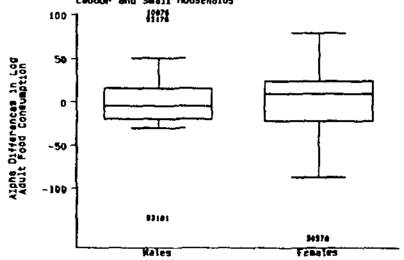


Figure 26b : Adult Food Expenditures 2, Approx 3
Labour and Small Households

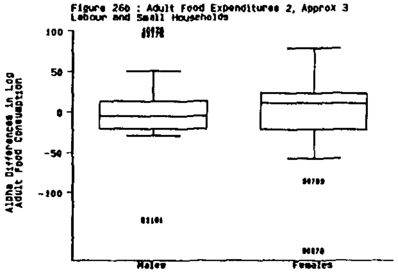


Figure 27 . Narcotics Expenditures, Approx 3
Labour and Small Households

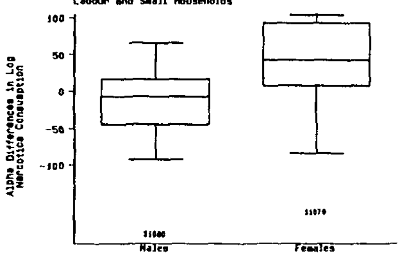


Table 8 : Estimation Results for Total Consumption, Medium and Large Landed Households, 1976-81

Dep.variable: $(X_{t+1} - X_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.153 (0.13)	-0.141 (0.11)	-0.153 (0.11)	-0.206 (0.12)	-0.212 (0.12)
$\overline{\Delta C}$		0.911 (0.34)			
$\overline{\Delta C_R}$			0.911 (0.34)	0.930 (0.35)	0.974 (0.35)
M_{t-1}				-0.050 (0.07)	-0.039 (0.07)
F_{t-1}				-0.165 (0.16)	-0.151 (0.16)
ΔY					0.155 (0.18)
Intercept	0.019 (0.13)	-0.023 (0.11)	0.019 (0.11)	0.234 (0.20)	0.223 (0.20)
R-Sqd	0.069	0.334	0.334	0.399	0.427

Table 9 : Estimation Results for Total Food Consumption, Medium and Large Landed Households, 1975-84

Dep.variable: $(X^f_{t+1} - X^f_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.133 (0.07)	-0.183 (0.07)	-0.125 (0.07)	-0.183 (0.06)	-0.193 (0.07)	-0.206 (0.07)
$\overline{\Delta C}$			0.612 (0.19)			
$\overline{\Delta C_R}$				0.612 (0.19)	0.630 (0.19)	0.650 (0.19)
M_{t-1}					-0.009 (0.05)	0.001 (0.05)
F_{t-1}					-0.039 (0.08)	-0.051 (0.09)
ΔY						0.128 (0.12)
Intercept	-0.050 (0.08)	-0.099 (0.07)	-0.052 (0.07)	-0.099 (0.06)	-0.054 (0.11)	-0.054 (0.11)
R-Sqd	0.070	0.142	0.329	0.329	0.334	0.364

Table 10a : Estimation Results for Adult-Food Consumption, Medium and Large Landed Households, 1975-84

Dep.variable: $((X^f_{t+1} - \tilde{B}_f) - X^f_{t-1})$,

where $\tilde{B}_f = 100$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.117 (0.08)	-0.167 (0.07)	-0.107 (0.07)	-0.167 (0.06)	-0.178 (0.07)	-0.190 (0.07)
$\overline{\Delta C}$			0.625 (0.19)			
$\overline{\Delta C_R}$				0.625 (0.19)	0.646 (0.19)	0.666 (0.19)
M_{t-1}					-0.007 (0.05)	0.003 (0.05)
F_{t-1}					-0.048 (0.08)	-0.059 (0.09)
ΔY						0.122 (0.12)
Intercept	-0.066 (0.08)	-0.116 (0.07)	-0.068 (0.07)	-0.116 (0.06)	-0.066 (0.11)	-0.065 (0.12)
R-Sqd	0.054	0.118	0.314	0.314	0.321	0.349

Table 10b : Estimation Results for Adult-Food Consumption, Medium and Large Landed Households, 1975-84

Dep.variable: $((X^{f}_{t+1} - \tilde{B}_f) - X^{f}_{t-1})$,

where $\tilde{B}_f = 150$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.109 (0.08)	-0.159 (0.07)	-0.098 (0.07)	-0.159 (0.06)	-0.170 (0.07)	-0.182 (0.07)
$\overline{\Delta C}$			0.631 (0.19)			
$\overline{\Delta C_R}$				0.631 (0.19)	0.655 (0.19)	0.675 (0.19)
M_{t-1}					-0.005 (0.05)	0.004 (0.05)
F_{t-1}					-0.052 (0.09)	-0.064 (0.09)
ΔY						0.118 (0.12)
Intercept	-0.075 (0.08)	-0.125 (0.07)	-0.076 (0.07)	-0.124 (0.06)	-0.072 (0.11)	-0.071 (0.12)
R-Sqd	0.050	0.107	0.306	0.306	0.314	0.341

Table 11 : Estimation Results for Adult Goods (narcotics etc), Medium and Large Landed Households, 1976-81

Dep.variable: $(C^n_{t+1} - C^n_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.098 (0.16)	-0.064 (0.13)	-0.098 (0.13)	-0.051 (0.15)	-0.051 (0.15)
$\overline{\Delta C}$		0.637 (0.22)			
$\overline{\Delta C_R}$			0.637 (0.22)	0.618 (0.23)	0.618 (0.23)
M_{t-1}				0.037 (0.09)	0.037 (0.09)
F_{t-1}				0.165 (0.19)	0.165 (0.20)
ΔY					0.004 (0.22)
Intercept	-0.253 (0.16)	-0.225 (0.13)	-0.253 (0.13)	-0.451 (0.25)	-0.451 (0.25)
R-Sqd	0.020	0.335	0.335	0.373	0.373

Table 12 : Estimation Results for Total Consumption, Labour and Small Landed Households, 1976-81

Dep.variable: $(X_{t+1} - X_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	0.094 (0.05)	0.079 (0.06)	0.094 (0.05)	0.106 (0.06)	0.109 (0.06)
$\overline{\Delta C}$		0.252 (0.38)			
$\overline{\Delta C_R}$			0.252 (0.38)	0.210 (0.41)	0.315 (0.44)
M_{t-1}				-0.026 (0.07)	-0.027 (0.08)
F_{t-1}				0.025 (0.05)	0.020 (0.05)
ΔY					0.115 (0.15)
Intercept	0.061 (0.05)	0.033 (0.07)	0.061 (0.05)	0.057 (0.12)	0.076 (0.12)
R-Sqd	0.149	0.171	0.171	0.187	0.218

Table 13 : Estimation Results for Total Food Consumption, Labour and Small Landed Households, 1975-84

Dep.variable: $(X^f_{t+1} - X^f_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.065 (0.07)	-0.057 (0.04)	-0.049 (0.03)	-0.057 (0.03)	-0.058 (0.03)	-0.063 (0.03)
$\overline{\Delta C}$			0.581 (0.09)			
$\overline{\Delta C_R}$				0.581 (0.09)	0.592 (0.09)	0.547 (0.10)
M_{t-1}					-0.019 (0.04)	-0.025 (0.04)
F_{t-1}					-0.009 (0.03)	-0.015 (0.03)
ΔY						-0.161 (0.10)
Intercept	-0.034 (0.07)	0.016 (0.04)	0.013 (0.03)	0.016 (0.03)	0.052 (0.07)	0.077 (0.07)
R-Sqd	0.016	0.036	0.484	0.484	0.488	0.517

Table 14a : Estimation Results for Adult-Food Consumption, Labour and Small Landed Households, 1975-84

Dep.variable: $((X^f_{t+1} - \tilde{B}_f) - X^f_{t-1})$,

where $\tilde{B}_f = 100$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.042 (0.08)	-0.037 (0.04)	-0.029 (0.03)	-0.037 (0.03)	-0.039 (0.03)	-0.043 (0.03)
$\overline{\Delta C}$			0.587 (0.09)			
$\overline{\Delta C_R}$				0.587 (0.09)	0.597 (0.10)	0.549 (0.10)
M_{t-1}					-0.016 (0.04)	-0.022 (0.04)
F_{t-1}					-0.009 (0.03)	-0.016 (0.03)
ΔY						-0.169 (0.11)
Intercept	-0.057 (0.08)	-0.003 (0.04)	-0.007 (0.03)	-0.004 (0.03)	0.029 (0.07)	0.055 (0.07)
R-Sqd	0.006	0.015	0.472	0.472	0.476	0.507

Table 14b : Estimation Results for Adult-Food Consumption, Labour and Small Landed Households, 1975-84

Dep.variable: $((X^f_{t+1} - \tilde{B}_f) - X^f_{t-1})$,

where $\tilde{B}_f = 150$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.029 (0.08)	-0.026 (0.05)	-0.019 (0.03)	-0.026 (0.03)	-0.028 (0.03)	-0.034 (0.03)
$\overline{\Delta C}$			0.591 (0.09)			
$\overline{\Delta C_R}$				0.591 (0.10)	0.599 (0.10)	0.551 (0.10)
M_{t-1}					-0.014 (0.04)	-0.021 (0.04)
F_{t-1}					-0.009 (0.03)	-0.016 (0.03)
ΔY						-0.173 (0.11)
Intercept	-0.070 (0.08)	-0.014 (0.05)	-0.018 (0.03)	-0.014 (0.03)	0.017 (0.07)	0.043 (0.08)
R-Sqd	0.003	0.008	0.468	0.468	0.471	0.504

Table 15 : Estimation Results for Adult Goods (narcotics etc), Labour and Small Landed Households, 1976-81

Dep.variable: $(C^n_{t+1} - C^n_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	0.358 (0.21)	0.274 (0.20)	0.256 (0.21)	0.274 (0.20)	0.324 (0.24)	0.351 (0.28)
$\overline{\Delta C}$			0.726 (0.69)			
$\overline{\Delta C_R}$				0.726 (0.69)	0.694 (0.75)	0.819 (1.02)
M_{t-1}					-0.054 (0.29)	-0.034 (0.32)
F_{t-1}					0.102 (0.20)	0.113 (0.21)
ΔY						0.214 (1.14)
Intercept	0.082 (0.21)	0.165 (0.20)	0.177 (0.20)	0.165 (0.20)	0.083 (0.48)	0.049 (0.53)
R-Sqd	0.138	0.095	0.153	0.153	0.170	0.172

Table 16 : Estimation Results for Total Consumption, α - Approximation I, Medium and Large Landed Households, 1976-81

Dep.variable: $\alpha*(X_{t+1} - X_t) + (1-\alpha)*(X_t - X_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.047 (0.07)	-0.053 (0.06)	-0.047 (0.06)	-0.070 (0.07)	-0.068 (0.07)
$\overline{\Delta C}$		0.923 (0.33)			
$\overline{\Delta C_R}$			0.923 (0.33)	0.987 (0.36)	0.956 (0.36)
M_{t-1}				-0.017 (0.04)	-0.007 (0.04)
F_{t-1}				-0.087 (0.09)	-0.088 (0.09)
ΔY					0.171 (0.16)
Intercept	0.036 (0.07)	-0.020 (0.06)	0.036 (0.06)	0.138 (0.11)	0.123 (0.11)
R-Sqd	0.022	0.322	0.322	0.369	0.415

Table 17 : Estimation Results for Total Food Consumption, α - Approximation I, Medium and Large Landed Households, 1975-84

Dep.variable: $\alpha*(X^f_{t+1} - X^f_t) + (1-\alpha)*(X^f_t - X^f_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.056 (0.05)	-0.091 (0.04)	-0.064 (0.04)	-0.091 (0.04)	-0.091 (0.04)	-0.093 (0.04)
$\overline{\Delta C}$			0.802 (0.18)			
$\overline{\Delta C_R}$				0.802 (0.18)	0.789 (0.18)	0.754 (0.19)
M_{t-1}					0.023 (0.03)	0.029 (0.03)
F_{t-1}					-0.027 (0.04)	-0.025 (0.05)
ΔY						0.075 (0.08)
Intercept	-0.015 (0.05)	-0.050 (0.04)	-0.048 (0.04)	-0.050 (0.04)	-0.054 (0.06)	-0.067 (0.07)
R-Sqd	0.035	0.104	0.424	0.424	0.436	0.449

Table 18a : Estimation Results for Adult-Food Consumption, α - Approximation I, Medium and Large Landed Households, 1975-84

$$\textit{Dep.variable}: \alpha * ((X^f_{t+1} - \tilde{B}_f) - (X^f_t - \tilde{B}_f)) + (1-\alpha) * ((X^f_t - \tilde{B}_f) - X^f_{t-1})$$

$$\textit{where } \tilde{B}_f = 100$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.047 (0.05)	-0.082 (0.05)	-0.052 (0.04)	-0.082 (0.04)	-0.084 (0.04)	-0.086 (0.04)
$\overline{\Delta C}$			0.860 (0.18)			
$\overline{\Delta C_R}$				0.860 (0.18)	0.855 (0.19)	0.811 (0.19)
M_{t-1}					0.023 (0.03)	0.030 (0.03)
F_{t-1}					-0.041 (0.05)	-0.037 (0.05)
ΔY						0.093 (0.09)
Intercept	-0.024 (0.05)	-0.059 (0.05)	-0.057 (0.04)	-0.059 (0.04)	-0.051 (0.06)	-0.068 (0.07)
R-Sqd	0.023	0.080	0.432	0.432	0.450	0.469

Table 18b : Estimation Results for Adult-Food Consumption, α - Approximation I, Medium and Large Landed Households, 1975-84

$$\textit{Dep.variable:}\ \alpha*((X^f_{t+1}-\tilde{B}_f) - (X^f_t-\tilde{B}_f)) + (1-\alpha)*((X^f_t-\tilde{B}_f) - X^f_{t-1}),$$

$$\textit{where}\ \tilde{B}_f = 150$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.042 (0.05)	-0.077 (0.05)	-0.046 (0.04)	-0.077 (0.04)	-0.080 (0.04)	-0.083 (0.04)
$\overline{\Delta C}$			0.893 (0.18)			
$\overline{\Delta C_R}$				0.893 (0.18)	0.892 (0.19)	0.843 (0.19)
M_{t-1}					0.023 (0.03)	0.031 (0.03)
F_{t-1}					-0.048 (0.05)	-0.044 (0.05)
ΔY						0.103 (0.09)
Intercept	-0.030 (0.05)	-0.064 (0.05)	-0.062 (0.04)	-0.064 (0.04)	-0.049 (0.06)	-0.069 (0.07)
R-Sqd	0.020	0.069	0.436	0.436	0.457	0.480

Table 19 : Estimation Results for Adult Goods (Narcotics etc), α - Approximation I, Medium and Large Landed Households, 1976-81

Dep.variable: $\alpha * (C^n_{t+1} - C^n_t) + (1-\alpha) * (C^n_t - C^n_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.178 (0.12)	-0.153 (0.10)	-0.178 (0.10)	-0.112 (0.09)	-0.113 (0.10)
$\overline{\Delta C}$		1.251 (0.38)			
$\overline{\Delta C_R}$			1.251 (0.38)	1.140 (0.36)	1.155 (0.37)
M_{t-1}				0.031 (0.06)	0.027 (0.06)
F_{t-1}				0.284 (0.13)	0.284 (0.14)
ΔY					-0.081 (0.24)
Intercept	-0.229 (0.12)	-0.213 (0.10)	-0.229 (0.10)	-0.532 (0.16)	-0.525 (0.17)
R-Sqd	0.099	0.436	0.436	0.574	0.578

Table 20 : Estimation Results for Total Consumption, α - Approximation I, Labour and Small Landed Households, 1976-81

Dep.variable: $\alpha*(X_{t+1} - X_t) + (1-\alpha)*(X_t - X_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)
D	0.073 (0.05)	0.054 (0.05)	0.073 (0.05)	0.082 (0.05)	0.092 (0.05)
$\overline{\Delta C}$		0.432 (0.49)			
$\overline{\Delta C_R}$			0.432 (0.49)	0.421 (0.52)	0.811 (0.68)
M_{t-1}				-0.034 (0.06)	-0.048 (0.07)
F_{t-1}				0.012 (0.04)	0.020 (0.04)
ΔY					0.208 (0.23)
Intercept	0.028 (0.05)	-0.005 (0.06)	0.028 (0.05)	0.051 (0.09)	0.059 (0.09)
R-Sqd	0.123	0.162	0.162	0.180	0.223

Table 21 : Estimation Results for Total Food Consumption, α - Approximation I, Labour and Small Landed Households, 1975-84

Dep.variable: $\alpha*(X_{t+1}^f - X_t^f) + (1-\alpha)*(X_t^f - X_{t-1}^f)$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.025 (0.05)	0.015 (0.03)	-0.004 (0.03)	0.015 (0.03)	0.031 (0.03)	0.034 (0.03)
$\overline{\Delta C}$			0.517 (0.16)			
$\overline{\Delta C_R}$				0.517 (0.16)	0.534 (0.16)	0.601 (0.18)
M_{t-1}					-0.017 (0.03)	-0.016 (0.03)
F_{t-1}					0.042 (0.03)	0.046 (0.03)
ΔY						0.094 (0.12)
Intercept	0.001 (0.05)	0.015 (0.03)	-0.008 (0.03)	0.015 (0.03)	-0.017 (0.07)	-0.027 (0.07)
R-Sqd	0.006	0.006	0.221	0.221	0.274	0.285

Table 22a : Estimation Results for Adult-Food Consumption, α - Approximation I, Labour and Small Landed Households, 1975-84

$$\textit{Dep.variable}: \alpha*((X^f_{t+1} - \tilde{B}_f) - (X^f_t - \tilde{B}_f)) + (1-\alpha)*((X^f_t - \tilde{B}_f) - X^f_{t-1})$$

$$\tilde{B}_f = 100$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.012 (0.05)	0.026 (0.03)	0.006 (0.03)	0.026 (0.03)	0.042 (0.03)	0.046 (0.03)
$\overline{\Delta C}$			0.523 (0.16)			
$\overline{\Delta C_R}$				0.523 (0.16)	0.541 (0.16)	0.612 (0.18)
M_{t-1}					-0.018 (0.03)	-0.017 (0.03)
F_{t-1}					0.043 (0.03)	0.048 (0.03)
ΔY						0.098 (0.12)
Intercept	-0.012 (0.05)	0.005 (0.03)	-0.018 (0.03)	0.005 (0.03)	-0.026 (0.07)	-0.037 (0.07)
R-Sqd	0.001	0.015	0.231	0.231	0.285	0.298

Table 22b : Estimation Results for Adult-Food Consumption, α - Approximation I, Labour and Small Landed Households, 1975-84

$$\textit{Dep.variable}: \ \alpha*((X^f_{t+1}-\tilde{B}_f) - (X^f_t-\tilde{B}_f)) + (1-\alpha)*((X^f_t-\tilde{B}_f) - X^f_{t-1}),$$

$$\textit{where } \tilde{B}_f = 150$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.005 (0.05)	0.010 (0.04)	-0.005 (0.03)	0.010 (0.03)	0.022 (0.03)	0.023 (0.03)
$\overline{\Delta C}$			0.645 (0.15)			
$\overline{\Delta C_R}$				0.645 (0.15)	0.675 (0.15)	0.734 (0.19)
M_{t-1}					-0.028 (0.03)	-0.028 (0.03)
F_{t-1}					0.028 (0.03)	0.031 (0.03)
ΔY						0.073 (0.13)
Intercept	-0.019 (0.05)	0.020 (0.04)	-0.018 (0.03)	0.020 (0.03)	0.026 (0.07)	0.019 (0.07)
R-Sqd	0.001	0.002	0.307	0.307	0.338	0.345

Table 23 : Estimation Results for Adult Goods (Narcotics etc), α - Approximation I, Labour and Small Landed Households, 1976-81

Dep.variable: $\alpha*(C^n_{t+1} - C^n_t) + (1-\alpha)*(C^n_t - C^n_{t-1})$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	0.202 (0.12)	0.132 (0.11)	0.126 (0.11)	0.132 (0.11)	0.128 (0.13)	0.095 (0.14)
$\overline{\Delta C}$			0.427 (0.55)			
$\overline{\Delta C_R}$				0.427 (0.55)	0.392 (0.59)	0.048 (0.87)
M_{t-1}					-0.053 (0.15)	-0.062 (0.16)
F_{t-1}					-0.022 (0.11)	-0.051 (0.12)
ΔY						-0.388 (0.69)
Intercept	0.049 (0.12)	0.119 (0.11)	0.118 (0.11)	0.119 (0.11)	0.215 (0.26)	0.274 (0.28)
R-Sqd	0.130	0.082	0.115	0.115	0.126	0.147

Table 24 : Estimation Results for Total Consumption, α - Approximation II, Medium and Large Landed Households, 1975-84

***Dep.variable*:**

$$[1-(1-\alpha)(1-2\alpha)]*X_{t+1} + (1-2\alpha)*X_t - [1+\alpha(1-2\alpha)]*X_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.111 (0.12)	-0.090 (0.10)	-0.111 (0.10)	-0.150 (0.11)	-0.148 (0.11)
$\overline{\Delta C}$		0.912 (0.36)			
$\overline{\Delta C_R}$			0.912 (0.36)	0.959 (0.40)	1.038 (0.40)
M_{t-1}				-0.036 (0.07)	-0.025 (0.07)
F_{t-1}				-0.123 (0.15)	-0.123 (0.15)
ΔY					0.189 (0.17)
Intercept	0.047 (0.12)	-0.016 (0.11)	0.047 (0.10)	0.205 (0.19)	0.194 (0.19)
R-Sqd	0.044	0.291	0.291	0.333	0.382

Table 25 : Estimation Results for Total Food Consumption, α - Approximation II, Medium and Large Landed Households, 1975-84

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*X^f_{t+1} + (1-2\alpha)*X^f_t - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.088 (0.07)	-0.145 (0.07)	-0.088 (0.06)	-0.145 (0.06)	-0.147 (0.06)	-0.155 (0.06)
$\overline{\Delta C}$			0.728 (0.21)			
$\overline{\Delta C_R}$				0.728 (0.21)	0.721 (0.22)	0.738 (0.22)
M_{t-1}					0.025 (0.05)	0.035 (0.05)
F_{t-1}					-0.043 (0.07)	-0.048 (0.08)
ΔY						0.114 (0.10)
Intercept	-0.022 (0.07)	-0.079 (0.07)	-0.060 (0.06)	-0.079 (0.06)	-0.072 (0.10)	-0.084 (0.11)
R-Sqd	0.035	0.107	0.327	0.327	0.336	0.362

Table 26a : Estimation Results for Adult-Food Consumption, α - Approximation II, Medium and Large Landed Households, 1975-84

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*(X^f_{t+1}-\tilde{B}_f) + (1-2\alpha)*(X^f_t-\tilde{B}_f) - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

$$\textit{where } \tilde{B}_f = 100$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.074 (0.08)	-0.131 (0.07)	-0.071 (0.06)	-0.131 (0.06)	-0.135 (0.06)	-0.144 (0.07)
$\overline{\Delta C}$			0.761 (0.21)			
$\overline{\Delta C_R}$				0.761 (0.21)	0.758 (0.22)	0.775 (0.23)
M_{t-1}					0.028 (0.05)	0.039 (0.05)
F_{t-1}					-0.059 (0.08)	-0.063 (0.08)
ΔY						0.125 (0.11)
Intercept	-0.037 (0.08)	-0.094 (0.07)	-0.074 (0.06)	-0.094 (0.06)	-0.075 (0.10)	-0.089 (0.11)
R-Sqd	0.024	0.085	0.319	0.319	0.333	0.362

Table 26b : Estimation Results for Adult-Food Consumption, α - Approximation II, Medium and Large Landed Households, 1975-84

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*(X^f_{t+1}-\tilde{B}_f) + (1-2\alpha)*(X^f_t-\tilde{B}_f) - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

$$\text{where } \tilde{B}_f = 150$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.067 (0.08)	-0.146 (0.06)	-0.093 (0.06)	-0.146 (0.05)	-0.143 (0.06)	-0.157 (0.06)
$\overline{\Delta C}$			0.613 (0.20)			
$\overline{\Delta C_R}$				0.613 (0.20)	0.618 (0.21)	0.617 (0.20)
M_{t-1}					-0.005 (0.05)	0.007 (0.05)
F_{t-1}					-0.002 (0.07)	0.007 (0.07)
ΔY						0.205 (0.09)
Intercept	-0.044 (0.08)	-0.078 (0.06)	-0.067 (0.06)	-0.078 (0.05)	-0.075 (0.09)	-0.106 (0.10)
R-Sqd	0.019	0.133	0.315	0.315	0.315	0.405

<u>Table 27</u> : <u>Estimation Results for Adult Goods (Narcotics etc), α - Approximation II, Medium and Large Landed Households, 1976-81</u>

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*C^n_{t+1} + (1-2\alpha)*C^n_t - [1+\alpha(1-2\alpha)]*C^n_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)
D	-0.199 (0.16)	-0.162 (0.13)	-0.199 (0.13)	-0.099 (0.12)	-0.101 (0.12)
$\overline{\Delta C}$		1.068 (0.31)			
$\overline{\Delta C_R}$			1.068 (0.31)	1.083 (0.27)	1.076 (0.28)
M_{t-1}				0.048 (0.07)	0.041 (0.08)
F_{t-1}				0.429 (0.16)	0.430 (0.17)
ΔY					-0.080 (0.19)
Intercept	-0.303 (0.16)	-0.180 (0.14)	-0.303 (0.13)	-0.760 (0.20)	-0.754 (0.21)
R-Sqd	0.072	0.437	0.437	0.623	0.627

<u>Table 28</u> : <u>Estimation Results for Total Consumption, α - Approximation II, Labour and Small Landed Households, 1976-81</u>

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*X_{t+1} + (1-2\alpha)*X_t - [1+\alpha(1-2\alpha)]*X_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	0.091 (0.05)	0.088 (0.05)	0.041 (0.05)	0.088 (0.04)	0.088 (0.05)	0.085 (0.05)
$\overline{\Delta C}$			0.793 (0.41)			
$\overline{\Delta C_R}$				0.793 (0.41)	0.791 (0.45)	0.775 (0.47)
M_{t-1}					-0.002 (0.06)	0.000 (0.06)
F_{t-1}					-0.000 (0.04)	-0.001 (0.04)
ΔY						-0.025 (0.14)
Intercept	0.032 (0.05)	0.028 (0.05)	-0.040 (0.06)	0.028 (0.04)	0.030 (0.09)	0.027 (0.10)
R-Sqd	0.133	0.175	0.339	0.339	0.339	0.341

Table 29 : Estimation Results for Total Food Consumption, α - Approximation II, Labour and Small Landed Households, 1975-84

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*X^f_{t+1} + (1-2\alpha)*X^f_t - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.040 (0.07)	-0.059 (0.05)	-0.056 (0.04)	-0.059 (0.04)	-0.053 (0.04)	-0.057 (0.04)
$\overline{\Delta C}$			0.674 (0.14)			
$\overline{\Delta C_R}$				0.674 (0.14)	0.694 (0.14)	0.619 (0.16)
M_{t-1}					-0.033 (0.04)	-0.038 (0.04)
F_{t-1}					0.006 (0.04)	-0.001 (0.04)
ΔY						-0.105 (0.12)
Intercept	0.014 (0.07)	0.052 (0.05)	-0.005 (0.04)	0.052 (0.04)	0.092 (0.08)	0.110 (0.08)
R-Sqd	0.008	0.039	0.407	0.407	0.420	0.432

Table 30a : Estimation Results for Adult-Food Consumption, α - Approximation II, Labour and Small Landed Households, 1975-84

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*(X^f_{t+1}-\tilde{B}_f) + (1-2\alpha)*(X^f_t-\tilde{B}_f) - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

$$\tilde{B}_f = 100$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.022 (0.07)	0.029 (0.05)	0.028 (0.05)	0.029 (0.05)	0.055 (0.05)	0.061 (0.05)
$\overline{\Delta C}$			0.177 (0.18)			
$\overline{\Delta C_R}$				0.177 (0.18)	0.220 (0.18)	0.374 (0.17)
M_{t-1}					-0.042 (0.05)	-0.026 (0.05)
F_{t-1}					0.050 (0.04)	0.052 (0.04)
ΔY						0.233 (0.08)
Intercept	-0.019 (0.07)	0.008 (0.05)	-0.009 (0.05)	0.008 (0.05)	0.007 (0.10)	-0.008 (0.09)
R-Sqd	0.002	0.009	0.033	0.033	0.074	0.260

Table 30b : Estimation Results for Adult-Food Consumption, α - Approximation II, Labour and Small Landed Households, 1975-84

***Dep.variable*:**

$$[1-(1-\alpha)(1-2\alpha)]*(X^f_{t+1}-\tilde{B}_f) + (1-2\alpha)*(X^f_t-\tilde{B}_f) - [1+\alpha(1-2\alpha)]*X^f_{t-1}$$

$$\tilde{B}_f = 150$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	-0.025 (0.07)	0.054 (0.04)	0.054 (0.04)	0.054 (0.04)	0.070 (0.05)	0.069 (0.05)
$\overline{\Delta C}$			0.179 (0.16)			
$\overline{\Delta C_R}$				0.179 (0.16)	0.204 (0.16)	0.284 (0.18)
M_{t-1}					-0.010 (0.05)	-0.014 (0.05)
F_{t-1}					0.051 (0.04)	0.052 (0.04)
ΔY						0.113 (0.12)
Intercept	-0.032 (0.07)	0.022 (0.04)	0.005 (0.05)	0.022 (0.04)	-0.026 (0.09)	-0.024 (0.09)
R-Sqd	0.003	0.038	0.069	0.069	0.107	0.130

Table 31 : Estimation Results for Adult Goods (Narcotics etc), α - Approximation II, Labour and Small Landed Households, 1976-81

Dep.variable:

$$[1-(1-\alpha)(1-2\alpha)]*C^n_{t+1} + (1-2\alpha)*C^n_t - [1+\alpha(1-2\alpha)]*C^n_{t-1}$$

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D	0.243 (0.18)	0.253 (0.13)	0.243 (0.13)	0.253 (0.13)	0.238 (0.14)	0.099 (0.14)
$\overline{\Delta C}$			0.367 (0.48)			
$\overline{\Delta C_R}$				0.367 (0.48)	0.367 (0.06)	-0.634 (0.62)
M_{t-1}					-0.180 (0.17)	-0.261 (0.16)
F_{t-1}					-0.089 (0.12)	-0.198 (0.12)
ΔY						-1.050 (0.52)
Intercept	0.004 (0.18)	0.205 (0.13)	0.199 (0.13)	0.205 (0.13)	0.559 (0.29)	0.831 (0.30)
R-Sqd	0.091	0.203	0.232	0.232	0.325	0.499

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ESSAY 3

A Theory of Remittances

1. Introduction

Remittances sent by migrants in developing countries play an important role in the process of economic development. This form of income transfers, besides contributing to investments in the agricultural sector, is also an important determinant of income distribution. While there is no lack of theories on the process of migration or the associated urban job-search activities of migrants in the literature on economic development, there is no theory of urban to rural remittances that could provide answers to some important questions regarding remittances. This paper is an attempt to fill some of that gap in the form of a theory of remittances along the lines of the literature on the economics of the family.

The basic question that we ask here is: *what is the motivation or rationale on the part of rural-urban migrants in developing countries to send home remittances?* One answer to this question would be that migrants remit because they care about their family members. This imposes the assumption of altruism on the preferences of migrants. But without any such assumption regarding migrants' preferences, can we still get some predictions on the magnitude of the flow of remittances? In this Essay we do not assume that the migrants are altruists: on the contrary, we assume that they are self-interested[1]. These behavioural assumptions are crucial because of their welfare implications: in the altruistic case, rural-urban income differentials do not matter because remittances are automatically forthcoming from the migrant without any reciprocal transfers from the family.

Motives for private transfers are important also because they determine the effects on any public policy of such transfers. In the altruistic framework, any changes in public transfers will be simply offset by corresponding changes in the private domain. Barro (1974) shows that private transfers can completely undo the intended effects of forced intergenerational transfers associated with government deficit spending and social security, under altruism. His seminal study predicts that with positive private

1. We have outlined a model in the appendix in which the migrant is also an altruist, for the purpose of comparing it with the main model presented in the paper.

intergenerational transfers, national debt will not affect the future generations because older ones will leave higher bequests (because of their altruism), thus mitigating the effect of budget deficits on either (old and young) generation. In the case of social security, public transfers from the young to the old will merely reduce the altruistic private transfers.

In a model in which the migrant (or in general, a donor) is altruistic towards the family members (or in general, recipients), it can be easily shown that transfers from the migrant are determined so as to equalize the marginal utility of income of the migrant with those of the recipients. However, in the non-altruistic case income inequality is a matter for concern. The simple two period model developed in this Essay is based on an exchange motive: in return for the remittances, the migrant gets a share in the family bequests. It is shown that the migrant remits only if (at least) some of the remittances are invested in agricultural development, which augments the family bequests.

The results in this paper show that remittances are non-monotonic in the donor's or the recipient's incomes, whereas in the altruistic model (or in models with utilitarian welfare functions) the relationship between transfers and donor's/recipient's incomes is monotonic. It is also shown that the migrant's decision to transfer resources or not depends crucially on the rural-urban differences in incomes. Migrants remit only if their urban incomes fall within a certain interval, given the income of the rural family. To be more specific, migrants do not remit if the difference between their incomes and the rural incomes is too low or too high; they remit only in a middle range. Intuitively, the migrant does not remit at low incomes because of lack of resources and the parental bequest transfers to compensate for his incomes reduce any incentive to remit. At high incomes as well, the migrant does not have any incentive to remit because of the low (or no) bequest transfers. We also obtain some interesting comparative static predictions, given the migrant's decision to remit: it is shown that the migrant acts as if he is altruist, because his behaviour is conditioned by the parental bequest transfers.

The format of this Essay is as follows: in Section 2, we present a brief review of the literature. In Section 3 we discuss the structure of the model, then present and discuss our propositions. Section 4 provides the comparative static predictions of the model, and Section 5 concludes the Essay.

2. *A Brief Review of the Literature*

We begin with a review of the literature on the economics of the family, since it has some common elements with the framework and results in this paper. Becker's (1981) Rotten Kid Theorem - RKT - states that if an altruistic family member transfers monetary resources to other selfish individuals within the family, then even without any strategic precommitment by the altruist, all the selfish individuals will take actions that maximize the family income. In Becker's one-period model, if the altruistic parent makes an operative (non-zero) transfer to the selfish child and the child's utility is a normal good to the parent, then the child will always act in the interest of the whole family[2]. Obviously, for the RKT to hold, the parent must make the transfer after the child has taken his actions. Also, the utilities of the child and the parent must depend solely on money income, or transferable goods, for RKT to hold.

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2. If the household head attempts to maximize his utility $U(X_1,...,X_n)$ where X_i stands for the consumption of the ith family member, subject to the constraint $\Sigma X_i = \Sigma Y_i$, then RKT states that no selfish beneficiary will take an action that reduces the total family income. Any selfish beneficiary who has some opportunity to increase total family income (even at the cost of reducing her own income) will do so, since it will lead to an increase in the head's transfer, and hence consumption, to her.

Bergstrom (1989) investigates the assumptions required for RKT to hold. He analyzes two interesting cases: one, the lazy rotten kids example in which RKT fails if work effort of children is introduced into the model (they will choose too little effort); and two, the night-light example in which RKT fails upon the introduction of a public good, the night-light, into the utility functions of a benevolent husband and a selfish wife. In their bequest-motive model, Bernheim, Shleifer, and Summers (1985) show that RKT does not hold if the parent's utility is a function of the child's actions (attention given to the parent by the child). In a two-period setting, RKT holds only if the parent makes an operative second period transfer (even if the first period transfer is inoperative)[3]. Lindbeck and Weibull (1988) and Bruce and Waldman (1990) present this two-period case. Bergstrom's (1989) results show that RKT can be rehabilitated if utility is transferable[4]. In the night-light example, he shows that RKT holds if utility is

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3. But in this case, there will be another form of inefficiency, known as the Samaritan's Dilemma. The child will take efficient actions in both periods (since he will get the transfer only in the second period), but he will save an amount that is too low and consume an amount that is too high relative to the efficient levels of saving and consumption in the first period, in order to impoverish himself in the second period to get a larger transfer from the parent.

4. In a two-person economy, there is transferable utility if there exists some utility representation of preferences such that the utility possibility frontier is a set of the form:

$$\{(u_1, u_2) > (\hat{u}_1, \hat{u}_2) \mid (u_1 + u_2) = I\}$$

for some money income, I, and some vector of lower bound utilities $(\hat{u}_1, \hat{u}_2)$. Bergstrom (1989) derives the functional form for preferences that exhibit the transferable utility property.

transferable and the income to be divided between the altruist-husband and the selfish-wife depends on the amount of the public good, in this case the night-light.

In the context of the present paper, "actions" by the child take the form of monetary transfers (remittances) by the migrant: here it is shown that RKT does not hold in the sense that the migrant does not remit if remittances are not used in augmenting the total bequest by the family. This outcome is similar to the "Smart Kid Theorem" (Lindbeck and Weibull (1988)). The migrant acts "smart" or rational in not sending any remittances, because the amount of bequests that the migrant gets is independent of remittances and it is possible to earn a positive rate of interest in the market. However, if remittances are invested in augmenting the available bequest then there is an equilibrium in which the migrant remits a positive amount, and hence the RKT holds in this case.

Empirical evidence on private transfer behaviour is mixed: there is some support for both the altruistic and the exchange motives for private transfers. Adams (1980), Menchik and David (1983), and Tomes (1981) in their applications of Becker's altruism model to study bequest behaviour in the United States find support for the altruistic motive. Cox (1987) presents a simple model of inter-vivos transfers, in which he derives predictions for the altruistic vs exchange motives and tests them with U.S.

data. He finds that transfers are based on an exchange motive, rather than altruistic considerations. Bernheim, Shleifer and Summers (1985) also find some support for the strategic-exchange motive outlined in the paper. Hoddinott (1992) provides evidence that children support their parents with remittances and services out of self-interest in Kenya.

Lucas and Stark (1985), in the first study to look at the determinants of remittances within the household-theoretic framework, find empirical support that remittances by migrants in Botswana are based on exchange considerations. Instead of the strict dichotomy between pure altruism and pure self-interest, they argue that migrants may remit either because of tempered altruism or enlightened self-interest. Their hypotheses are, however, not based on a rigorously formulated model. Rempel and Lobdell (1978), in their survey of the literature on remittances, come to the conclusion that remittances should be seen as payments made out of self-interest of the migrants. Also, as Cox and Jimenez (1990) note, even if private transfers are determined by both altruistic and selfish motives, only one predominates in equilibrium.

3. *The Model*

In order to capture the migrant-family interaction fully, we present a two-period framework. There are three players in the game: the migrant (M), the migrant's parent/s (P) and the migrant's sibling (H). P and H stay in the rural area. In the first period the migrant has an income of y_{1m} and chooses how much to remit, t; he can alternatively save an amount s at a rate of interest, r, or consume. The family starts with land/assets worth b_o. This is under the control of P in the first period and cannot be consumed. In addition there is some money income, y_{1h}, available in the first period to be consumed or invested, under the control of H. Given the migrant's remittances t, H chooses how much to consume in the first period, c_{1h}, and invests the remaining available income $y_{1h} + t - c_{1h}$. If H invests an amount of money x then the family obtains land/assets worth

$$b(x) = b_o + \tau x \qquad (1)$$

in the second period. Thus in the second period the family's assets are worth $b(y_{1h} + t - c_{1h})$, which P decides how to divide between M and H as bequests. We denote the bequests that the migrant gets by b_m.

To summarize, the sequence of moves in the game is as follows: t and s are chosen first by M, followed by H choosing c_{1h}, then P chooses b_m. Note that we assume everywhere that t, s and c_{1m} are observed by P and H. Note also that this model does not explain why or how migration takes place.

Both M and H are selfish: they do not care about each other or about P. But P is a utilitarian and cares about M and H equally in the sense that the weights assigned to the utilities of M and H are equal in his utility function. In a sense, the parent acts as a social planner who decides about the division of bequests between M and H, given their decisions. Apart from this role, P does not have any consumption decision to make for himself.

We first formulate the general problem, then work with additive-separable (over time) logarithmic utility functions. The parent's (second period) problem, given t, s and c_{1h}, is as follows:

$$\underset{b_m}{Max}\ [U_m(y_{1m}-t-s,\ y_{2m}+(1+r)s+b_m)\ +\ U_h(c_{1h},\ y_{2h}+b(y_{1h}+t-c_{1h})-b_m)] \qquad (2)$$

$$subject\ to\ 0 \leq b_m \leq b(y_{1h}+t-c_{1h})$$

Let the solution to this problem be $b_m^*(t,s,c_{1h})$.

The sibling's problem, given t,s and b_m^*, is

$$\max_{c_{1h}} U_h(c_{1h},\ y_{2h} + b(y_{1h} + t - c_{1h}) - b_m^*(t,s,c_{1h})) \tag{3}$$

$$\text{subject to } 0 \leq c_{1h} \leq y_{1h} + t$$

Let the solution to this problem be $c_{1h}^*(t,s)$.

The migrant's problem, given b_m^* and c_{1h}^*, is

$$\max_{t,s} U_m(y_{1m} - t - s,\ y_{2m} + (1+r)s + b_m^*(t,s,c_{1h}^*(t,s))) \tag{4}$$

$$\text{subject to } s + t \leq y_{1m},\ t \geq 0,\ s \geq 0$$

Let the solution to this problem be (t^*,s^*).

The functions U_m and U_h are assumed to have the usual properties: each function U_i is continuous, twice continuously differentiable and strictly concave; $D_jU_i(c_{ji}) \to \infty$ as $c_{ji} \to 0$ for i=m,h and j=1,2. We now specify one such type of function with the above properties, additive-logarithmic utility functions, which will be used throughout in this Essay.

Let $U_i(x,y) = \log x + \log y$ for i=m, h. Then the above problems are:

For P:

$$\underset{b_m}{Max}[\log(y_{1m}-t-s) + \log(y_{2m}+(1+r)s+b_m) + \log(c_{1h}) + \log(y_{2h}+b(y_{1h}+t-c_{1h})-b_m)] \tag{5}$$

$$subject\ to\ 0 \leq b_m \leq b(y_{1h}+t-c_{1h})$$

which has the same solution $b_m^*(t,s,c_{1h})$ as the following problem, since y_{1m} - t - s and c_{1h} are given in period 2:

$$\underset{b_m}{Max}[\log(y_{2m} + (1+r)s + b_m) + \log(y_{2h} + b(y_{1h} + t - c_{1h}) - b_m)] \tag{5.1}$$

$$subject\ to\ 0 \leq b_m \leq b(y_{1h} + t - c_{1h})$$

For H:

$$\underset{c_{1h}}{Max}[\log(c_{1h}) + \log(y_{2h} + b(y_{1h} + t - c_{1h}) - b_m^*(t,s,c_{1h}))] \tag{6}$$

$$subject\ to\ 0 \leq c_{1h} \leq y_{1h}+t$$

For M:

$$\underset{t,s}{Max}[\log(y_{1m} - t - s) + \log(y_{2m} + (1+r)s + b_m^*(t,s,c_{1h}^*(t,s)))] \tag{7}$$

$$subject\ to\ s + t \leq y_{1m},\ t \geq 0,\ s \geq 0$$

The concept of equilibrium that we use is subgame perfect equilibrium: a subgame perfect equilibrium of the game consists of functions b_m^* and c_{1h}^* and values of t^* and s^* that solve (5), (6) and (7).

We consider two cases separately in order to make the intuition behind the results of the model clear: the bequest-augmenting role of remittances is the one that induces the migrant to remit when investment decisions are made by the rural based family. We first look at the polar case in which the family does not utilize the remittances in augmenting the bequests.

Case 1: This case deals with a corner solution for H's problem, abstracting from H's choice problem: H consumes all of his income and the remittances in the first period, in other words $c_{1h} = y_{1h} + t$, or remittances are not invested. The following proposition states the no-remittance result for additively separable utility functions for H and M.

Proposition 1: In any subgame perfect equilibrium in which $c_{1h}^*(t^*,s^*) = y_{1h} + t^*$, the migrant does not remit anything ($t^*=0$) in period 1.

Proof: If $c_{1h} = y_{1h} + t$, then $0 \leq b_m^*(t,s,c_{1h}(t,s)) \leq b(0)$ and it follows easily that $D_1 b_m^*(t,s,y_{1h}+t) = 0$ (the derivative of the bequest function with respect to t is zero). Therefore, from the migrant's problem it is clear that he will choose $t^* = 0$.

Q.E.D.

Intuitively, if remittances are not invested then the migrant gets a fixed amount of bequests, independent of t. Given the alternatives (to save or consume), he chooses not to remit anything.

Remark: This result holds for any strictly concave utility function (not just for the additively separable case) since the derivative of the bequest function with respect to t is less than or equal to zero:

$$D_1 b_m^*(t,s,c_{1h}(t,s)) = \frac{D_{12}\ U_h + D_{12}\ U_m}{D_{22}\ U_h + D_{22}\ U_m} \tag{9}$$

The above expression is less than or equal to zero since $D_{12}U_h \geq 0$, $D_{12}U_m \geq 0$, $D_{22}U_h \leq 0$ and $D_{22}U_m \leq 0$ for strictly concave functions. Then from the migrant's problem $t^* = 0$. In this case, RKT does not hold in the sense that the migrant does not remit anything. However, it is not that the migrant is "rotten" but he is rational (or "smart") in that he chooses not to remit because of the zero returns to remitting[5].

Case 2: In this case, I first look at interior solutions to the three choice problems, for b_m, c_{1h} and t. Assuming interior solutions to the problems gives the size of the remittances (as a function of the variables and parameters in the problems). If there are interior solutions to P's and H's problems, then there is an interior solution for M's problem. Then I look at the possible corner solutions for these problems: this is useful for analysing the migrant's problem in two stages, (a) decision regarding remittances -

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5. This result is similar to the Smart Kid Theorem in Lindbeck and Weibull (1988): in their paper, the selfish recipient does not save in the equilibrium because the altruistic donor's transfer decreases in the recipient's savings.

whether to remit or not? (b) given a decision to remit, how much to remit? The following propositions state the results.

Proposition 2: In any subgame perfect equilibrium in which

$$(a)\ 0 < c^*_{1h}(t^*,s^*) < y_{1h} + t^*,$$

$$(b)\ 0 < b^*_m(t^*,s^*,c_{1h}(t^*,s^*)) < b(y_{1h} + t^* - c_{1h}(t^*,s^*)),\ and$$

$$(c)\ y_{2m} + y_{2h} + b_0 < \tau(y_{1m} - y_{1h})$$

we have $t^* > 0$ and $s^* = 0$ if $\tau < 1+r$, and $t^* = 0$ and $s^* > 0$ if $\tau > 1+r$.

Proof: Under these assumptions we have

$$b^*_m(t^*,s^*,c_{1h}(t^*,s^*)) = \frac{1}{2}[y_{2h} - y_{2m} + b(y_{1h} + t^* - c_{1h}(t^*,s^*)) - (1+r)s^*] \quad (10)$$

$$c^*_{1h}(t^*,s^*) = \frac{1}{2\tau}[y_{2h} + y_{2m} + b_o + \tau(y_{1h} + t^*) + (1+r)s^*] \quad (11)$$

Now, solving the first order conditions for the migrant's problem stated in (7) we have

$$t = \frac{\tau(y_{1m} - y_{1h}) - (y_{2m} + y_{2h} + b_o + (\tau + (1+r))s)}{2\tau} \quad (12)$$

and

$$s = \frac{(1+r)y_{1m} - \tau y_{1h} - (y_{2m} + y_{2h} + b_o + (\tau + (1+r))t)}{2(1+r)}, \tag{13}$$

so that

$$t^* = \frac{(1+r)y_{1m} + y_{2m} + \tau y_{1h} + y_{2h} + b_0}{(1+r) - \tau} \tag{14}$$

$$s^* = \frac{\tau y_{1m} + y_{2m} + \tau y_{1h} + y_{2h} + b_0}{\tau - (1+r)} \tag{15}$$

If $(1+r) > \tau$, then it follows from (16) that $s^* < 0$, which is not a legitimate solution. Given the shape of the objective function, it turns out that in this case we have $s^* = 0$ and hence

$$t^* = \frac{\tau(y_{1m} - y_{1h}) - (y_{2m} + y_{2h} + b_o)}{2\tau} > 0 \tag{16}$$

If $\tau > 1+r$, then symmetrically $t^* = 0$ and

$$s^* = \frac{(1+r)y_{1m} - (\tau y_{1h} + y_{2m} + y_{2h} + b_o)}{2(1+r)} > 0. \qquad (17)$$

Q.E.D.

Intuitively if the family invests some of the remittances (or equivalently, if there is an interior solution to H's problem), then the migrant has an incentive to remit because the remittances augment the size of the bequests from which he gets a share. The next proposition states the result pertaining to the decision to remit: it shows that in the case that M's and H's incomes are the same in both periods the migrant makes a positive remittance if and only if his income is not too small or too large relative to that of the family.

Proposition 3: Let $y_{1i} = y_{1i} = y_i$ for $i = m, h$. For each value of y_h there exist values $\underline{y_m}$ and $\overline{y_m}$ of y_m such that the migrant makes a positive remittance if and only if $\underline{y_m} < y_m < \overline{y_m}$.

Proof: In Appendix B we solve P's and H's problems. The solutions, as functions of t and s, are given in Figure 1. (Note that in region 1 the solutions to both choice problems are interior). We now consider M's problem. In any solution either $t^* = 0$ or $s^* = 0$ - that is, the solution lies on one of the axes in Figure 1. This follows from Proposition 2.

When t = 0 the migrant's maximized payoff is:

$$\log[(((1+r)+1)y_m + (\tau+1)y_h + b_0)/2(1+r)] + \log[(((1+r)+1)y_m + (\tau+1)y_h + b_0)/8]$$

or

$$\log[(((1+r)+1)y_m + (\tau+1)y_h + b_0)^2/16(1+r)]$$

since s, c_{1h} and b_m take the following values (substituting t and s into the other two functions):

$$s = (ry_m - (\tau+1)y_h - b_0)/2(1+r)$$

$$c_{1h} = ((\tau+1)y_h + b_0 + (1+r)y_m)/4\tau \qquad (19)$$

$$b_m = (5(\tau+1)y_h + 5b_0 - 3y_m(2+r))/8$$

When s = 0 the migrant's maximized payoff is:

$$\log[((\tau+1)y_m + (\tau+1)y_h + b_0)/2\tau] + \log[((\tau+1)y_m + (\tau+1)y_h + b_0)/8] \quad \textit{or} \quad \log[((\tau+1)y_m + (\tau+1)y_h + b_0)^2/16\tau] \tag{20}$$

since t, c_{1h} and b_m take the following values (substituting t and s into the other two functions) :

$$t = ((\tau-1)y_m - (\tau+1)y_h - b_0)/2\tau$$

$$c_{1h} = ((\tau+1)y_m + (\tau+1)y_h + b_0)/4\tau \tag{21}$$

$$b_m = ((\tau+1)y_h + b_0 - (\tau-7)y_m)/8$$

A necessary condition for the migrant's problem to have a solution in which $t^* > 0$ is

$$U_m(\hat{t},0) > U_m(0,\hat{s})$$

where $\hat{t}$ is the optimal value of t when s = 0 and $\hat{s}$ is the optimal value of s when t=0, or

$$2\sqrt{1+r}[(1+\tau)y_h + b_o] > [(2+r)4\sqrt{\tau} - 2\sqrt{1+r}(1+\tau)]y_m \tag{22}$$

If this condition is satisfied then the solution of the migrant's problem is

$$(t^*, s^*) = \left(\frac{(\tau-1)y_m - (\tau+1)y_h - b_0}{2\tau}, 0\right) \tag{23}$$

so that for $t^* > 0$ we need

$$(1+\tau)y_h + b_0 < (\tau-1)y_m \tag{24}$$

In addition, we need the condition that the solution to the migrant's problem be in region 1 of Figure 1 (the only region in which both P's and H's problems have interior solutions),

$$(7-\tau)y_h - b_0 < (\tau+1)y_m \tag{25}$$

It should be noted that only one of (24) and (25) is binding in equilibrium.

It is informative to present the above inequality conditions as intervals of the migrant's income in terms of H's income and the baseline bequest, b_0. Thus, depending on (which condition is binding)

$$\frac{(1+\tau)y_h + b_o}{\tau-1} \gtrless \frac{(7-\tau)y_h - b_0}{\tau+1},$$

which is the same condition as $(3-\tau)y_h - y_m - b_0 \lessgtr 0$, where $(3-\tau)y_h - y_m - b_0$ is the point where the boundary for region 1 in Figure 1 touches the t-axis, one of the following intervals holds in equilibrium:

$$\frac{2\sqrt{(1+r)}[(1+\tau)y_h + b_o]}{(2+r)4\sqrt{\tau} - 2\sqrt{(1+r)}(1+\tau)} > y_m > \frac{(1+\tau)y_h + b_o}{\tau-1} \qquad \textbf{(26a)}$$

or,

$$\frac{2\sqrt{(1+r)}[(1+r)y_h + b_o]}{(2+r)4\sqrt{\tau} - 2\sqrt{(1+r)}(1+\tau)} > y_m > \frac{(7-\tau)y_h - b_o}{\tau+1} \qquad \textbf{(26b)}$$

These intervals are plotted in Figure 2. If the migrant's income (relative to the rural family's income, y_h) falls in the interval(s) given in (26a) or (26b), then he chooses

$$t^{*} = \frac{(\tau - 1)y_m - (1+\tau)y_h - b_o}{2\tau}, \quad s^{*} = 0$$

as given in (23) above. If his income is either above the upper boundary or below the lower boundary, then he does not remit anything in equilibrium.

Q.E.D.

The argument presented in the above proof shows that if the migrant is rich or poor relative to the rural family, he does not remit. He remits only if his income falls within the interval(s) specified above in (26a) and (26b), and does not remit anything at high (or low) levels of y_m. Figure 2 also presents the income interval for the case in which the migrant does not have the savings alternative.

4. *Comparative Statics*

From (12) it follows that remittances, given that $t^* > 0$, increase with the migrant's first period income and fall with his second period income and with the rural incomes in both periods (or, when M's and H's incomes are the same in both periods, remittances increase with his income and fall with the rural income, see (23)). However, when we look at the decision to remit, Proposition 3 and Figure 2 show that the relationship between the level of remittances and incomes, as well as the initial wealth-holding of the family, is non-monotonic: as the migrant's income increases, remittances first increase, then drop to zero, while as rural income increases, remittances first jump to some positive level, then decline to zero (see Figures 3a, 3b and 3c).

In models with an altruistic donor, transfers from the donor to the recipients increase monotonically with the donor's income and fall monotonically with the recipients' incomes (or resources). But here, with two-way transfers and one-sided altruism (P is altruistic), transfers from the selfish "donor" (the migrant) are non-monotonically related to the income levels. Given the family's income, if the migrant's income falls outside the interval in Figure 2, then he does not remit.

Intuitively, if the migrant's income is low he does not remit because of lack of resources; also he gets compensated with bequests from the parent if his income is low, so there is no inducement for him to remit. If the migrant is rich, then he receives very little or no bequest from the parent and hence he does not remit. This intuition also brings out the feature that the parent, acting as a social planner with equal concern for M and H, attempts to equalize utilities between his two children. If his income falls in the interval shown in Figure 2, then the migrant chooses to remit. The reduced form for the bequest function can be obtained by substituting equations (11) and (12) into (10):

$$b_m^* = \frac{1}{8}[\tau(y_{1h} + y_{1m}) + y_{2h} - 7y_{2m} + b_o] \tag{27}$$

it follows from (27), by setting $y_{1i} = y_{2i}$ for i=M,H, that the amount of bequests goes down if the migrant's income increases (assuming that $\tau < 7$). The bequest to the migrant also increases monotonically with H's income (in both periods).

Figure 3b shows the non-monotonicity in the relationship between remittances and the rural family's income, y_h. Given $t^* > 0$, remittances decrease with y_h: the migrant compensates by remitting if y_h is low (but not too low, below the lower level indicated in Figure 3a), though his actions are based on the size of the bequests he receives. He reduces remittances if y_h increases, because from (27) it is clear that his bequest goes up with y_h. At very low levels of y_h, since the level of bequests to the migrant is also low, the migrant does not remit; at very high levels of y_h he does not remit either, since there is no incentive for him to remit given the high level of bequests. The migrant's role, though he is self-interested, of transferring resources in the first period if y_h is low is crucial, given that rural credit markets are not organized well in a number of developing countries. Thus the parent, by choosing the level of bequests in the second period, can induce the migrant to compensate H at low levels of y_h in the first period.

Another point to be noted here is the non-monotonicity in the relationship between remittances and the initial wealth-holding of the family (b_o), shown in Figure 3c. At very low or very high levels of b_0, the migrant does not remit: if b_0 is too low, then his bequest is also low, and at very high levels of b_0, he does not have any incentive to remit because of the high level of bequests. Given $t^* > 0$, remittances decrease with b_0, so the migrant compensates if the initial wealth holding is low. These comparative static predictions (given an interior solution for t) are similar to what one would expect in a model with altruistic behaviour on the migrant's part, because here the altruistic parent influences the migrant's behaviour through his division of bequests within the family. However, if we consider the first stage, in which the migrant decides whether to remit or not, the predictions do not concur with those of an altruistic model in which transfers are monotonic in the recipients' incomes.

5. Summary and Conclusions

Urban-rural remittances are an important form of private income transfers in developing countries. The motives that migrants may have for remitting have important implications for income inequality between the rural and urban sectors of an economy, hence they are also important for any government policies that deal with redistribution of income through public transfers. Migrants may remit out of pure altruism. Remittances may be seen as informal credit, given that credit markets do not work well in rural areas in many developing countries. They may also be seen as payments for past loans, or for future inheritance.

The theory presented in this Essay assumes that migrants are self-interested. The interaction between the migrant and the rural family is modelled as a simple two period game, in which the migrant decides whether to remit (if so, how much) or not (and save at the market rate of interest instead) in the first period. Then the migrant's sibling decides on the level of investments out of the remittances sent; in the second period the parent, whose role of dividing the bequests between the migrant and the rural sibling is similar to that of a social planner, decides on the level of bequests to the migrant. The sibling is self-interested as well, but the parent is altruistic towards both his children. The model assumes a simple linear technology which augments the family bequests, with the remittance as the sole input. An additive-logarithmic form is assumed for all the utility functions.

The model yields many simple and intuitive results: in any equilibrium the migrant remits only if the family engages in augmenting the bequests with positive investments out of the remittances. I consider the solution to the migrant's problem in two stages: the decision to remit, then the size of remittances - when corner solutions are accounted for, an interesting result emerges: the migrant remits only if his income falls within a certain interval that depends on the parameters of the problem, given the income of the rural sibling or the baseline bequest of the family, and does not remit anything if his income falls outside this interval. In terms of relative income levels, the migrant does not remit if the income inequality (between his income and the rural resources) is too high or too low, but only if the incomes fall in the specified ranges. This has the natural implication that very rich or poor migrants do not remit.

In terms of the comparative static predictions, the crucial difference in this model is the non-monotonicity in the relationships between the migrant's remittances, and his income and the rural family's resources. Remittances are non-monotonically related to the migrant's income, his sibling's income and the baseline bequests: as stated above, there is a corner solution for remittances if the migrant's income, and the rural family's resources are too low or too high. For example, if the rural family is rich, then the migrant does not remit. This result is in contrast to what models in the literature in which the donor is self-interested yield. The model also offers an entirely different set of predictions than what one would expect to obtain with self-interested behaviour on the part of the migrant, once an interior solution is assumed for remittances. Within the income interval specified, the migrant's remittances increase with his income. Also, within the ranges specified, his remittances decrease with the family's resources. This result of positive relationship between the migrant's transfers and his income, and negative relationship between the remittances and the rural resources, given that remittances are positive, is the usual outcome in models with altruism on the migrant's part. However, in an altruistic model the relationship is always monotonic.

Thus, given an interior solution for remittances, the comparative static predictions of this model are the same as those in models with altruism. Intuitively this result obtains here because the parent, acting as a social planner, makes his decision after the migrant has chosen the level of remittances, thus influencing the migrant's behaviour. However, when we consider interior as well as corner solutions, the non-monotonicity in the relationships shows that the migrant's decision on whether to remit or not still depends on his self-interest. These outcomes may be interpreted to mean that the migrant acts in the way the altruistic parent would act if he were to choose the level of remittances for the migrant (in the interior), yet he makes a rational decision on his part. One may also label this behaviour as "enlightened self-interest" along the lines of Lucas and Stark (1985).

Figure 1 : Solutions of P's and H's Problems as Functions of t and s

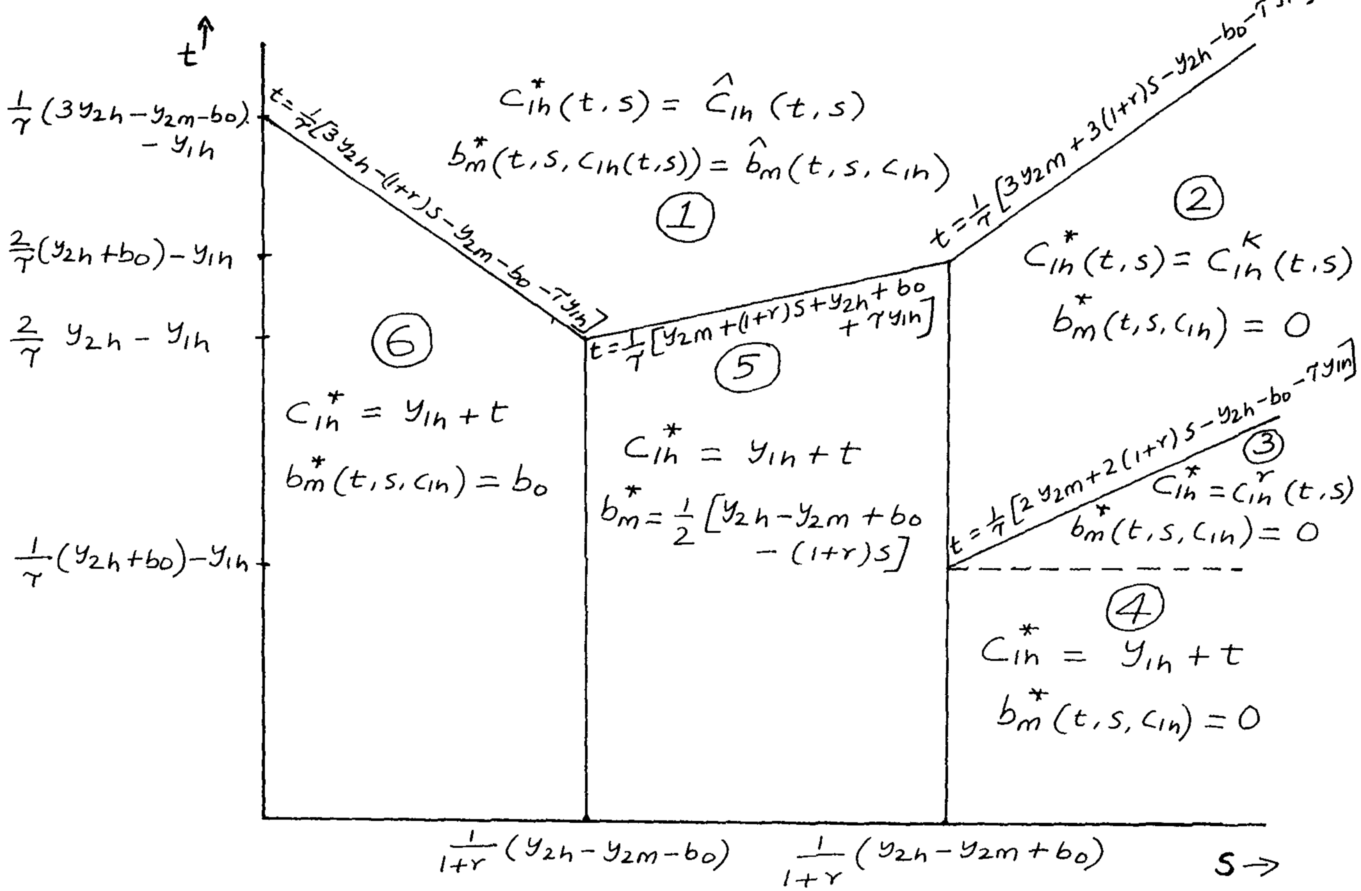


Figure 2 : Income Intervals for the Migrant's Decision

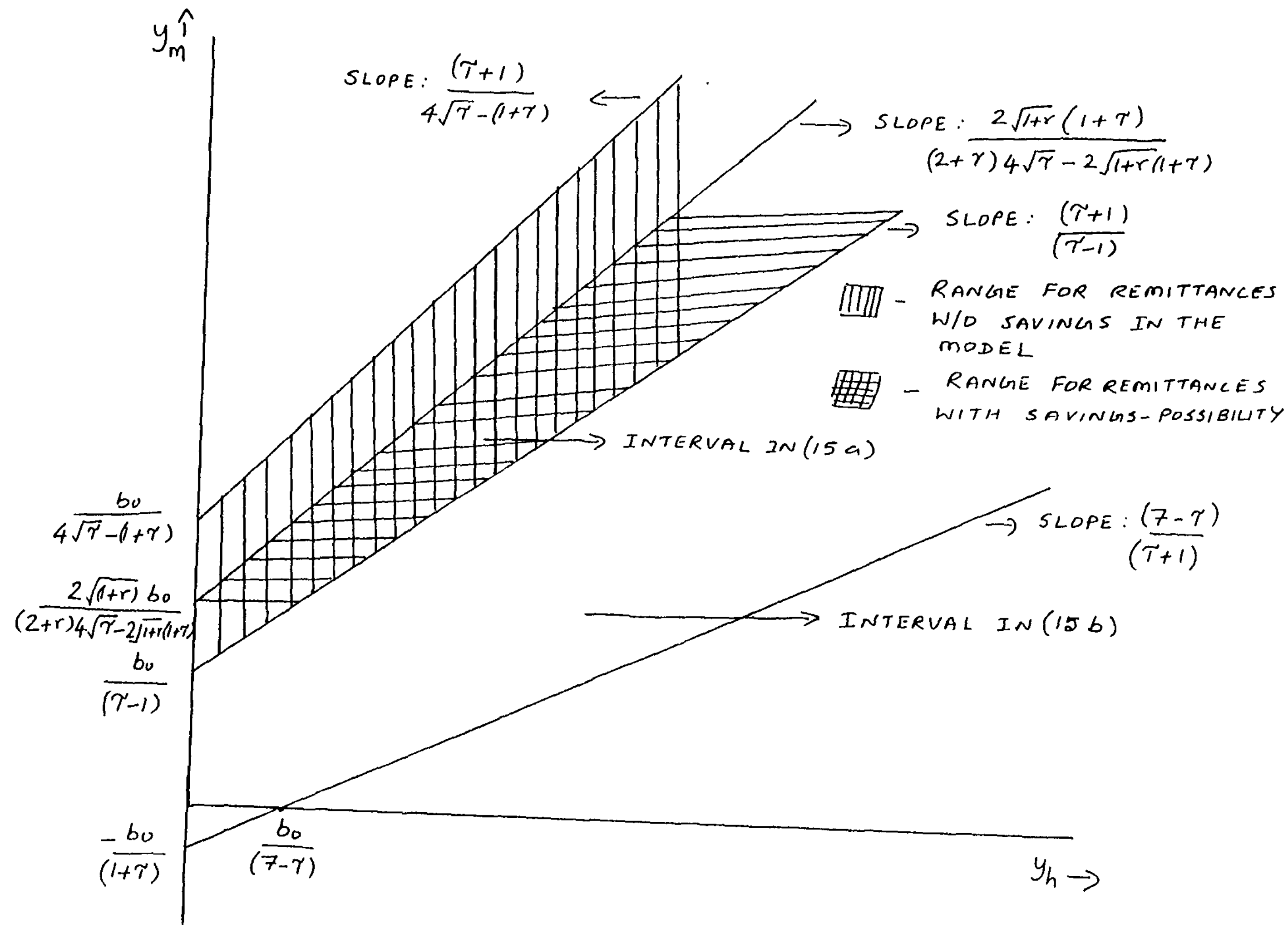


Figure 3a

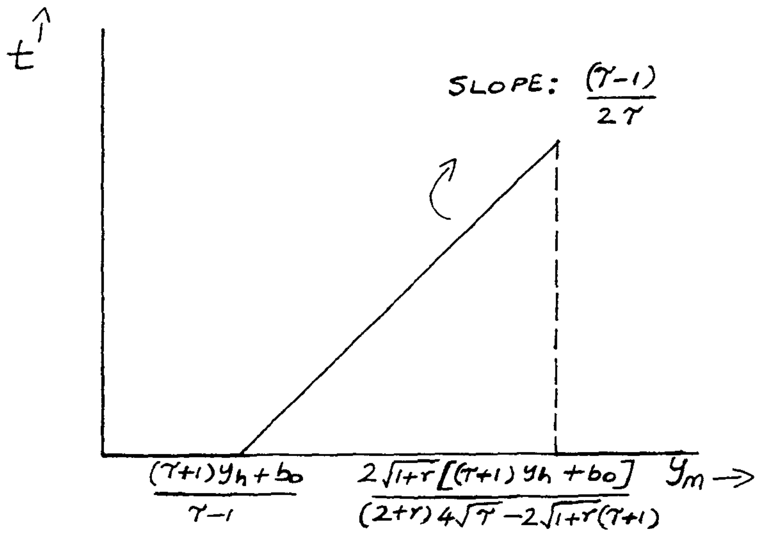


Figure 3b

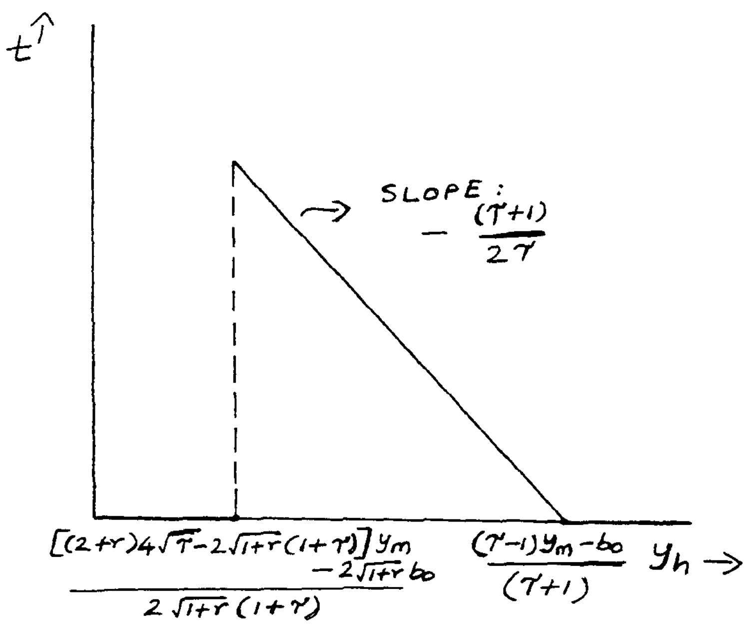
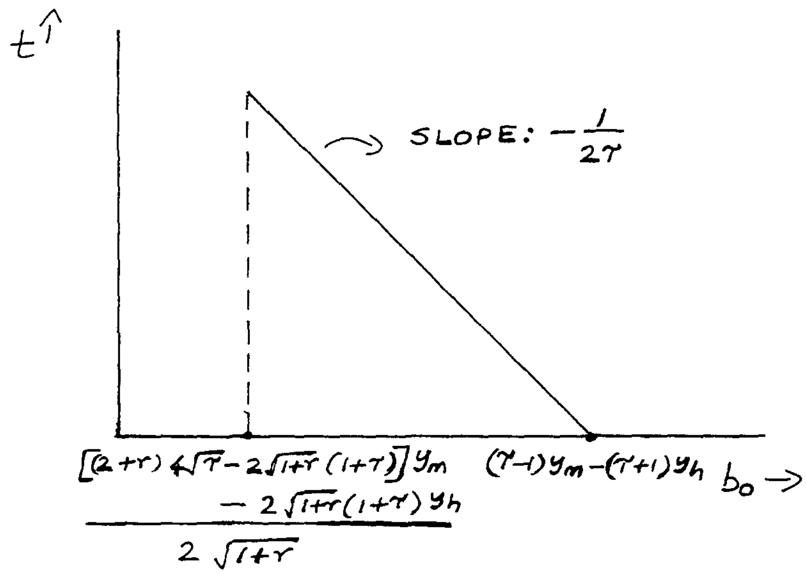


Figure 3c



Appendix A

The model presented in the paper treats the migrant as a selfish individual. But if the migrant is also an altruist, then the migrant may remit a positive amount even under Case 1. For this case, the utility functions can be written as:

for the parent:

$$U_h(y_{1h}+t, y_{2h}+b-b_m) \; + \; \alpha_p \, U_m(y_{1m}-t, y_{2m}+b_m) \tag{A1}$$

for the migrant:

$$U_m(y_{1m}-t, y_{2m}+b_m) \; + \; \alpha_m \, U_h(y_{1h}+t, y_{2h}+b-b_m) \tag{A2}$$

where α_i is the altruistic coefficient of i=p,m. In the model presented in the Essay, α_p is set equal to 1 and α_m equal to 0.

With $\alpha_p = 1$, the parent's problem is the same as the one presented in the Essay. The derivative expression, $b_m'(t)$ is the same as (9). For the migrant's problem of choosing the level of remittances, the first order condition is as follows:

$$D_2 U_m . b_m'(t) - D_1 U_m = \alpha_m (D_2 U_h . b_m'(t) - D_1 U_h) \tag{A3}$$

In words, (A3) translates into:

Marginal Net Utility to m from t = α_m (Marginal Net Utility to h from t)

<u>**An Example**</u>: If the utility functions of h and m are of the Cobb-Douglas type, then it is easy to show that the optimal choice for the level of remittances is:

$$t^* = (\alpha_m/1 + \alpha_m) y_{1m} - (1/1 + \alpha_m) y_{1h} \tag{A4}$$

For these utility functions, $b_m'(t) = 0$. In the model presented in the Essay, the optimal choice for m under such a case is $t^* = 0$. But here, if $Y_{1m} > Y_{1h}$, the migrant will send home some remittances.

Appendix B

In this appendix, I solve P's and H's choice problems.

P's Problem:

Let the function $g(b_m)$ denote the derivative of P's objective function:

$$g(b_m) = \frac{1}{y_{2m} + (1+r)s + b_m} - \frac{1}{y_{2h} + b(y_{1h}+t-c_{1h}) - b_m} \qquad \textbf{(B1)}$$

The second derivative of this function is negative, therefore:

* if $g(0) \leq 0$ and $g(b(y_{1h} + t - c_{1h})) \leq 0$ then $b_m^*(t,s,c_{1h}) = 0$

* if $g(0) \geq 0$ and $g(b(y_{1h} + t - c_{1h})) \geq 0$ then $b_m^*(t,s,c_{1h}) = b(y_{1h}+t-c_{1h})$

* otherwise the solution is interior: $b_m^*(t,s,c_{1h}) = \frac{1}{2}(y_{2h} - y_{2m} + b(y_{1h}+t-c_{1h}) - (1+r)s)$

Now, $g(0) \geq 0$ if and only if $y_{2h} \geq y_{2m} + (1+r)s - b(y_{1h}+t-c_{1h})$ and $g(b(y_{1h}+t-c_{1h})) \geq 0$ if and only if $y_{2h} \geq y_{2m} + (1+r)s + b(y_{1h}+t-c_{1h})$. Therefore,

* if $y_{2h} \leq y_{2m} + (1+r)s - b(y_{1h}+t-c_{1h})$ then $b_m^*(t,s,c_{1h}) = 0$

* if $y_{2h} \geq y_{2m} + (1+r)s + b(y_{1h}+t-c_{1h})$ then $b_m^*(t,s,c_{1h}) = b(y_{1h}+t-c_{1h})$

* otherwise the solution is interior: $b_m^*(t,s,c_{1h}) = \frac{1}{2}(y_{2h} - y_{2m} + b(y_{1h}+t-c_{1h}) - (1+r)s)$

Let

$$\hat{b}(t,s,c_{1h}) = \frac{1}{2}[y_{2h} - y_{2m} + b(y_{1h}+t-c_{1h}) - (1+r)s], \tag{B2}$$

so that

$$\hat{b}(t,s,c_{1h}) \geq 0 \ \textit{iff} \ c_{1h} \leq \frac{1}{\tau}[y_{2h} - y_{2m} - (1+r)s + b_o + \tau(y_{1h}+t)]$$

Then in summary we have

$$b_m^*(t,s,c_{1h}) = \begin{cases} 0 & \textit{if } y_{2h} \leq y_{2m} + (1+r)s - b(y_{1h}+t-c_{1h}) \\ \hat{b}(t,s,c_{1h}) & \textit{otherwise} \\ b(y_{1h}+t-c_{1h}) & \textit{if } y_{2h} \geq y_{2m} + (1+r)s + b(y_{1h}+t-c_{1h}) \end{cases} \tag{B3}$$

H's Problem:

It is useful to graph $b_m^*(t,s,c_{1h})$ against c_{1h}: the following figures present the various cases.

***Figure* 4** : $s \geq \frac{1}{1+r}(y_{2h} - y_{2m} + b_0)$

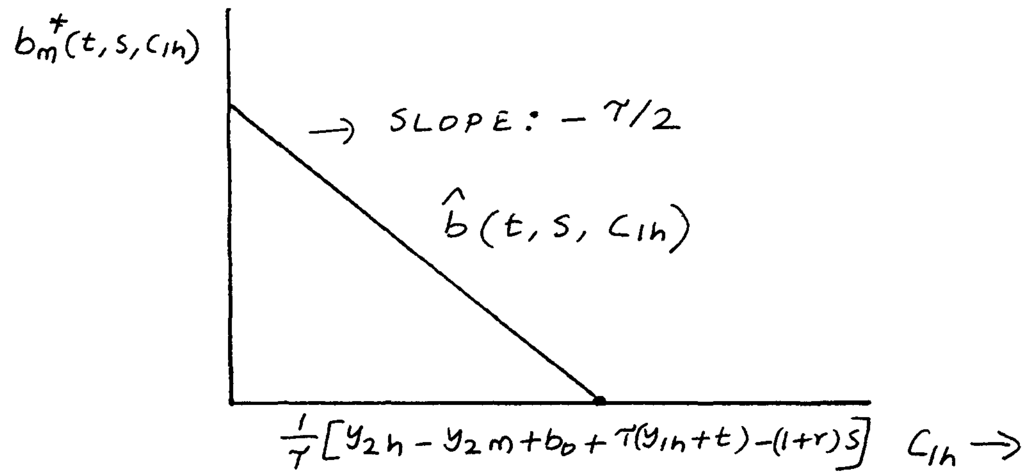


***Figure* 5** : $\frac{1}{1+r}(y_{2h} - y_{2m} - b_0) \leq s \leq \frac{1}{1+r}(y_{2h} - y_{2m} + b_0)$

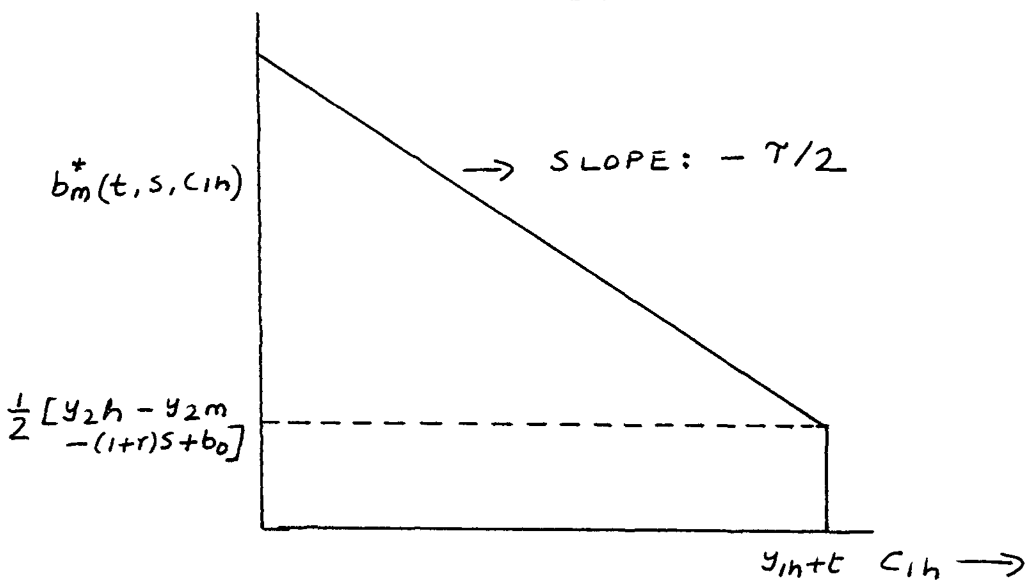
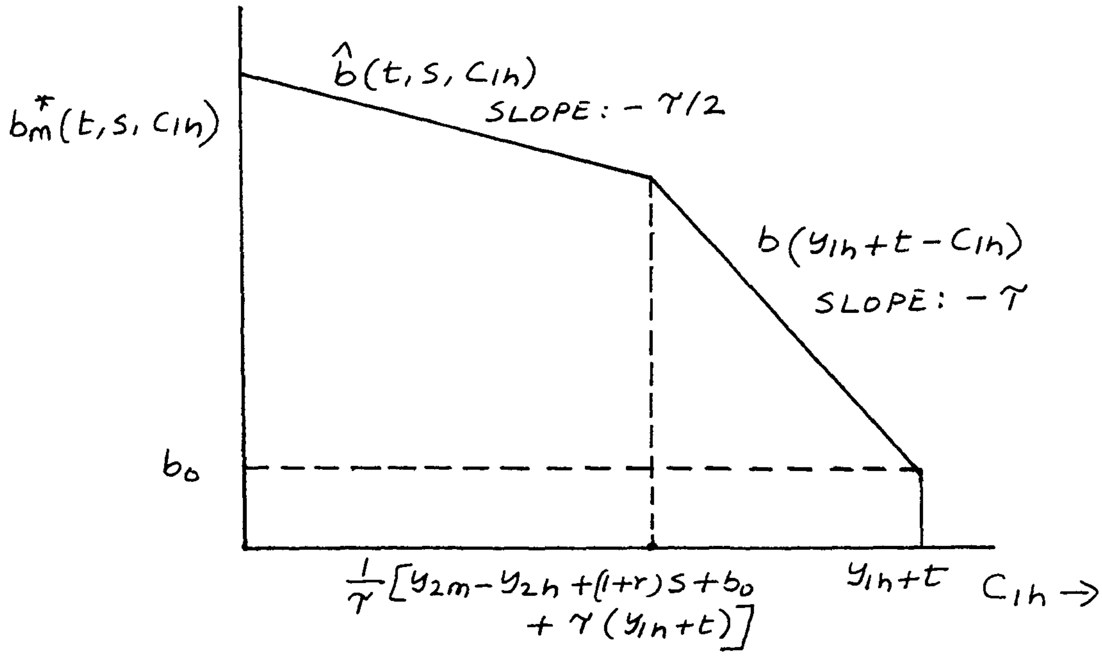


Figure 6 : $s \leq \frac{1}{1+r}(y_{2h} - y_{2m} - b_0)$



Based on the above graphs, equation (B3) can be written as:

if $y_{2h} \leq y_{2m} + (1+r)s + b_o$:

$$b^*_m(t,s,c_{1h}) = \max\{0, \hat{b}(t,s,c_{1h})\}$$

B4

if $y_{2h} \geq y_{2m} + (1+r)s + b_o$:

$$b^*_m(t,s,c_{1h}) = \begin{cases} \hat{b}(t,s,c_{1h}) & \textit{if } c_{1h} \leq \frac{1}{\tau}[y_{2m} - y_{2h} + (1+r)s + b_o + \tau(y_{1h}+t)] \\ b(y_{1h}+t-c_{1h}) & \textit{otherwise} \end{cases}$$

To solve H's problem, I start with the case presented in Figure 4 above. If $y_{2h} \leq y_{2m} + (1+r)s - b_o$, then the derivative(s) of H's objective function takes either of the following values (to the left, L, or to the right, R, of the cut-off point):

$$h(c_{1h}) = \begin{cases} \dfrac{1}{c_{1h}} - \dfrac{\tau}{y_{2h} + y_{2m} + b_o + \tau(y_{1h} + t - c_{1h}) + (1+r)s} & L \\ \dfrac{1}{c_{1h}} - \dfrac{\tau}{y_{2h} + b_o + \tau(y_{1h} + t - c_{1h}} & R \end{cases} \tag{B5}$$

The second derivative is negative and the derivative goes to ∞ as c_{1h} goes to 0, so the solution is either interior or y_{1h}+t. It follows that the solution of H's problem (together with that of P's problem) is given as follows:

If $y_{2h} \leq y_{2m} + (1+r)s - b_o$ or $s \geq (y_{2h} - y_{2m} + b_o)/1+r$ (Figure 4 above and the given regions in Figure 1 in Text):

<u>Region 1 in Figure 1</u> (i.e. $t \geq \frac{1}{\tau}[3(y_{2m} + (1+r)s) - y_{2h} - b_o - \tau y_{1h}]$) **- interior solution on the left part in Equation B5 above:**

$$\begin{aligned} b_m^*(t,s,c_{1h}) &= \hat{b}(t,s,c_{1h}) \\ c_{1h}^*(t,s) &= \hat{c}(t,s) = \frac{1}{2}\tau[y_{2h} + y_{2m} + b_o + \tau(y_{1h} + t) + (1+r)s] \end{aligned} \tag{B6}$$

Region 3 in Figure 1 (i.e. $\frac{1}{\tau}[2(y_{2m}+(1+r)s)-y_{2h}-b_o-\tau y_{1h}] \geq t \geq \frac{1}{\tau}[y_{2h}-\tau y_{1h}+b_o]$) (interior solution on the right part in Equation B5 above):

$$b_m^*(t,s,c_{1h}) = 0$$
$$c_{1h}^*(t,s) = c_{1h}^r(t,s) = \frac{1}{2}\tau[y_{2h}+b_o+\tau(y_{1h}+t)] \tag{B7}$$

Region 2 in Figure 1

(i.e. $\frac{1}{\tau}[3(y_{2m}+(1+r)s)-y_{2h}-b_o-\tau y_{1h}] \geq t \geq \frac{1}{\tau}[2(y_{2m}+(1+r)s)-y_{2h}-b_o-\tau y_{1h}]$) - solution at the kink:

$$b_m^*(t,s,c_{1h}) = 0$$
$$c_{1h}^*(t,s) = c_{1h}^k(t,s) = \frac{1}{\tau}[y_{2h}-y_{2m}+b_o+\tau(y_{1h}+t)-(1+r)s] \tag{B8}$$

Region 4 in Figure 1 (i.e. $t \leq \frac{1}{\tau}[y_{2h}-\tau y_{1h}+b_o]$) - corner solution:

$$b_m^*(t,s,c_{1h}) = 0$$
$$c_{1h}^*(t,s) = y_{1h}+t \tag{B9}$$

If y_{2m} + (1+r)s - $b_o \leq y_{2h} \leq y_{2m}$ + (1+r)s + b_o or

(y_{2h} - y_{2m} -b_o)/1+r ≤ s ≤ (y_{2h} - y_{2m} + b_o): (Figure 5 above and the given regions in Figure 1 in Text):

<u>**Region 1 in Figure 1**</u> **(i.e.** $t \geq \frac{1}{\tau}[y_{2m} + (1+r)s + y_{2h} + b_o - \tau y_{1h}]$**) - interior solution:**

$$\begin{aligned} b_m^*(t,s,c_{1h}) &= \hat{b}(t,s,c_{1h}) \\ c_{1h}^*(t,s) &= \hat{c}(t,s) = \frac{1}{2\tau}[y_{2h} + y_{2m} + b_o + \tau(y_{1h} + t) + (1+r)s] \end{aligned} \qquad \text{(B10)}$$

<u>**Region 5 in Figure 1**</u> **(i.e.** $t \leq \frac{1}{\tau}[y_{2m} + (1+r)s + y_{2h} + b_o - \tau y_{1h}]$**) - corner solution:**

$$\begin{aligned} b_m^*(t,s,c_{1h}) &= \hat{b}(t,s,c_{1h}) \\ c_{1h}^*(t,s) &= \hat{c}(t,s) = \frac{1}{2\tau}[y_{2h} + y_{2m} + b_o + \tau(y_{1h} + t) + (1+r)s] \end{aligned} \qquad \text{(B11)}$$

If $y_{2h} \geq y_{2m} + (1+r)s + b_o$ or $s \leq (y_{2h} - y_{2m} - b_o)/1+r$ (Figure 6 above and the given regions in Figure 1 in Text):

<u>Region 1 in Figure 1</u> (i.e. $t \geq \frac{1}{\tau}[3y_{2h} - (1+r)s - y_{2m} - b_o - \tau y_{1h}]$) **- interior solution:**

$$b_m^*(t,s,c_{1h}) = \hat{b}(t,s,c_{1h}) \qquad \textbf{(B12)}$$
$$c_{1h}^*(t,s) = \hat{c}(t,s)$$

<u>Region 6 in Figure 1</u> (i.e. $t \leq \frac{1}{\tau}[3y_{2h} - (1+r)s - y_{2m} - b_o - \tau y_{1h}]$) **- corner solution:**

$$b_m^*(t,s,c_{1h}) = b(t,s,c_{1h}) \qquad \textbf{(B13)}$$
$$c_{1h}^*(t,s) = y_{1h} + t$$

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