Human Capital Diversification within the Household. Findings from Rural Tanzania.

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Abstract

Lack of primary schooling among rural children in developing countries is often attributed to credit constraints and household demand for child labour, implying that direct and indirect costs of schooling are high. Surprisingly few studies have considered the importance of parents' expected returns of investing in their children's human capital, despite the fact that most parents rely on their children for old-age support and subsistence. In this paper, I propose an alternative model for human capital investment based on the household, rather than the individual child, incorporating the fact that parents bear the costs of educating *all* their children and face uncertainty about the level and share of future returns. This uncertainty can make it optimal for parents to ensure a certain degree of human capital diversification within the household. The model implications allow me to test whether it is the need for diversification or the costs of schooling that dominate the human capital investment decision in rural households. Using extraordinary long panel data from a rural region in Northwestern Tanzania, I find strong empirical evidence of diversification effects for rural sons, but not for rural daughters. Exactly in line with what should be expected for a patrilineal society. This can potentially have far reaching policy implications.

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1 Introduction

Schooling rates are continuously low among rural children in many developing countries. Classic human capital investment theory dictates that an individual should invest in education as long as the discounted future returns exceed the current direct and indirect costs of such an investment, e.g. Ben-Porath (1967). Such a cost benefit argument is simple and straightforward. However, the investment decision is more complex when it comes to primary school education of children in developing countries. The human capital investment decision is not an individual decision for each child, but rather a joint decision made by parents for *all* children. The complexity arises from the fact that parents bear the costs of primary education of their children, whereas the individual child receives the future benefits. Parents therefore face uncertainty about both the level and the possible share of future returns to education.

There is a vast amount of literature on the choice of child labour and schooling among households in developing countries. This literature has a strong emphasis on the cost side of the human capital investment decision and the inability of parents to borrow against the future returns of their children's education, see Edmonds (2007). The literature so far has illustrated that costs and credit constraints are important in the schooling decisions of households. I investigate whether the need for risk diversification due to uncertainty about future returns is equally important for the schooling decision. Two recent papers have introduced uncertainty in Baland and Robinson (2000)'s, by now, standard human capital investment model for the *individual* child and show, analytically, that this can result in less schooling, Pouliot (2005) and Estevan and Baland (2007). However, these papers do not make any rigorous attempt at estimating the importance of uncertainty in the household schooling decision empirically.

In this paper, I ask the following question: Can the need for ex-ante risk diversification be so strong that it alone results in some children not being sent to school in order to diversify the human capital portfolio of the household? This contributes to the existing schooling and child labour literature by focusing explicitly on the expected future returns to parents from investing in the human capital of their children, and by modelling the human capital investment decision jointly for *all* children in the household, rather than for each individual child, using a simple human capital portfolio model. I allow for two types of human capital, general human capital acquired through formal schooling directing children towards the urban sector, and specific human capital acquired through traditional on-farm learning-by-doing directing children towards the agricultural sector. The model is set up and calibrated both with and without liquidity constraints and child labour in order to separate implications of uncertain returns, *portfolio effects*, from implications of costs and liquidity constraints, *constraint effects* on the joint schooling decision. Portfolio effects result in a positive relationship between fertility and schooling within a household, whereas constraint effects result in a negative relationship. The calibration results are essential for generating precise model predictions, which can be tested empirically, and thereby provide guidance in how to take the model to the data.

Both calibrations and the empirical analysis are based on a data set from a household survey in the region of Kagera in Northwestern Tanzania with an extraordinary long time horizon of 13 years[1]. The data set has detailed information on schooling, fertility and migrant children. The long time horizon allows me to focus on households with completed fertility and completed human capital investment decisions of all their children. In addition, issues which are left unanswered by the model or the data, are resolved by the use of qualitative data, which are crucial for getting a better understanding of the influence of social norms, in particular in terms of gender differences in the schooling decision.

The analytical and empirical results show clear evidence of human capital diversification among children within households. I find strong empirical evidence of portfolio effects consistent with human capital diversification happening due to uncertainty, and for which I find no other observationally equivalent alternative. Furthermore, the positive portfolio effects dominate only among sons and not among daughters, which is exactly what the social norms would predict for a patrilineal society as Kagera. This gender difference provides strong support for the human capital portfolio model. There are no other observationally equivalent explanation, which can generate a similar predicted gender difference. All model assumptions and other implications are also consistent with the data.

These findings have important for policy implications. If policy makers solely act on the cost side of the educational decisions of the household, while the return side is neglected, the objective of full primary school enrolment might not be achieved. The schooling system should be able to accomodate the need for future income source diversification and provide the life skills necessary for children to be sucessful both in the agricultural and in the urban sector.

The paper is organised as follows. In section 2, I describe the ethnographic evidence forming the background for the model assumptions. In section 3, the simple portfolio model is set up and calibrated under the different scenarios allowing for uncertainty, liquidity constraints and child labour. Section 4 is a description of the KHDS data, while section 5 includes a detailed empirical investigation of each of the testable model assumptions and implications. Possible alternative explanations for the key result are discussed in section 6. Section 7 concludes and policy implications are discussed.

2 Ethnographic Evidence

Rural Kagera is, in many ways, a very different setting from modern industrialised societies, also in terms of social norms and expectations about the role of parents, as well as the role of children. The influence of norms is difficult to detect in quantitative empirical analyses.

[1]The Kagera Health and Development Survey, KHDS I+II.

Qualitative data can therefore be useful complements, especially when the set of norms dicussed is different from ones own reference set. Lassen and I therefore decided to collect qualitative data from 12 out of the 49 KHDS sample villages in Kagera to gain local insight, Lassen and Lilleør (2005).

During semi-structured focus group discussions on schooling, family, networks, migration and old-age security, a certain picture emerged about norms and expectations in the relationship between parents and children. First, it quickly became clear that old-aged people first and foremost rely on their children for subsistence and care. If they have no children or these fail to provide the assistance needed, old-age support can also be provided by clan members or by fellow villagers who then, in return, would inherit any assets. 'The property one has may help him when he is sick as he may sell some so as to get some money or may give a will to someone he trusts to take care of him and take his property when he dies..."Take care of me and you will take me property when I die."'(Cluster 12). Old people without assets or 'faithfull or loving' children can expect little assistance.

Second, the expected assistance from children differs depending on their gender, education and residence. Norms clearly dictate that sons should provide for their old-aged parents, whereas daughters cannot be expected to do so. Once married the obligations of daughters lie with their family in-law. 'A boy is the heir of the family because a girl will later on be married and go away (...) a girl is likely to benefit the clan of her husband', (Cluster 8) and 'educating a girl is taking the whole wealth to her in-laws', (Cluster 21). There is even a local saying in Haya "Omswisiki taba wawe", meaning 'the daughter is always not yours', (Cluster 21), and a ritual linked to the gender difference already when infants: 'When a female child is born, at the age of three months she is brought into the living room and directed to front door facing out as a ritual that she will have to leave the family when she is old enough', (Cluster 50). Even so, it seems that many daughters still try to help their old age parents as much as they can, and they are therefore often considered more 'faithfull' and 'show more love' than their brothers, (Cluster 17). This expectation of daughters being more loving, is repeatedly given as a reason for sending girls to school in the hope of future returns even though she will marry and belong to the familiy of a different clan. 'Girls have a reputation of caring more for their parents than boys when they succeed in life', (Cluster 23). 'Boys tend to forget their past and their families.' (Cluster 8). The focus group in cluster 50 very clearly stated the dilemma of parents, when asked who would be given priority in terms of schooling if they had to choose between a daughter and a son. 'The participants said that they would send a boy in case they had to choose. This is because the boy is expected to become the successor when parents die. If the boy was not the successor the girl would be sent to school because she is more likely to help the parents.' In addition, schooling may be important for the marriage market. 'It is easier for [girls with primary school] to be married to a highly educated person', (Cluster 50).

On the other hand, there also seems to be fear of pregnancy if girls attend school in teenage years 'girls are more likely to get pregnant which will result in drop out', (Cluster 19) .

Third, the expected migration pattern, and with it, the type of old-age assistance, also seems to differ for sons and daughters. Whereas marriage seems to be the primary factor determining the migration of a daughter, education is the key for whether or not a son migrates. Sons without primary school are not expected to migrate and mainly fail if they do so because their familiarity lies in the local agricultural environment. They will engage in farming and be of general assistance to their parents in terms of supplying 'farm produce, manual work, and nursing the sick'. 'Their education limits them from gaining more than their working strength. Since they live closer to their families they assist on daily events', (Cluster 13). Likewise, on the general description of an uneducated son they note that 'His most important asset is his own strength which can be used any where that he is familiar with', 'He will attend all the cultural practices for the family, and help the father with manual works', 'His help is important as he is used to the environment [of the village] ', (Cluster 50). In return for his assistance, a son without formal education 'expects all life support, e.g. shamba, from parents so he has to work hard for them', (Cluster 21).

Sons with education, on the other hand, are seen as likely to migrate out of the rural village, and their assistance will be in terms of remittances, upon request, if they succeed in life and are good or loving sons that do not forget their past and their family. The educated migrant son sends 'more remittances as much as he can to keep his family relative to his income', (Cluster10), 'sends cash money when requested, more than once', and 'has good income but only responds to the call of the father.', 'When married he turns weak to his wife. He concentrates on his household and lives an expensive life while he is forgetting his [parental] family, (Cluster 50). In addition, migrant children living far away are generally thought of as harder to reach and less reliable when it come to ald-age assistance. The focus group in cluster 12 pointed this out by using a Swahili saying '"Fimbo ya mbali haiui nyoka - the far stick cannot kill a snake" This gives excuse for the child staying in distant places. Parents will not have more expectations to those children staying far.' Parents thus loose control over migrant children.

Fourth, schooling in itself also carries an element of uncertainty. It is seen as 'risky' if the educated child is not able to find employment and does not become 'self-dependent', but rather continues as a burden to the parents. It is seen as 'not risky' if the educated child finds employment, becomes 'self-dependent' and as a 'good investment' if he, in addition, is a 'loving' child and starts remitting. 'Schooling is a good investment when a child does not turn back to the parents to depend on them', (Cluster 12). 'Every parent expects to benefit from the good result with investment on their children (...) a farmer planting good seeds, he always expects to get good yields', 'the value of education is seen especially when a child gets success', (Cluster 19). 'Primary education is the good investment only if: a child after school does not depend on parents, but works for himself; if he/she is employed by the government, a child will be sure of monthly salary and out of this will be helping the parents at home; if he/she remits home, (Cluster 17).

Finally, it was mentioned repeatedly, by the use of a Haya proverb, that if other migrant children in the village were doing well and remitting home, this would have a positive influence on the parents' decision to send their own children to school: '"Rutachuba talima ntanu - without jealousy you cannot open a new banana farm" meaning one cannot be successful', (e.g. Cluster 12, 13, and 23). That is, only if you also wish do do well when you see others doing well, will you succeed. The concept of 'jealousy' is used in a positive manner, incentives to invest in schooling are improved, when others are able to generate good returns from the same type of investment.

3 Model

As outlined above, parents have different expectations and face different uncertainties about future assistance from their chidlren, depending on the gender, schooling and residence. This section provides a simple portfolio model of the human capital investment decisions faced by parents with more than one child. The model is set up as a two period model, where children are educated in the first period and, as adults, provide for their parents in the second period. The model differs from most models in the existing child labour literature, because it incorporates old-age dependency on children; parental uncertainty about the future income from children; sibling dependency in the human capital investment decision; and a clear distinction between the urban and the agricultural sector. The model is set up to analyse the effects of uncertainty about future income transfers from children to parents on the present human capital investment decisions parents have to make on behalf of their young children. The model and its underlying assumptions generate a set of empirical implications, which can be directly tested in the data. Some of these implications differ markedly from the ones generated by conventional theories of child labour. I do not distinguish between gender in the model, but given the qualitative findings, the model is expected only to hold for sons.

3.1 A Basic Portfolio Model

The model is a unitary household model, where parents function as a unified sole decision maker. It consists of two periods, $t = 1, 2$, and there is no discounting of the future and no interest rate on savings or credit. The model will be calibrated under two different scenarios in section 3.2 to facilitate comparison of the empirical implications of the model with those of more conventional theories of child labour and human capital investment. Below, the model is outlined under a 'no liquidity constraint, no child labour' scenario. Later, I will impose both liquidity constraints and child labour.

In the first period, parents earn agricultural income Y_1, which they allocate between first period household consumption c_1, savings s, and the education expenses for their N children. N is assumed to be exogenously given, since the emphasis here is not on the effect of uncertainty on fertility decisions, but on the effect of uncertainty on the joint human capital investment decision of children, given the fertility of the household.[2] There are two types of education in the model, general formal education achieved through primary schooling and specific traditional education achieved through on-farm learning-by-doing. Traditional education directs children towards future employment in the agricultural sector (a), whereas formal education directs children towards future employment in the non-agricultural urban sector (b) in the second period. Parents face a discrete choice for each of the N children of whether he or she should be educated traditionally or formally. A child can only receive one type of education[3].

In the second period, traditionally educated children earn agricultural income, y_2^a , whereas formally educated children earn urban income, y_2^b. Parents do not generate any income in the second period, but rely fully on their savings and the joint agricultural and urban income transfers from their N children for second period household consumption, c_2. Second period income is uncertain. Parents therefore maximise a joint von Neuman-Morgenstern expected utility function defined over and separable in household consumption, c_t, where $t = 1, 2$. The utility function is assumed to be concave, such that $U'(c) > 0$ and $U''(c) < 0$. The household solves the following maximisation problem

$$\max_{\pi,s} EW(c_1, c_2) = U(c_1) + EU(c_2) \tag{1}$$

subject to the budget constraints for period 1 and period 2, respectively

$$\begin{aligned} c_1 &= Y_1 - (1-\pi)Ne^a - \pi Ne^b - s \\ c_2 &= N^{-\alpha}((1-\pi)Ny_2^a + \pi Ny_2^b) + s \end{aligned} \tag{2}$$

where π is the proportion of children, which parents chose to educate formally through schooling. That is, π is the portfolio allocation of children between traditional and formal human capital investments. The number of children who receive schooling in the first period is thus given by πN and the number who are educated within the traditional agricultural based system is $(1-\pi)N$.[4] The total amount of educational expenses is $(1-\pi)Ne^a + \pi Ne^b$, where e^a is

[2] It is conceivable that the fertility decision and the human capital investment decision of the born and unborn children are both influenced by the parents' preference for old-age security, which suggests modelling the two decisions jointly. However, to keep things simple, I focus on the effect of future income uncertainty on the human capital investmnet decision of children conditional on the household having completed their fertility.

[3] This is a simplifying assumption. The choice here is not on how many hours a child spends in school or working, but rather whether he or she graduates with full primary school education or not.

[4] For analytical simplicity, π is written as continuous in the theoretical model, but it will be treated as discrete

the educational expenditure for each child in traditional education, e.g. supervisional costs of parents, and e^b is the educational expenditure for each child in formal education, e.g. tuition fees and uniform costs. Educational expenditures are allowed to differ over the two sectors, and they are, for now, both non-negative and therefore considered as a cost.[5]

Second period consumption will equal any capital transfers from period one in terms of savings or dissavings, s, plus a fraction, $1/N^{\alpha}$ of total income from all children. Total second period of the children amounts to the agricultural sector income $(1-\pi)Ny_2^a$, and the urban sector income $\pi N y_2^b$. Children are assumed to transfer a certain fraction of their income to their parents. The fraction is the same for all children, irrespective of their sector of employment, but it depends on their number of siblings for $\alpha > 0$. When assuming $0 < \alpha < 1$, there will be a positive, but diminishing marginal effect of having more children on total second period income received from children.

While second period urban income will come from migrant children, second period agricultural income will come from home children educated by their parents. It is therefore reasonable to assume that, to the extend that parents have actually concentrated on passing on their specific human capital skills to their children, the second period agricultural income of these, y_2^a will be positively correlated with the current agricultural income of the parents, Y_1, such that $y_2^a = f(Y_1)$, where $f' > 0$. Furthermore, not only specific human capital will matter for the agricultural productivity of children, but also the inputs available at local level, which are likely to be highly correlated over generations.

Savings can be negative, and both the discount rate and the interest rate are normalised to unity and are thus explicitly left out of the model for simplicity. By assuming perfect credit markets, I can ignore any effect of liquidity constraints on the schooling decision and thus focus on the effect of future income uncertainty on the joint human capital portfolio decision of all N children in the household. The quation is: can this alone result in less than full school enrolment among siblings, i.e. a model prediction of at least one child being educated traditionally and thus resulting in $\pi < 1$ solely due to uncertainty about future income transfers.

When there are no liquidity constraints, parents are faced with two choice variables; how much to save or dissave s, and which proportion of their children to educate formally through schooling π, the human capital portfolio allocation. The first order condition with respect to s

in the calibrations.

[5] While the literature on child labour and schooling generally set e^a as negative and thus as a source of income, I here follow Bock (2002) in stating that the overall learning potential in the tasks completed by children in agriculture is higher than the immediate return. If children were only undertaking tasks with no learning, but high immediate output, such as fetching water or firewoods, there would be no transfer of farm-specific human capital from parents to children and therefore no future agricultural return from such activities. thus for e^a to be an educational expense, children have to be allocated tasks of with a certain degree of complexity and, thus, a learning potential. See Lilleør (2008) for more detail.

is[6]

$$U'(c_1) = EU'(c_2) \tag{3}$$

That is, savings s will be chosen such that marginal utility in period one equals the expected marginal utility of period two. The first order condition with respect to π is given by equation (4), where π^* is the optimal solution for the maximisation problem above

$$\begin{aligned} N(e^b - e^a)U'(c_1) &= E[N^{1-\alpha}(y_2^b - y_2^a)U'(c_2)], \quad \text{for } 0 < \pi^* < 1 \\ N(e^b - e^a)U'(c_1) &> E[N^{1-\alpha}(y_2^b - y_2^a)U'(c_2)], \quad \text{for } \pi^* = 0 \\ N(e^b - e^a)U'(c_1) &< E[N^{1-\alpha}(y_2^b - y_2^a)U'(c_2)], \quad \text{for } \pi^* = 1 \end{aligned} \tag{4}$$

Parents face two sources of uncertainty with respect to future income transfers from their children. There is uncertainty about the future employment of a child, but there can also be uncertainty about whether the successful child will send the expected level of remittances to his parents, that is an uncertainty about whether the child is a 'loving' child or not, as noted by some of the focus group participants. Lucas and Stark (1985) emphasise how parents may be more likely to loose control or family command over migrant children as compared to home children.[7]

In the following, I assume, that there is no covariant uncertainty between second period transfers from children in the urban sector and children in the agricultural sector. This allows me to simplify the problem by normalising uncertainty about agricultural remittances to zero, and thus solely focus on the effect of uncertainty about urban remittances or income transfers on the optimal proportion of children in formal schooling, π^*. This is not to say that there is no uncertainty associated with agricultural income transfers or in-kind assistance, but rather that uncertainty associated with transfers from distant migrant children in the urban sector is higher. Urban migrants face higher income levels, but also relatively more variation, since the urban labour market entails a fundamental risk of unemployment, which is not present among subsistence farmers in the agricultural sector. Furthermore, parents may also perceive the size and the frequency of remittances from urban migrant children to be more uncertain compared to the daily support and in-kind assistance from home children engaged in local agricultural sector[8]. Finally, because y_2^a is likely to be strongly correlated with Y_1, parents will be able to make more precise predictions about the future value of y_2^a given their priors, than about the future value of y_2^b.

[6] When liquidity constraints are imposed $s = 0$ and parents only have one choice variable, π. The maximisation problem therefore reduces to one first order condition, eq. (4) below.

[7] For a detailed literature review on this subject, please refer to Lilleør (2008).

[8] This is, in effect, an agency problem between parents and migrant children. The degree of success of migrant children is harder to monitor for parents and family control is likely to decrease with the distance. Social sanctions are often mentioned as effective means in overcoming such agency problems and thereby helping to reduce at least one source of future uncertainty. Lassen and Lilleør (2008) analyse the effect of such sanctions on the demand for formal schooling.

In short, the uncertainty faced by parents about second period income is modelled for the urban sector, where each migrant child can either get a good (typically formal sector) job or not; and where migrant children in good jobs can remit more than migrant children without a good job, but they may not do so. This is modelled as a simple mean preserving spread, where 'loving' children with good jobs remit a share of their high urban income, $y_2^b = \mu + \varepsilon$; whereas less 'loving' children with good jobs mimic children without good jobs and thus only remit a share of a low urban income, $y_2^b = \mu - \varepsilon$. Second period urban income is given by

$$y_2^b = \begin{cases} \mu + \varepsilon & \text{w.p.} \quad p = 0.5 \\ \mu - \varepsilon & \text{w.p.} \quad (1-p) = 0.5 \end{cases}$$

The mean and the variance for each child in the urban sector is $E(y_2^b) = \mu$ and $Var(y_2^b) = \varepsilon^2$, respectively. The expected total income transfers in period 2 from all the πN formally educated children in the urban sector, is simply $E(\pi N^{1-\alpha} y_2^b) = \pi N^{1-\alpha}\mu$, independent of the degree of correlation among children in the uncertainty structure. However, the variance of the expected total income transfers, $Var(\pi N^{1-\alpha} y_2^b)$ and the covariance in the first order condition for π, $cov(N^{1-\alpha} y_2^b, U'(c_2))$ will both depend on the degree of correlation. I consider the two extremes of either perfect correlation or perfect uncorrelation in the uncertainty structure of urban remittances. Reality is likely to lie somewhere in between. When there is perfect correlation in ε among migrant siblings, they will all either have a good draw and be good remitters, and then their income transfers will amount to $\pi N^{1-\alpha}(\mu + \varepsilon)$, or they will all have a bad draw or all be bad remitters, and then their income transfers will amount to $\pi N^{1-\alpha}(\mu - \varepsilon)$, hence the variance is $Var(\pi N^{1-\alpha} y_2^b) = \pi^2 N^{2-2\alpha}\varepsilon^2$. When the individual ε's are perfectly uncorrelated, migrant children all face the same urban labour market lottery irrespective of the labour market outcomes of their siblings and they decide independently on their level of remittances to parents. The variance under no risk correlation is thus smaller and depends on the binomial coefficient $\binom{\pi N}{i}$, where i denotes the number of successful siblings in the urban labour market (i.e. those where $y_2^b = \mu + \varepsilon$) and πN is the total number of siblings in the urban sector in the second period, $Var(\pi N^{1-\alpha} y_2^b) = N^{-\alpha} \sum_{i=0}^{\pi N} \binom{\pi N}{i} \frac{1}{2^{\pi N}} (i\varepsilon - (\pi N - i)\varepsilon)^2 = \pi N^{1-\alpha}\varepsilon^2$.

As long as there is no covariance between the uncertainty associated with the agricultural sector income transfers and the uncertainty associated with urban sector income transfers, households will have an incentive to diversify their human capital investments between these two sectors to reduce future risk exposure. If the need for diversification away from the urban sector is strong enough, that is the second period covariance term, $cov(N^{1-\alpha} y_2^b, U'(c_2))$ is sufficiently negative, this will have a negative impact on the number of children sent to school in the optimal human capital portfolio of the household, π^*. It will then be optimal for the risk averse parents to direct one or more children towards future employment in the agricultural sector by educating them traditionally on the farm.

3.2 Model Calibrations

In the following, I first calibrate the portfolio model using standard CRRA preferences under both the 'no liquidity constraint, no child labour' scenario, and later introduce both liquidity constraints and child labour. By doing so, I am able to separate out which empirical implications originate from uncertainty and the portfolio model as such, and which empirical implications originate from a household being liquidity constrained.

The model is calibrated using simple summary statistics from the KHDS data (see table 4.1 for detail). It is calibrated for the average rural household, using the average values for household expenditure as a proxy for agricultural income, Y_1 and y_2^a and for number of children N, while the village average is used for schooling expenditure. Second period urban income, y_2^b is proxied by the average level of household expenditure in urban areas. All expenditure variables are measured as daily adult equivalent terms in USD. Calibrating the model based on real data is helpful in determining the relative levels of exogenous variables. The variable values and their normalisation in the calibrations are listed below in table 3.1

Table 3.1. Summary statistics of KHDS variables and their model equivalents.

KHDS I variable		KHDS data	Normalisation	Model
AE daily HH expenditure, urban HHs	mean	0.75	2.02	y_2^b
	s.d.	0.86	1.78	ε
Rural Households				
AE daily HH expenditure, agricultural HHs	mean	0.37	1	$Y_1 = y_2^a$
	s.d.	0.20	0	
Annual school expenditure, cluster mean	mean	4.65	0.03	e^b
Total number of children in HH	mean	8.21		N
Proportion of children in/through school	mean	0.67		π^*
# Rural Households in sample		365		

Note: All expenditure amounts are in USD, where 1 USD =455 Tsh. AE: adult equivalent

In the calibrations, I assume that the correlation between first period parental agricultural income and second period agricultural income of children is perfect and that the mapping is 1:1. That is, parents transfer all of their specific human capital skills through traditional education to the children destined for agriculture. Agricultural income levels in the two periods are normalised to unity, $Y_1 = y_2^a = 1$ with zero standard deviation. This results in an adjustment of the urban sector second period income, such that $E(y_2^b) = \mu = 0.75/0.37 = 2.02$ and the uncertainty measure, here proxied by the standard deviation, $\varepsilon = s.d.(y_2^b) = (0.86 - 0.20)/0.37 = 1.78$. The annual expenditures of schooling in rural areas, including school fees and school uniform costs, are 3% of household expenditures per child, thus $e^b = 0.03$. Since I have no plausible measure of the supervision costs of traditional education, I simply set it at half of the schooling costs, such that $e^a = 0.015$ under the 'no liquidity, no child labour' scenario. Thus, for the average KHDS household formal education is always more profitable than traditional education. The question is then how much uncertainty about future returns to formal education is needed for the household to diversify future income sources and thus educate at least one child traditionally.

In the following, graphs are calibrated using $\gamma = 2$ as the relative risk aversion parameter in the CRRA utility function. To avoid heavy consumption smoothing incentives, $\alpha = 0.95$ and thereby ensuring that first and second period consumption are of the same magnitude. In the graphs, $y_2^b, \gamma, \alpha, e^a$ and e^b are held constant, whereas $N, Y_1 = y_2^a$ and ε are allowed to vary. The urban income transfer uncertainty, ε runs in the $[0; 2]$ interval, thereby including in the upper end the actual expenditure spread present in the data of $\varepsilon = 1.78$. For the maximum level of uncertainty ($\varepsilon = 2$), the migrant child is in a situation of virtually no income or an income four times that of the agricultural sector. The number of children, N can vary from 2-16. Although the total number of children on average is 8, the average number of sons is 4. Given the qualitative findings on gender differences, the model is likely to be less applicable to girls. I will return to this in the empirical analysis below. Finally, note that since the model is calibrated for discrete numbers of children, π is also of a discrete character.

3.2.1 No liquidity constraints and no child labour

The main contribution of the simple portfolio model above is captured in figure 3.1. It shows the effect of uncertainty on the human capital investment decision under perfect correlation and uncorrelation in the uncertainty measure ε, respectively.

[Figure 3.1]

For $\varepsilon = 0$, there is no future uncertainty and thus no need for future income source diversification. The household will always choose the optimal corner solution for π, which for the average KHDS household is $\pi^* = 1$. For low levels of ε, the household does not alter its optimal human capital allocation between the traditional agricultural sector and formal schooling. However, as the uncertainty about future income transfers from migrant children increases, the need for future income source diversification shifts the optimal portfolio allocation away from 100% enrolment in schooling. There is nothing new about this. For any risk averse agent, there is an optimal trade-off between risk and returns of investments. What is new is that this is applied to the human capital investment decision of rural households in developing countries. The key point here is that even in a world of no liquidity constraints and no immediate returns to child labour, households would still not send all of their children to school if there is a certain level of uncertainty or risk associated with returns to schooling. For the average KHDS household with 8 children, this implies that for an income spread in the urban sector of $\varepsilon = 1.8$, roughly as we see in the data, the optimal proportion of children in school under the two extremes of either perfect correlation or perfect uncorrelation in the ε risk measure, π^* is 0.875 and 0.125, respectively. This should be compared to the actual intra-household proportion of children with formal education of $\pi = 0.67$, which is right in between.

Allowing for sibling dependency is one of the main contributions of the portfolio model compared to the existing literature on child labour. The effect of changes in N on π^* can be characterised as the *portfolio effect*. Analysing the human capital investment decision of the full set of children jointly, rather than for each child independently and then adding up, yields very different results because the total number of children influences the covariance term in the first order condition for π. Standard model on child labour and schooling typically set the number of children to one for simplicity, e.g. Baland and Robinson (2000), Ranjan (1999), and Basu and Van (1998). These model more or less explicitly argue, that the decision is identical for all n children. They therefore implicitly assume away any sibling dependency in the schooling or child labour decisions. Such models will, by construction, always predict a corner solution for π since the household schooling rate is given by n times the optimal solution for the individual child. Interior solutions for π can, in such models, only be the result of changes in the household resources over time, such that some children may have been subject to binding liquidity constraints, others not. In the portfolio model, the disregard for sibling dependence corresponds to looking at the case of $N = 1$ and then subsequently applying that specific solution for π^* to all children. For $N = 1$, the model predicts that when $\varepsilon > 1.4$, the optimal choice of π shifts from schooling to agriculture under a relative risk aversion parameter of $\rho = 2$. And, when $\varepsilon \leq 1.4$ the household will always send all children to school ($\pi = 1$), and for $\varepsilon > 1.4$ the household sends none ($\pi = 0$). Looking at figure 3.1, this is clearly not the case for $N > 1$. There is an obvious portfolio effect on π^* of changes in N. There is even some indication of convergence as N increases.

[Figure 3.2]

Figure 3.2 is an alternative illustration of the same results. It show the effect of changes in N on π for different levels of uncertainty. For the uncorrelated $\varepsilon = 1.78$, there is a clear positive effect on π^* of increases in N until π^* reaches the neighbourhood of 0.8, where it seems to stabilise. For the perfectly correlated ε, the convergence happens much earlier and the clear cut positive effects of N on π are only present for low levels of N. This is not surprising. By introducing perfect correlation in ε, I am assuming the same outcome for all migrant children. Thus, the risk diversification can only take place between the rural and urban sector, whereas for uncorrelated ε it can take place both between the rural and urban sector as well as among the migrant children within the urban sector.

The effects of changes in parental agricultural income Y_1, in α, and in the probability of parent receiving remittances in the second period from the migrant children, p are all trivial. Although it should be noted that the sectoral divide in returns to education generates a negative effect of high agricultural income on π^* once the traditional agricultural sector becomes a profitable risk-free alternative to formal education. There is a positive effect on π^* when $\alpha = 1$ compared to $\alpha = 0$. Finally, there is a clear positive effect on π^* of increases in p, i.e. the higher the probability of receiving second period remittance, the more profitable is the investment in formal human capital and parents will choose to send a larger proportion of their children to school[9].

The most interesting point to take from this exercise is that uncertainty matters for the human capital investment decision. Potentially it matters a lot. Even in a world conducive in any aspect, but risk, to full school enrolment, a simple model of utility maximisation with standard risk averse agents predicts optimal intra-household school enrolment rates well below unity for actual levels of urban income spread.

3.2.2 Liquidity constraints and child labour

When the model is calibrated under liquidity constraints, there is no transfer of capital between periods and $s = 0$[10]. Parents are thus maximising eq. (1) with respect to π subject to

$$\begin{aligned} c_1 &= Y_1 - (1-\pi)Ne^a - \pi N e^b \\ c_2 &= N^{-\alpha}((1-\pi)Ny_2^a + \pi N y_2^b) \end{aligned} \tag{5}$$

For the model to resemble the standard child labour and schooling literature as much as possible, there should also be high opportunity costs of schooling in terms of child labour. This is achieved by ensuring that the immediate return to traditional education outweighs the learning costs associated with the task complexity, such that $e^a < 0$. This means that $-e^a$ resembles a wage for each child in the agricultural sector. However, child labour is still regarded as a means of acquiring traditional education and thereby future agricultural returns, such that y_2^a is tied to the parental level of Y_1. If the type of child labour in question is indeed detrimental to human capital accumulation of the child and thus to his future agricultural earning capabilities, a stronger version of child labour should be imposed where $y_2^a < Y_1$ because only an incomplete transfer of specific human capital from parents to the child has taken place. In the following, I assume full transfer of specific human capital skills from parents to the traditionally educated children, thus setting $y_2^a = Y_1$.

[9] It should be noted that as soon as $p \neq 0.5$, the uncertainty is no longer modelled as a mean preserving spread and thus increasing p has two implications. It increases both the mean and the variance of second period urban income transfers.

[10] In the calibrations, I allow $s \geq 0$.

The introduction of a liquidity constraint, where households no longer can borrow against future income ($s \geq 0$), has the expected negative effect on the proportion of children sent to school, but only in households with many children, see figure 3.3. For households with up to eight children, there is no effect on π^* when the uncertainty measure is uncorrelated and only a slight negative effect of the liquidity constraint under perfectly correlated ε's. Under no uncertainty, the liquidity constraint only really binds for $N \geq 10$, which is equivalent of the schooling expenditure amounting to 30% of total household expenditure.

[Figure 3.3]

While the inability to borrow against future income is most likely reality for most households in developing countries, the true cost of schooling, it is often argued, has to be measured in terms of the opportunity costs of children's time. The model is therefore also calibrated allowing for not only future but also immediate returns to traditional education and thereby introducing the concept of child labour. This is simply done by setting $e^a = -0.03$. One child in the agricultural sector can then finance one child in school. These immediate returns to children engaged in the agricultural sector in the first period offers a possibility of improved consumption smoothing between period one and two, compared to the situation of no immediate returns to traditional agricultural education. Under no uncertainty, the liquidity constraint now binds for $N \geq 4$, see figure 3.4.

[Figure 3.4]

It is also clear from figure 3.3. and 3.4 that for the special case of $N = 1$, which is the standard case in the schooling and child labour literature, there is no effect on the optimal decision of introducing liquidity constraints and only a very marginal effect of also introducing child labour. The optimal education choice shifts from formal to traditional education in agriculture at $\varepsilon = 1.5$ when there is no child labour, and at $\varepsilon = 1.4$ when there is child labour. The, by the child labour literature, predicted strong effects of households being liquidity constrained are thus hard to confirm analytically for one-child households given the numerical values for school costs and household income.

The pure portfolio effect of changes in N on π^* is contaminated once the household is liquidity constrained. However, since the constraint only really binds for households with more than four (ten) children with (without) the introduction of child labour, the portfolio effect is less affected by the liquidity constraint for lower levels N. This is also clear from figures 3.5 and 3.6 below, which corresponds to figure 3.2 only now the household is liquidity constrained (figure 3.5) and is also able to benefit from immediate returns to children's engagement in agriculture, i.e. child labour (figure 3.6).

[Figure 3.5] & [Figure 3.6]

In order to analyse the effect of variations in agricultural income on the optimal portfolio allocation, I let first and second period agricultural income vary in the interval $Y_1 = y_2^a = [0.2; 3]$. Thereby it is possible to analyse the effects of income when the liquidity constraint is strong for low levels of Y_1 as well as when the agricultural returns make traditional education an attractive alternative to formal education for high levels of y_2^a. For households with $N = 4$, the simple liquidity constraint is binding for agricultural income levels below $Y_1 < 0.5$ in the sense that it is optimal for the household not to send all four children to school. Allowing for child labour, the household will allocate at least one child to the agricultural sector for income levels below $Y_1 < 1.1$, despite future returns to agriculture being very low.

[Figure 3.7] & [Figure 3.8]

From figure 3.7 and 3.8 it is clear, that this yields interesting empirical implications. The effect of increases in agricultural income is positive when the liquidity constraint is binding, but negative for higher levels of agricultural income, when the agricultural (here risk free) sector offers returns to traditional education which can match the returns to formal education. This generates an inverse U shaped relationship between the proportion of children in school and income. The strength of this inverse U shape is, not surprisingly, affected by the degree of risk aversion given to the utility function, but is nevertheless present both for $\rho = 1$ and $\rho = 3$.

Finally, it should be noted, that the interval of negative effect of high agricultural income on π^* increases as ε increase. That is, the turning point for the inverse U shape shifts inwards as uncertainty increases. This is obvious from figure 3.7 and 3.8 above. For $\varepsilon = 0$, the shift from formal to traditional education happens when agricultural income reaches the mean level of urban income, but as ε increases the shift happens for lower levels of agricultural income.

3.3 Empirical Implications

The differences between the model implications under the different scenarios guides the empirical analysis below. It is not possible to identify the true effect of uncertainty about future remittance on schooling, but by using the set of model implications as guidelines, it is possible to test whether the empirical findings are indicative of the existence of uncertainty in the human capital investment decision.

The main implication of the portfolio model is that uncertainty about future income transfers from children, ε has a negative effect on the optimal proportion of children educated formally, π^*. Empirically, it is virtually impossible to find an appropriate measure of the uncertainty perceived by parents, it relates both to the uncertainty about the future urban labour market for each of the migrant children, and to the uncertainty about the intergenerational contract, that is whether children, if successful in the labour market, will in fact send the expected remittances.[11] There are, however, a set of testable empirical implications of the model and its assumptions. Each of these are indirectly a test of the model. If just one of them is rejected in the data, the relevance of the model is clearly questionable when it comes to analysing the human capital investment decisions within the household.

I will distinguish between the empirical implications relating to the model assumptions and those relating to the existence of uncertainty. Although the assumptions of the model are based on previous findings and conclusions in the literature (for a detailed literature review, see Lilleør (2008)), they should also be consistent with the data at hand in order for the model implications to be of any empirical contribution.

There are three central assumptions, which have to be consistent with the data: (i) urban income levels and urban income spreads are assumed to be higher than agricultural income levels and spreads, respectively, but without stochastically dominating the agricultural income distribution; (ii) parents are assumed to rely on their children for old-age support; and (iii) it assumed that there is a sectoral divide in returns to formal and traditional education. That is, there are only returns to formal education in the urban sector and only returns to traditional education in the agricultural sector. In addition, these three assumptions generate two empirical implications, which also have to be consistent with the data: (i) there should be an inverse U relationship between the proportion of children in school and agricultural income; (ii) the probability of receiving remittances from migrant children should have a positive effect on the proportion of children in formal education. I return to the empirical tests of each of these assumptions and their model implications in section 5 below.

The uncertainty aspect of the human capital portfolio model also yields testable empirical implications: (i) the overall low enrolment rate in primary schools should to a large extend be caused by within household variation rather than between household corner solutions of zero or full enrolment; (ii) the empirical effect of the total number of children on the optimal human capital portfolio of the household can give indications of the relative strength of a portfolio effect and thus of the influence of uncertainty and risk management considerations in the human capital investment decision relative to the constraint effects; and (iii) the portfolio effect should only be found among sons, not daughters, if the qualitative findings on gender differences with respect to norms for old age support can be generalised. Testing all of these implications empirically is a test of whether the model is consistent with the findings in the data.

While the first empirical implication of the model, that the majority of intra-household schooling rates should not be at a corner, is necessary for the model to have any relevance

[11] Lassen and Lilleør (2008) analyse the effect of reduced uncertainty about remittances on schooling by using variation in civil society structures and social norms across villages, captured by a tribal fractionalisation index. Even so, the analysis captures the effect of differences in expected income transfers rather than the effect of differences in their spread and, thus, the risk.

at all, it is also a very general implication supported by many alternative hypotheses about schooling and child labour.

The most central empirical implication of the model is therefore the positive portfolio effect of N on π^*. This implication requires the portfolio effect to dominate any negative effect of liquidity constraints. It is thus not only a (somewhat restrictive) test of the portfolio model as such, but also a test of the relevance of the portfolio model compared to the general liquidity constraint explanation in the literature. This implication is central because it only holds for positive levels of ε, which, in the calibrations above, as a minimum needs to be in the neighbourhood of $\varepsilon = 1$ (which means an income spread of the same size as the average level of agricultural income), making it an indirect test of whether future income uncertainty affects the human capital investment portfolio of the household today. If it is possible to identify a positive portfolio effect of N on π^* empirically, then the model provides an unambiguous indication of sibling dependence in the need for risk diversification, and thus an indication of income uncertainty affecting the choice of human capital investment.[12] However, if the effect of N on π^* is zero or negative, the model cannot provide any unambiguous conclusions of whether the human capital investments in the household are influenced by future income uncertainty. Thus, testing the effect of N on π^* negative is not necessarily a rejection of the model, it could be due to a dominance of the liquidity constraint effects compared to the portfolio effect, or it could simply be that there is no portfolio effect.

Most of the empirical implications are straightforward and fairly constant over the different scenarios. However, two of the implications are less so. Their calibration results are therefore summarised in table 3.2. The table gives a brief overview of the model predictions with respect to the effects of fertility, N, and income, Y_1 on the optimal proportion of children in school, π^* under the three different scenarios of liquidity constraints (LC) and child labour (CL) and for different values of and correlations structures in the uncertainty measure, ε. It is clear from the table that a positive effect of N on π^* is only possible for high levels of uncertainty and it is only unambiguous when ε is uncorrelated across migrant children and there is no child labour, $e^a > 0$. In the remaining cases, the positive effect of N is only dominant for low levels of N. The relationship between π^* and N is therefore likely to be non-monotonic. In the following empirical analysis, I will therefore test for different functional forms, including a fully flexible non-parametric specification.

[12] This, of course, hinges upon the positive effect of N not being driven purely by observationally equivalent alternatives, I will return to this in section 6 below.

Table 3.2. Empirical implications

		no LC, no CL			LC,no CL			LC, CL		
		$s \lesseqgtr 0, e^a = 0.015$			$s \geq 0, e^a = 0.015$			$s \geq 0, e^a = -0.03$		
		$\varepsilon = 0$	$\varepsilon < 1$	$\varepsilon \geq 1$	$\varepsilon = 0$	$\varepsilon < 1$	$\varepsilon \geq 1$	$\varepsilon = 0$	$\varepsilon < 1$	$\varepsilon \geq 1$
$\frac{d\pi^*}{dN}$	corr ε	$= 0$	≤ 0	$\lesseqgtr 0$	$= 0$	< 0	$\lesseqgtr 0$	< 0	< 0	$\lesseqgtr 0$
	uncorr ε	$= 0$	$= 0$	> 0	$= 0$	$= 0$	$\lesseqgtr 0$	< 0	< 0	$\lesseqgtr 0$
$\frac{d\pi^*}{dY_1}$	corr ε	$= 0$	≤ 0	≤ 0	inv U	inv U	inv U	inv U	inv U	inv U
	uncorr ε	$= 0$	≤ 0	≤ 0	inv U	inv U	inv U	inv U	inv U	inv U

Note: For $\frac{d\pi^*}{dY_1}$, the total number of children is held constant at $N = 4$, corresponding to the average number of sons in a household. The negative effect of Y_1 on π^*exists for lower levels of Y_1 as ε increases.

The non-monotonic relationship between agricultural income and the proportion of children in school is an interesting point relative to the existing literature on child labour, where non-monotonicity is often used to explain weak empirical effects of household economic status on schooling enrolment or child labour. The reasons given for non-monotonicity are generally based on *local* non-linearities for certain intervals in the data. This can stem from imperfection in the land and/or labour markets (Bhalotra and Heady (2003)), from discrepancies between own judgement and children's judgement of the economic status of parents in old age and thus expectations of low future intergenerational transfers if parents are not poor 'enough' seen with the eyes of the children (Rogers and Swinnerton (2004)), from dramatic non-linearities in the neighbourhood of the poverty line because as soon as parents can afford not to let their children work, they will do so, as suggested by the 'luxury axiom' of Basu and Van (1998) and tested empirically on Vietnamese data by Edmonds (2005).

Non-monotonicity in the relation between economic status and child labour or schooling could also arise as a *global* phenomenon. Edmonds touch upon this in handbook chapter on child labour, where he notes that a positive relationship between child labour and economic status can be explained by employment opportunities, Edmonds (2007). This is exactly what the assumption of a sectoral divide in returns to formal and traditional education is about. Learning-by-doing in agriculture generates future returns in the agricultural sector, schooling generates future returns in the formal urban sector. If the urban employment opportunities are limited, and the expected returns to formal schooling therefore low or if agricultural incomes are high, the traditional educational alternative of the agricultural sector is therefore relatively more attractive. The assumption of a sectoral divide in returns to education therefore generates an empirical implication of *global* non-monotonicity. For low levels of agricultural income, the liquidity constraint is binding and the agricultural sector as such is unattractive, increasing income will therefore have a positive effect on the optimal allocation of children in formal schooling. However, if the agricultural income levels are high enough to be able to compete with urban income levels, the traditional educational alternative becomes relatively more attractive and the optimal human capital portfolio shifts more towards future agricultural employment, that is as $Y_1 = y_2^a$ get high enough, π starts falling again. This generates a negative or an inverse U relationship between agricultural income and the optimal π^*. This generates a very simple alternative explanation for a possible non-monotonic relationship between income and schooling or child labour among rural household. Such a hypothesis is easy to test in the data.

Finally, it should be noted that the interval in which there is a negative effect of Y_1 on π^* increases as uncertainty ε increases, that is the turning point for the inverse U relation between Y_1 and π^* moves inwards. This is natural consequence of risk aversion, once the variance of future urban income increases, the risk-free alternative becomes more attractive even though the expected mean is lower. This implication of the model is harder to test directly, although gender differences indicate that uncertainty should matter more for sons than for daughters and thus a direct implication would be that the turning point of the inverse U is lower for sons than for daughters.

4 Data and Setting

Both the qualitative and quantitative data used in this paper were collected in the Kagera Region. A predominantly rural area in the Northwestern part of Tanzania bordering Lake Victoria to the East, Uganda to the North and Rwanda and Burundi to the West, see map in Appendix A1. The population (about 2 million in 2002) is primarily engaged in agriculture and, to some extend, trading. The agriculture is a mixture of food and cash crop production, dominated by bananas and coffee in the North and by maize, sorghum and tobacco in the South. For more detail, see De Weerdt (2007).

The data set used for estimation in this paper is unique. The Kagera Health and Development Survey data is a long term panel based on household surveys with a time span of 13 years, the first round of surveys were originally conducted in 1991-1994, (KHDS I) and then again in 2004, (KHDS II). This time horizon is a particular advantage for studying the human capital investment decision outlined in the portfolio model, which relies on the assumption that households have completed their fertility decisions in order to get a good estimate of the completed human capital investment decision, π^*. It is when children are of school age that the schooling decisions are likely to be made, but given the sequential nature of having children, it is only possible to observe the final π^* years later. The long time horizon is therefore crucial, because it allows me to use 2004 information about the proportion of children with a primary school degree, but 1991-1994 information about household characteristics relevant when the human capital portfolio decision is actually made. In addition, the KHDS has an explicit module with detailed information on migrant children. This is unusual for household surveys, which normally only survey household members, then children living elsewhere are not included and generally not accounted for.

In 2005, Lassen and I supplemented the quantitative KHDS data with qualitative data based on focus group discussions and semi-structured interviews from 12 of the 49 KHDS villages, working with the team that collected the new round of KHDS data in 2004. The main purpose of the qualitative data collection was to get a closer to an understanding of what affects the schooling decisions made by parents and whether they are influenced by the future prospects for their children, urban migration and expected level of remittances as well as old-age dependency, inheritance rules and social norms. Issues, which to some extend can be tested for quantitatively, but where qualitative confirmation is reassuring. A typical focus group session had a duration of three and a half hours including a break and included approximately ten villagers with some knowledge of schooling, comprising all adult age groups and both men and women, selected in cooperation with the village leader (an elected local) and the village executive officer (appointed by the central government, not local). All sessions were conducted with the same facilitator and the same note taker, and reporting procedures were set up so as to ensure a uniform reporting across villages. Survey instruments and outcomes are documented in Lassen and Lilleør (2005).

4.1 Data and Sample Selection

The data from the Kagera Health and Development Survey consists of five waves. The first four waves were conducted with 6 months interval from 1991 to 1994 covering 915 households in total. All individual household members from the first four waves were attempted re-interviewed in a fifth wave in 2004, (Beegle, DeWeerdt, and Dercon (2006))[13]. This implied tracking each individual, even if they moved out of the village, region or country. The tracking in KHDS 2004 is exceptional with a re-interview rate of 91% of the surviving baseline households from KHDS 1991-94, and an overall re-interview rate of 82% of the surviving household members[14], (Beegle, DeWeerdt, and Dercon (2006)). For the selected sample of households used below, the re-interview rate among the surviving children is almost 93%. Slightly more than 8% of the children in these households die between KHDS I and KHDS II.

The sample selection is based on the following critera. Only rural households with children of the head or his/her spouse are included, and at least one of these children must be of school age in wave 1. I define primary school age to be between 7-17 years old, allowing for the widespread delayed enrolment. Households must be interviewed both in the first wave and in the fifth wave, but there are no requirements of survey participation in the three intermediate

[13] KHDS I was undertaken by the World Bank and e Muhimbili University College of Health Sciences, whereas KHDS II was funded by DANIDA and World Bank and implemented by E.D.I. (Economic Development Initiatives) in Kagera.

[14] A household is characterised as re-interviewed when at least one member of the baseline household is re-interviewed in 2004.

waves. This means that all households will have at least one child aged between 20-30 years old in 2004, who typically has a group of siblings. None of these siblings are allowed to be younger than 7 years old in 2004, this is to avoid including households which may not yet have completed their fertility and schooling decisions. The final sample is 370 households[15].

Since it is the long time horizon, rather than the dynamics of the panel as such, that are of importance for taking the model to the data, it is worth making a note on the exact use of the data. Basically, I create a pseudo cross-section, where variables relating to children and their education (i.e. measures of N and π^*) are based on 2004 information, whereas variables relating to the schooling decision, such as educational expenditures and household income (i.e. measures of e^a, e^b and Y_1) are based on averages from the pooled 1991-94 data. The five waves are thus collapsed to one, where the variable values are either an average over time of the first four waves, or 2004 values. To get the most exact measure of completed fertility and the completed human capital investment decisions, N and π^*, I include educational information on the dead and the untraced children using the latest information available in KHDS I. This way, attrition is virtually nil among children of participating households.

Finally, it should be noted that KHDS was collected as a two-stage stratified random sample, based on geography and on mortality risk within the household. Since one of the main purposes of the KHDS was to analyse the effect of fatal adult illness on remaining household members, there was a strong oversampling of 'sick' households. A 'sick' household is defined as a household where at least one adult is ill and unable to work or where there has been recent adult mortality of anyone between 15-50 years of age in the 12 months preceding the enumeration interview. A total of 16 households were sampled in each cluster, 14 of these where 'sick' households. Such a heavy stratification calls for careful consideration in any estimation analysis. However, if the stratification is based on variables exogenous to the question of interest, it can be ignored in the sense that any M-estimator will still produce consistent estimates and inference is still valid, (Deaton (1998), Wooldridge (2002)). I return to this below in section 5.4.

4.2 The Local Setting of Final Sample

By 2004, the households included in the final sample have an average of 8.2 children and 67.4 % of these have completed or are attending primary school. There are roughly the same number of sons and daughters and, on average, they are being equally educated in terms of schooling. The intra-household proportions of children with formal education is given by the total number of children who have completed primary school or are still attending primary school divided by the total number of children of the household. I include children that have died, if they were

[15] The household attrition rate is 4.7%, or 18 of the households which fulfil the sample selection criteria are not re-interviewed in 2004. These households are in general smaller, with fewer children, less land, but slightly higher expenditure levels. Household heads are younger and with less schooling than the average in the sample.

at least 7 years of age at time of death. They are included both in the fertility measure and the portfolio measure using the latest schooling information available.

Households in Kagera have many children. 5% of the sample have more than 16 children, and typically their fathers have more than one wife. I drop any household with more than 25 children to avoid that these households are driving the empirical results. This reduces the sample by 1.5% to 365 households.

In the early 1990s, the sample households had average daily expenditure levels per adult equivalent of 0.37 USD, well below the global poverty line of 1 USD/day. An alternative measure of how tightly the liquidity constraint may be binding, is the food share out of total household expenditure, which on average was 66%. The households owned slightly more than 2 hectares of land, and almost a quarter of them had a small herd of cattle, sheep, goats or pigs. Income source diversification is not just a matter for future risk management, but also happened to a large extent at present in early 1990s. The questionaire allows for six different sources of income: agricultural income, wage income, self-employment business income, rental income, transfers and other non-labour income. More than 90% of the households had at least three sources of income. All households had agricultural income and most households also have rental income and income from transfers, typically remittances. 20% of the households have income from non-agricultural self-employment and 40% from wage employment.

Household heads were on average 50 years old and slightly more than a third of them had a primary school degree. During a period of 12 months, 30% of the migrant children of the village had sent remittances, and around 20% of migrant children have succeeded in finding wage employment. The Kagera region is predominantly inhabited by Haya people. The tribal fractionalisation index is therefore also relatively low with a value of 0.2. Households lived in villages with almost 4000 inhabitants on average, and where the average distance to the local primary school was less than 2 km. The annual school fee was 40 cents, but school uniforms were considerably more expensive and averaged more than 4 USD. Class sizes were 50 students and generally there were 3-4 students per text book. Almost 70% of the teachers had either a grade A or grade B degree. These latter variables will be used as school quality controls in the regression analyses below.

[Table 4.1]

5 Empirical Estimates

Before continuing to the empirical analysis and tests of model implications, the validity of model assumptions are reviewed in section 5.1. The choice of the econometric model is discussed in section 5.2 and the empirical analysis of model implications is in section 5.3. In section 5.4, robustness checks of the model are carried out.

5.1 Testing model assumptions

The first assumption, that urban income levels are higher than agricultural income levels in expectation, and likewise for the spreads, is easily confirmed by looking at the means and standard deviations for household expenditure levels in rural and urban areas. As it is most commonly done, I use expenditure measures as proxies for lifetime income levels, as they are subject to less fluctuations and probably also smaller measurement errors.[16] The KHDS expenditure measure includes an estimate of the consumption of home-produced goods, which is an important component of any agricultural household food consumption. A simple one-sided t-test, where the alternative is that urban expenditure levels are higher than the corresponding rural levels, easily rejects the null of equality at 1% level. Likewise for the difference in standard deviations. The first assumption of $y_2^b < y_2^a$ and $\varepsilon^b > \varepsilon^a$ thus cannot be rejected in the data. Again, this is not to say that the uncertainty associated with agricultural income is negligible. There is lots of uncertainty associated with agricultural production. However, income shocks may be more temporary than in the urban sector, reducing the overall spread in agricultural income compared to urban income. The important, but untested, assumption is that the uncertainties associated with each of the two sectors are uncorrelated.

The second assumption that parents rely on their children for old-age support, is an assumption based on the findings of the fertility literature[17]. This is supported by the qualitative findings described above. Children are always mentioned as the first and most important source of old-age support, followed by fellow clan-members and villagers if the elderly owns assets to leave as inheritance in return for the assistance. A quick look at the KHDS I data, confirms the heavy dependence on children in old-age. Out of the roughly 200 individuals in KHDS I, who are 70 years of age or older, at least 60% live with their children and at least 92% either live with their children or have at some point during the 18 months interval of the survey received remittances directly from their children or from the households of their children. Combined with the findings of the qualitative data, this is a good indicator that also children in Kagera, as it has been found elsewhere, are important sources of old-age security for their parents. The model assumption is thus consistent with both qualitative and quantitative findings in the data.

The third assumption of a sectoral divide in the returns to formal and traditional education may at first glance seem controversial. However, here it is important to keep the local setting in mind. With an agricultural production system based on traditional methods and indigenous knowledge about the local agricultural cycle, the transfer of farm specific human

[16] Deaton (1998) notes that 'survey-based estimates of income are often substantially less than the survey-based estimates of consumption'(p.30), suggesting a strong underestimation of savings. Furthermore, 'for the large number of households that are involved in agriculture or in family business, personal and business incoming and outgoings are likely to be confused.' This complicates the measure of income even further.

[17] See Lilleør (2008) for a review of the fertility literature and the role of intergenerational transfers.

capital from parents to children is important. In particularly so, as long as more complex modern agricultural technologies are unavailable or beyond the financial reach of a subsistence farmer. The literature on agricultural production and returns to specific versus general human capital shows this distinction very clearly. A key contribution in this area is Rosenzweig (1995). He argues that when the agricultural production technology is simple, schooling does not increase productivity. Returns to formal education are only positive, when new advanced technologies are introduced, creating an environment for productive learning opportunities, (Rosenzweig and Wolpin (1985) and Rosenzweig (1996))[18]. Fafchamps and Quisumbing (1999) and Jolliffe (2004) confirm the findings by Rosenzweig of low or no returns when agricultural technologies are simple. They use data from rural Pakistan and rural Ghana, respectively, and show, that on-farm returns to education are low, while off-farm returns to schooling can be quite high. It should be noted that although the notion of no return to formal schooling in traditional agriculture and no returns to traditional agricultural education through learning-by-doing in the formal urban sector is not common in the child labour literature, it is also not new. Fafchamps and Wahba (2006) operate with a similar set-up and find strong indications of returns to learning-by-doing of, what they term, 'subsistence work' in the agricultural sector.

Taking a very crude look at the KHDS I data, there are some indications that also in Kagera there exists a sectoral divide in the returns to traditional and formal education. Figure 5.1 shows a non-parametric polynomial fit between average years of formal education among adult male household members and agricultural and non-agricultural income[19], respectively. Income measures are in logarithmic terms and per adult equivalent per day. There is a strong positive correlation between years of formal education and non-agricultural income levels, and virtually no correlation between years of formal education and agricultural income levels.

[Figure 5.1: adult males schooling and income]

When slicing the data slightly different and comparing the level of formal education among adult males in the bottom and top deciles of the agricultural and non-agricultural income distributions, respectively, the same finding emerges. There is no significant difference in the level of education among the 'best' and the 'worst' farming households measure in terms of agricultural income, both have an average of 5 years of formal education among adult males. There is, however, a significant difference of 2.3 years of formal education among the top and the bottom decile of the non-agricultural income distribution, where the bottom decile hosts males with an average of 4.5 years of formal education, compared to an average of 6.8 years of

[18] An example of this is the introduction of high-yielding variety seeds under the Green Revolution in India, where Foster and Rosenzweig (1996) find increasing returns to primary education during periods of technical progress, but low or no returns otherwise.

[19] Non-agricultural income is here the sum of wage income and business income from non-agricultural self-employment.

education in the top decile of the non-agricultural income distribution. Looking at the crude and partial correlation coefficients in data and testing for their significance level similar findings emerge, see table 5.1

Table 5.1. Correlation coefficient between years of formal education and income levels.

av. years of formal education		Agri.income	Non-agri. income
...among adult males in HH	no controls	0.01	0.25***
	w/ controls	0.00	0.10***
...among adult females in HH	no controls	0.04**	0.30***
	w/ controls	0.02*	0.10***

Note: *10%, **5%, ***1% significance levels. Income measure are in logarithmic term, per adult equivalent per day. Partial correlation coefficients are from pooled OLS regression of income on years of adult female and male schooling, as well as a number of controls, such as HH size, number of adult males and females, land, cattle, BMI, age, weight, and tribal affiliation.

Although the above findings are based on simple correlations in the data without any controls for selection issues or labour supply, they are consistent with the assumption of a sectoral divide in returns to schooling. There is an overall indication of positive correlation between more years of schooling and higher non-agricultural income levels, but much less so for agricultural income. These quantitative findings are confirmed by the qualitative ones, where, in particular, elderly respondents emphasised the lack of agricultural skills among primary and secondary school graduates. At a question of whether someone with an education is always better off than someone without, it was reported that "one old man opposed saying the one with primary education wastes their time at school instead of learning real life at home 'When they return to learning how to farm their fellows who did not go to school are far ahead'", (Cluster 2). In another cluster, when asked whether primary school is a risky investment, it was noted that "In case a child returns to weeding a farm it is a loss, then it is a risk investment", (Cluster 13), implying that students of primary schools only know enough about farming to be able to weed. Although the latter comment would imply negative returns to schooling in agriculture, the model only assumes no returns to formal education in agriculture, which seems to be consistent with the data.

5.2 Choice of econometric model

The optimal portfolio allocation of children between formal and traditional education, π^* is by construction a variable censored at 0 and at 1. I have therefore chosen to estimate the reduced form for π of the portfolio model using a two-sided censored Tobit regression. For each individual household i the optimal portfolio choice can then be described as

$$\pi_i^* = \beta' \mathbf{x}_i + u_i$$

where π_i^* is the latent variable. Although it might be optimal, in terms of the model, for the parents sometimes to choose values outside this range, it is not feasible. $\mathbf{x}_i$ contains each of the observable model variables, N, Y_1, e^b, p as well as a set of controls for household and village characteristics, and u_i is a normally distributed homoskedastic error term, $u_i \sim N(0, \sigma^2)$. . Given the censoring of π_i^*, I observe the following in the data

$$\begin{aligned} \pi_i &= 0, \ \text{ if } \pi_i^* \leq 0 \\ \pi_i &= \pi_i^*, \ \text{ if } 0 < \pi_i^* < 1 \\ \pi_i &= 1, \quad \text{if } \pi_i^* \geq 1 \end{aligned}$$

The double-sided Tobit log-likelihood function for each household is given then

$$\ln L_i = \sum_{\pi_i = 0} \ln \Phi \left[\frac{0 - \beta' \mathbf{x}_i}{\sigma} \right] + \sum_{0 < \pi_i < 1} \frac{1}{\sigma} \phi \left[\frac{\pi_i - \beta' \mathbf{x}_i}{\sigma} \right] + \sum_{\pi_i = 1} \ln \left(1 - \Phi \left[\frac{1 - \beta' \mathbf{x}_i}{\sigma} \right] \right)$$

The model is estimated using robust standard errors allowing for correlation within villages. However, consistent estimates of the β-coefficients in the Tobit model are subject to a set of assumptions. π^* should have characteristics of a random normal variable, which means that (i) the uncensored π^* must be a continuous variable, and (ii) the error term u_i must be both normally distributed and homoskedastic. Unfortunately, if these assumptions are not fulfilled, the coefficient estimates may be inconsistent.

Given the somewhat discrete nature of π, an obvious alternative to the Tobit model is a binomial count model. The dependent variable is then no longer the proportion of formally educated children, but rather the number of formally educated children, $N^b = \pi N$ out of the total number of children in the household, N. N^b is assumed to be binomially distributed and should be thought of as a sum of independent and homogenous Bernoulli-trials up until N. It is possible to relax the, in this setting, very restrictive assumptions of homogeneity and independence among siblings, by estimating the model using quasi-maximum likelihood. In section 5.4 , I will return to these robustness checks of the preferred reduced form specification.

5.3 Testing model implications

There are two groups of model implications, those relating to model assumptions and the standard human capital investment aspect without uncertainty, and those relating to uncertainty about returns and thus the human capital portfolio aspect. All implications are important for the model conclusions, but only by testing the implications relating to the latter group will it be possible to say anything about the importance of the portfolio effect relative to the constraint effect.

5.3.1 Model implications irrespective of uncertainty

There are three implictaions relating to the model and its assumptions, but which are not in any way a consequence of uncertainty about future returns. First, if formal education is indeed more profitable than traditional education, the model predicts a positive effect of parental income on π for households where the liquidity constraint is binding in the human capital investment decision. Second, if parents base their expectations about second period remittances from migrant children (p) on the current proportion of remitting migrant children in the village, this proportion should have a positive influence on the optimal choice of π^*. This is suggested by the qualitative findings, where 'jealousy' was a motivational factor for educating children in the sense that if parents perceive that other educated children from the village are doing well and remitting home, this will increase the current demand for schooling in the village. Parents want their own children to do as well as other children. This implication, however, also hinges upon the assumption of a sectoral divide in the returns to formal and traditional education. If remitting children were mostly traditionally educated, the effect should be negative. Third, a more direct implication of the sectoral divide in returns to formal and traditional education is the global non-monotonicity between agricultural income and the optimal portfolio allocation of children to formal education. That is, there should be a negative effect of high agricultural income levels on π, due to the relative shift in profitability between traditional and formal education. These three implications are tested in the reduced form of the Tobit π-regresssions in table 5.2.

[Table 5.2]

Model (1) in table 5.2 is the most basic reduced form regression for π. It includes measures of or proxies for the available key model variables, N, Y_1, e^b, and p, as well as a controls for household characteristica (age and education of household head, proportion of daughters, and household size excluding the number of children), and controls for school quality (number of students per math book and per Kiswahili book, proportion of teachers with grade A and grade B diploma, and class size).

Looking at the first column for all children, there is a positive and highly significant portfolio effect of the number of children, N on π and a positive effect of household expenditure (which is a proxy for Y_1), indicating the existence of a liquidity constraint. However, when splitting the sample by sons and daughters, the liquidity constraint only seems to bind for daughters, whereas the portfolio effect is clearly only dominant among the sons, as the qualitative findings suggest it should be if the portfolio model is valid. This seems to be a strong result in favour of the portfolio model above, which I will analyse in more detail in section 5.3 below.

The comparison of model (1) and model (2) is included for one reason. In model (1), there is a positive and significant effect of the village proportion of migrant children remitting to their parents, which is clearly driven by the sons as it should be according to the model predictions. However, this effect disappears completely when controls for the tribal composition and the fractionalisation index within the village are included. This should come as no surprise. These tribal controls are strongly significant and, as Lassen and I discuss in Lassen and Lilleør (2008), highly correlated with the probability of children remitting home. We find indications that the reason for this is a positive correlation between tribal homogeneity and the strength of social norms, and thus family control, within the village. Schooling expenditure is measured both in terms of average school distance within the village, school fees and uniform costs. There is a negative effect of the school distance, which is strong for sons in model (2). Despite the school quality controls not being jointly significant, they are still included because they are closely correlated with the school fee. Even so, the school fee still has a positive effect on the proportion of daughters in school.[20]

The positive effects of the proxies for both Y_1 and p, together with the findings of figure 5.1 and table 5.1 above, give some indications of the possible existence of a sectoral divide in the returns to schooling. The most direct implication is, however, the predicted inverse U relationship between π and Y_1, see model (3). When including the quadratic term of household expenditure, both the linear and the quadratic terms are strongly significant with the expected opposite signs. The negative effect of high agricultural income on π starts at the turning point of the inverse U, which for sons is at $Y_1 = 0.99$ USD in model (3) and in model (4), the latter includes wealth controls. This is in the neighbourhood of the 98th percentile of the expenditure distribution for rural households, and thus within sample range. For daughters the turning point is at $Y_1 = 1.13$ in model (3) and at $Y_1 = 1.17$ in model (4). The latter turning point is almost outside the range of the expenditure distribution, only two households have expenditure levels higher than 1.17 USD per adult equivalent per day. This can be an indication of girls being more subject to liquidity constraints than boys, and/or of uncertainty being more important in the optimal schooling decision for boys than for girls, as suggested by the portfolio model.

As a robustness check, model (3) is re-estimated without the top 5% of the expenditure distribution to ensure that the inverse U shape is not purely driven by one or two outliers, and the results are even stronger and more significant. The turning points move inward to the 70th and 88th percentile of the expenditure distribution for sons and daughters, respectively. In a similar spirit, I have used the quadratic of log expenditure. The qualitative results are the

[20] A similar positive effect for all children and for sons disappears after inclusion of school quality controls.

same, although the significance levels are somewhat lower. Overall, it seems safe to conclude that the inverse U shape between Y_1 and π predicted by the assumption of a sectoral divide in formal and traditional education is consistent with the data.

Finally, it should be mentioned, that the results are robust to several different model specifications. Controls for land, livestock, the use of agricultural inputs such as fertilizer and irrigation, the existence of road for motorised vehicles in the village, population size of village and whether or not the village has a daily market have all been included without affecting the remaining model coefficients significantly, see model (4).

5.3.2 Model implications of uncertainty

There are three empirical implications of the model which all are direct implications of the existence of uncertainty about future return to human capital. The key empirical implication is the possible dominance of a positive portfolio effect over a negative constraint effect of higher N on π. The null hypothesis is that the portfolio effect exists and is strong enough to generate a positive effect of the total number of children on the optimal proportion of children in school. Despite only being an indirect test of uncertainty, it is a clear unambiguous empirical implication of the model. A positive effect of N on π can only be due to the existence of uncertainty and thus a need to ensure future income diversification in the human capital portfolio allocation. It was already clear from table 5.2 that the positive portfolio effect does indeed dominate the negative resource constraint effect for sons, but not for daughters, as suggested by the qualitative results. Since this is the most central result of the model implications and the empirical analysis, let me go into its details.

The calibration results show that in case of liquidity constraints or perfectly correlated uncertainty measures, the positive effect will only dominate for low numbers of N because either the liquidity constraint starts to bind for higher numbers of N and/or the $N\varepsilon$ spread becomes too large when migrant children are perfectly correlated. This suggests allowing for a quadratic term in N and thereby being able to capture a possible negative effect for high N on π. Table 5.3 shows the linear and quadratic N models for sons, model (4) and model (5) respectively, as well as the quadratic N model for daughters, model (6).

[Table 5.3]

The quadratic N terms in model (5) are both highly significant and with the expected signs. The negative constraint or correlation effect only starts to dominate the positive portfolio effect of the total number of sons on their optimal proportion in school, π when there are more than ten sons in the household. Almost 97% of households have ten sons or less. To ensure that this is not solely driven by the choice of functional form, I have tested the quadratic specification in N against a fully flexible non-parameteric specification using indicator variables for $N = 2$

up to $N = 12$. A likelihood ratio test cannot reject that the quadratic specification is nested within the flexible non-parametric specification. This strong positive effect of the total number of sons is surprisingly close to the scenario of no liquidity constraint and no correlation in the uncertainty measure for migrant children illustrated in the calibration figure 3.2 above. Figure 5.2 below shows the raw mean of π for each N (the unconnected dots), a non-parametric fit of π on N using a Kernel weighted local mean smoothing function and its 95% confidence interval (dark blue line and shaded area), and the predicted value of π^* from model (5) are all shown in figure 5.2. below. The inverse U shape in the relation between total number of sons and the proportion of them being formally educated is clear, and the predicted value for π^* from the quadratic N model (5) fits comfortably within the confidence interval of the nonparametric fit of π on N.

[Figure 5.2]

However, the estimation of a quadratic relationship between N and π for the sons in model (5) comes at a cost. The inverse U effects from the quadratic expenditure specification disappear when the level of agricultural income is proxied by household expenditure. This is despite the fact that these two inverse U relationships are caused by opposite effects. The negative effect of a high number of sons is due to liquidity constraints, whereas the negative effect of high levels of expenditure is the opposite, the agricultural sector is now more attractive. If instead I use the non-food share of household expenditure as a proxy for disposable income in the household both quadratic terms survive, although they are now weaker for daughters. The negative effect of high disposable income among starts dominating around the 80th percentile for sons, see model (9).

While the positive portfolio effect of number sons should exist, but not necessarily dominate, for everyone, the negative effect of the quadratic term for number of sons should only exist for households which are liquidity constrained or where the urban income uncertainty is highly correlated among migrant children. Ignoring the latter, and thus assuming that the negative part is only driven by liquidity constraints, this would imply that among households, which are unlikely to be liquidity constrained, the positive effect should dominate the negative effect over the full range of N. That is, there should be no negative quadratic effect for this subset of households. This can be tested by comparing those households who are less likely to be liquidity constrained with the rest. Assuming that the liquidity constraint does not bind for the top quartile of the expenditure distribution, I define this group to be a HiEXP group. Model (7) corresponds to model (5), but now allowing for interaction terms between the functional form for number of sons $(N + N^2)$ and an indicator variable for whether the household belonged to the HiEXP group in KHDS I. Now both the quadratic terms for number of sons and the household expenditure are strengthened and significant with the expected signs. But, the HiEXP interaction terms are all insignificant, including the quadratic interaction. Unfortunately this does not tell us much, the insignificance can easily be due to sample size problems or it can be because there simply is no significant difference between the two groups. There are 85 households in the top quartile of the expenditure distribution. Taking a graphical look at the data, there is some indication, that sample size might cause the insignificance. Figure 5.3 corresponds to figure 5.2, but now the the predicted values for π^* are predicted for each of the two subgroups, HiEXp = 0 and HiEXP=1.

[Figure 5.3]

The negative liquidity constraint effect clearly dominates the positive portfolio effect for lower N among the lower 75% of the expenditure distribution compared to the top quartile. The inverse U relationship is virtually absent from the HiEXP group, as the portfolio model would predict. Estimating model (5) without the top quartile of the expenditure distribution predicts a turning point of the quadratic N relationship at eight sons, the liquidity constraint starts binding earlier than in the full model (5), where the turning point was ten sons. Similarly, the turning point for the quadratic Y_1 relationship is also lower (now 0.31 USD), corresponding to the median household. This could be an indication of households in the bottom three quartiles facing higher levels of uncertainty about future income transfers than the richer households of the top quartile, see model (8).

Second, for the model to be of any relevance it is necessary that the overall school enrolment rate is primarily driven by less than full enrolment within households, rather than being a result of averaging over corner solution between households. This is clearly the case. More than 70 per cent of the households have uncensored enrolment rates between 0 and 1, almost 20 per cent of the households are censored at $\pi = 1$ and the remaining are censored at $\pi = 0$. For sons and daughters, separately, the numbers are slightly higher with approximately 50 per cent of the households being uncensored. This is no surprise as the number of forced corner solutions is higher due to more observations with only one son or one daughter in the household. There is no significant difference between the censored and uncensored household enrolment rates, all are close to 0.65.

Table 5.4 Household primary school enrolment rates

	Mean π	# HHs	% HHs
Uncensored HHs	0.64	278	72.58
Censored HHs	0.67	105	27.42
All HHs	0.65	383	100.00

The final testable empirical implication of the portfolio model is the gender difference. The model should only apply to sons. If the relations above were all spurious, one should expect no difference between sons and daughters. The data tells a different story. Throughout results have been different by gender in the expected direction. Model (6), which is the quadratic N model for daughters only, confirms this once again. The model is estimated to ensure that the insignificance of the linear term of N was not due to misspecification of the functional form. Including a quadratic term does not alter the conclusion, there is no effect of the total number of daughters on the proportion of daughters which have received formal education. Not only are the coefficients insignificatnt, they are also jointly significantly different from those of sons at a 1% significance level. There has been a significantly negative effect of the proportion of daughter in the household throughout. This could be capturing some of the effect of the *number* daughters. Leaving out the variable controlling for the *proportion* of daughters in the household, the effect the *number* of daughters is negative and only significant at a 20% level. The combination of the lack of a positive portfolio effect of *number* of daughters on their optimal proportion in school and the strong dominance of the positive effect of household expenditure indicates that the human capital investment decision of the girls is largely influenced by resource constraints within the household, but not by the need for risk diversification. Although daughters are perceived as more loving as suggested by the ethnographic evidence, this perception is probably influenced by the fact that they are not expected to remit. This goes hand in hand with the quantitative finding in the data, that daughters are found to be more likely to remit, but their level of remittances is substantially below that their brothers. In the ethnographic evidence, it was often mentioned that daughetrs would remit in terms of gifts to their mothers (bars of soap, a dress), whereas sons remit cash to fathers.

Overall, it seems safe to conclude that the model implications and assumptions are consistent with the data. There are strong indications of positive portfolio effects for lower numbers of sons, although negative constraint effects seem to dominate for larger numbers of sons. There are also some, although not as strong, indications of the sectoral divide in returns to formal versus traditional education actually keeping children out of school if parents are doing relatively well in the agricultural sector. The negative effect of higher levels of expenditure tend to come into effect sooner for sons than for daughters, which is in line with the portfolio model suggesting that the more the optimal portfolio allocation π^* is affected by uncertainty, the sooner the negative effect of higher agricultural incomes will start dominating. Since the optimal portfolio allocation of sons is sensitive to uncertainty, whereas that of daughters is not, such a result is exacly what should be expected. The gender differences thus come into play at different levels.

5.4 Robustness Checks

The empirical specification, which most closely resembles the portfolio model, is the quadratic N and Y_1 model (5) in table 5.3 for sons. To have a rough idea of how well the econometric model does in terms of fitting the data, please refer to figure 5.4 below. It shows the actual π for sons and the associated predicted probabilities.

[Figure 5.4]

As mentioned above in section 5.1, the Tobit estimates are only consistent when the assumptions of normality and homoskedasticity of the error term u are fulfilled. In the following, I will look into these assumptions as well as check the robustness of the key results of model (5) by using alternative estimation methods. Table 5.5 below includes model (5) for comparison and a number of alternative econometric models.

The first alternative is a Tobit model estimation allowing for a specific functional form of heteroskedasticity, $Var(u|\mathbf{x}) = \sigma^2 \exp(\mathbf{z}\delta)$, where $\mathbf{z}$ is a subset of the explanatory $\mathbf{x}$ variables, model (10). In this specification $\mathbf{z}$ includes the total number of sons and log expenditure. More general formulations have also been tested, where household size, total number of children, proportion of daughters, school distance and the tribal fractionalisation index have been included, but these variables are all insignificant in the heteroskedaticity estimation. A Hausman test for equality of coefficients of the two Tobit models, where the model (5) is efficient and consistent under the null, and model (10) is consistent under both the null and the alternative hypothesis, is rejected. So is a likelihood ratio test of model (5) being nested in model (10). Even though there is indication of heteroskedasticity and a considerable drop in significance levels in model (10) compared to model (5), the main finding of a positive portfolio effect among the sons seems to be hold. However, as Deaton (1998) point out, it is somewhat arbitrary what to use as explanatory variables in the heteroskedasticity function and what to use in the regression function. This can result in situations where the coefficients in the heteroskedasticity function are estimated consistently, but those of the regression function are not. This method should therefore be used with caution. A comparison of model (10a) and model (10b) also show that including a different set of regressors in the heteroskedasticity function change the coefficient estimates.

The second assumption of the Tobit model is normality of the error terms. A possible way of testing the appropriateness of the Tobit model is thus to compare its estimates with estimates from models, which do not assume normality. In the censored setting, Powell's censored Least

Absolute Deviation estimator, which is based on an assumption of the conditional median $Med(u|\mathbf{x}) = 0$, rather than the conditional mean $E(u|\mathbf{x}) = 0$, is a typical choice. This estimator is consistent both for non-normal and heteroskedastic error terms. However, it only allows for one-sided censoring. The model is not very well estimated for two reasons, only being able to allow one-sided censoring I choose to enforce the upper censoring which has most data points. Second, in order to achieve convergence, the tribal controls have to be left out. Regression results are shown in the column of model (11), purely as a robustness check of the Tobit model. The coefficient estimates and their bootstrapped standard errors are generally all of the same magnitude.

Both the Tobit model and the Powells median estimator requires a continuous dependent variable. Although households in Kagera have many children, the continuity of π can be debated. An alternative robustness check is therefore to estimate the same model, but now as a binomial count model as mentioned above in section 5.1. The results of such an estimation are shown as model (12), standard errors are robust and cluster corrected. The signs and significance levels indicate that results are clearly in line with the above findings. Finally, a standard linear probability model has been estimated using ordinary least squared, again with robust and cluster corrected standard errors, see model (13). The OLS estimates should be scaled with the proportion of uncensored variables in the sample for better comparison with the Tobit estimates of model (5), as suggested by Greene (1981)[21]. For the sons, 50% of households have uncensored values of π which implies multiplying the OLS coefficients with 2. Again, both magnitudes and significance levels are comparable to those of the Tobit model. Thus, despite possible problems of non-normality and heteroskedasticity, it seems safe to conclude that the results are robust to the choice of econometric model.

[Table 5.5]

Another robustness check has to be done with respect to the heavy stratification in the data sampling between 'sick' and 'well' households. In the empirical analysis above, the sample stratification is assumed exogenous to the human capital investment decision. There are different reasons to think that this is not the case. The data collection was done with a focus on oversampling of possible HIV infected household. Investment decisions for better old-age security are likely to be altered if life expectancy either of the parents or of the children changes dramatically. This would then also influence the optimal human capital portfolio allocation within the household. Estevan and Baland (2007) argue that high mortality rates among adult children can generate enough uncertainty for parents to alter their human capital investment

[21] Wooldridge (2002) has a similar suggestion for checking the appropriateness of a Tobit by comparing the scaled Tobit coefficient estimates with those of a probit. The Tobit estimates should be scaled with estimated σ, (Wooldridge (2002):p.534). Such an eyeball comparison yields similar results; magnitudes, signs and significance levels are reasonably close.

decision, but they do not test this hypothesis in the data. There is in general only sparse empirical evidence on this issue. Using KHDS I data, Burke and Beegle (2004) find no effect of the death of parent on the total number of hours in school for boys or girls. Although, using KHDS I & II, Beegle, DeWeerdt, and Dercon (2005) find some indication of a negative impact on the long run level of educational attainment of orphans, but primarily so for children not already enrolled at the time of death of the parent. In my final sample of 365 households, only 40 households are classified as 'well'. Only very crude test of difference between the two groups have therefore been done. Simple t-test of differences in π, N, or Y_1 for all children, sons only and daughters only cannot show any significant difference between the two groups. Including a 'well' indicator variable and interaction terms with N and Y_1 in π-regressions for model (4) and (6) show no significant difference between the two groups. Due to the heavy oversampling of 'sick' households, the empirical results of this paper may therefore represent a lower bound in terms of schooling.

Finally, it should be mentioned that results are robust to sample selection. Inclusion of households with more than 25 children or with children under the age of 7 in 2004 only strengthens the results further, so does truncating the total number of sons and daughters, respectively, at 12.

6 Alternative Explanations

The positive quadratic portfolio effect for sons is the key result of the empirical findings providing support for the hypothesis that future income uncertainty generates a need for human capital diversification. Hence, an obvious question is what else could result in a positive effect of the number of sons on their intra-household schooling rate?

There are three possible explanations, which can all yield a positive effect of N on π. First, rural households could choose, for which ever reason, always to keep one son at home, who is destined for taking over the family farm once adult. Such a hypothesis has very accurate predictions for the value of π^* for each N, see figure 5.5 below. It is clear from this figure, that the hypothesis has some value compared to the non-parametric fit and its confidence interval. However, the one-son-behind hypothesis seems to underpredict for small N and, more importantly, overpredict when there are many sons in the household. The one-son-behind hypothesis is not able to capture the negative quadratic effect of large N on π. A raw F-test from a simple Tobit model of π regressed only on indicator variables for the number of sons in the household rejects that the estimated coefficients equal $(N-1)/N$. Likewise, if the positive effect of N on π in model (4) is purely driven by the one-son-hypothesis, there should be no statistically significant difference between the connected gray dots and the yellow ones in figure 5.5 over N. This can be tested by deducting $\widetilde{\pi} = (N-1)/N$ from the actual π and then testing for any remaining explanatory power of N in a $\pi - \widetilde{\pi}$ tobit regression, where the censoring limits now are (-1 + $1/N$) and ($1/N$), for the lower and upper limit respectively. Likelihood ratio tests against both the quadratic and the non-parametric functional form of N both reject the one-son-behind hypothesis, indicating that it is indeed not able to capture the non-monotonicity in the data.

[Figure 5.5]

The second alternative explanation is closely related. If there are diminishing returns in agriculture it might not be feasible to have more than one son taking over the family farm, it would therefore require additional land for any other son also being educated traditionally. The one-son-behind hypothesis is thus comparable to an explanation of strong diminishing returns to labour in agriculture, in the sense that the family farm cannot feed more than the family of one son. However, an explanation based on strong diminishing returns have to be coupled with local land scarcity, making it difficult or very expensive to acquire new land for the second or third son destined for agriculture. The KHDS data contain a community level variable of whether people in the village buy or sell land, however the measure changes dramatically over the first four waves, despite the very short time span. In the first wave, it is stated that only in 53% of the villages land is bought and sold, in wave 4 the number is almost 80%. Using the variable as an indirect measure of land scarcity[22] has no significant direct effect on π in model (4), nor does it affect the positive effect of N when introduced as an interaction term. However, the instrument might be weak given the large variation over time. A more appropriate measure of land scarcity is needed, in order to test the effect of land scarcity on π and on the $\pi - N$ relation properly. Furthermore, with strong diminishing returns π will never start dropping again for high levels of N. This explanation can therefore not capture the quadratic relationship between π and N found in the data. The qualitative data also give some hints on this matter. The issue of schooling versus the right to a plot of land was clearly an issue much debated during the focus group discussions. It was noted repeatedly that children have rights to one of the two, sometimes both. It was thus not uncommon for parents to acquire land, sometimes with the assistance of the local village council, for future inheritance to their sons, or for parents to split family plots between sons, if the size would make such a split feasible. Village councils would indeed allocate new land plots upon reasonable requests. However, in the more ancient villages[23] land tends to be more scarce and the local village councils have no or less free land to allocate. Although diminishing returns most likely are present and influence the schooling decision of the parents, it does not seem to be enough to explain what we are seeing.

[22] If villagers never buy or sell land, it can imply that all land is inherited and therefore difficult to come by through other channels.

[23] That is villages, which existed prior to the Ujamaa villagization programme of President Nyerere in the late 1960s. The programme forced all rural households into (often new) villages with access to water and schools.

Despite the fact that none of the above alternative explanations can be verified by the data, they might still have some credit. However, for the one-son-behind hypothesis to be a useful alternative explanation, the question still remains what the economic rationale behind it is. One can easily imagine the rationale being precisely what this paper is about, risk diversification. It should be emphasised though, that while both of the two alternative explanations can give plausible reasons for the positive effect of N on π, they are not able also to explain the negative quadratic effect of N on π^*, which is embedded in the portfolio model.

Finally, one might wonder whether child heterogeneity or non-constant returns to scale with respect to number of children and their education could generate a positive relationship between N and π. The model assumes both child homogeneity and constant returns to the number of children being educated. I am thus disregarding the classic Becker argument of a trade-off between quantity and quality of children. If such a trade-off exists, say because parents have to spread their efforts over more children, it should result in decreasing returns to the number of children being educated, and therefore predict a negative relationship between N and π. The question is then whether increasing returns to the number of children being educated is a plausible explanation. This should result in the youngest of many brothers on average doing better in the urban sector compared to the youngest of few brothers, everything else equal. There are no indications of this in the data, a simple test of whether the youngest out of maximum 4 sons compared to the youngest out of minimum 6 sons is less likely to be in wage employment is rejected. There is no significant difference what so ever.

The question then is whether unobserved heterogeneity with respect to ability can generate the inverse U relations between π^* and N. If all households sample from the same schooling ability distribution, then child heterogenity cannot generate a positive relationship between π and N. Only if households with more children sample from schooling ability distributions with considerably higher means than households with fewer children, could child heterogeneity generate such a positive relationship between π and N. This would require modelling N as endogenous such that households drawing high ability children among the first borns realise that they are drawing from a good ability distribution and therefore decide to have more children, whereas households drawing from bad ability distributions stop their fertility earlier. First born migrant sons should therefore be more successful in the urban labour market due to higher ability if they are from a large family rather than a small family. Again, there are no indications of this being the case in the data. Furthermore, this cannot explain the gender difference. It is hard to imagine that draws from the ability distribution should depend on gender.

7 Conclusions & Policy Implications

In this paper, the emphasis has been on modelling the household human capital investment decision jointly for all children and thereby allowing for sibling dependence, which goes beyond the much debated sibling rivalry for scarce resources. A simple human capital portfolio model is set up to analyse the effect of future income uncertainty on the optimal allocation of children between formal and traditional education, that is between future urban and agricultural income. Not surprisingly, it is easy to show analytically that as uncertainty about future income increases, risk averse parents will tend to diversify their human capital investments in children in order to diversify future income sources. This is a standard example of an ex-ante risk management strategy, only in this paper applied to a different setting, the educational choice of the children. It is not possible to get a credible measure of future uncertainty in data, and therefore not possible to identify such an effect directly. However, by calibrating the model under different scenarios using data driven numerical values, I am able to derive very specific model predictions for how sibling dependence due to portfolio effects can be separated from resource constraint effects in the empirical analysis.

Empirically, there are two findings, which provide strong support to the portfolio model. First of all, I find that positive portfolio effects are remarkably strong for sons and clearly dominate possible negative constraint effects as long as the number of sons is not too high. In households with many sons, the negative constraint effects seem to dominate. This generates a quadratic relationship between the number of sons in the household and the proportion of them being educated formally. Second, there is no such finding for daughters. The anecdotal evidence from the qualitative data on norms and expectations with respect to children's role as old-age security providers for their parents clearly supports the finding of a gender difference in the portfolio model. Norms dictate that parents can only ask for support from their sons (and, if any, their unmarried daughters) in old age. The obligations of married daughters lie solely with their families in law. There are, to the best of my knowledge, no other hypotheses or models, which are able to explain such relationships.

In addition, all model assumptions and their implications are consistent with data. This includes the key assumption of a sectoral divide in returns to education, the implication of which is an inverse U relationship between agricultural income levels and the proportion of children being educated formally. In standard models of child labour, which rely on poverty and liquidity constraints to explain child labour and lack of schooling, the relation between income and schooling is generally thought of as (at least globally) monotonic. The simple introduction of a sectoral divide in returns to education can imply global non-monotonicity. This is not an implication of modelling human capital investment decisions under uncertainty, but the interval for which one should expect a negative effect of agricultural income and schooling of sons can be widened by the presence of uncertainty.

These analytical and empirical findings can have potential far-reaching policy implications. If the objective of an educational policy is full enrolment into primary schools, policy makers should acknowledge both the role of sons as old-age security providers of their parents and the strength of the rural/urban sectoral divide, which clearly has implications for the human capital investment decisions within the household. One obvious, but also very expensive, policy implication is to copy the state intervention in developed countries, where the state has diminished the role of an intergenerational contract between parents and children, because they supply both schooling and old-age security via the tax system. Another more straightforward, and certainly cheaper, policy implication of the model is that full enrolment can be achieved if formal education is able to encompass the most important features of traditional education, the agricultural life-skills enabling children to become locally rooted future farmers. This could be achieved by introducing practical agricultural subjects focusing on some of the more complex tasks with high learning potential into the primary school curriculum in rural areas. Subjects, which at the moment are purely undertaken by parents through traditional education and learning-by-doing.

8 Figures

Figure 3.1. Effect of future urban income uncertainty on the optimal human capital portfolio

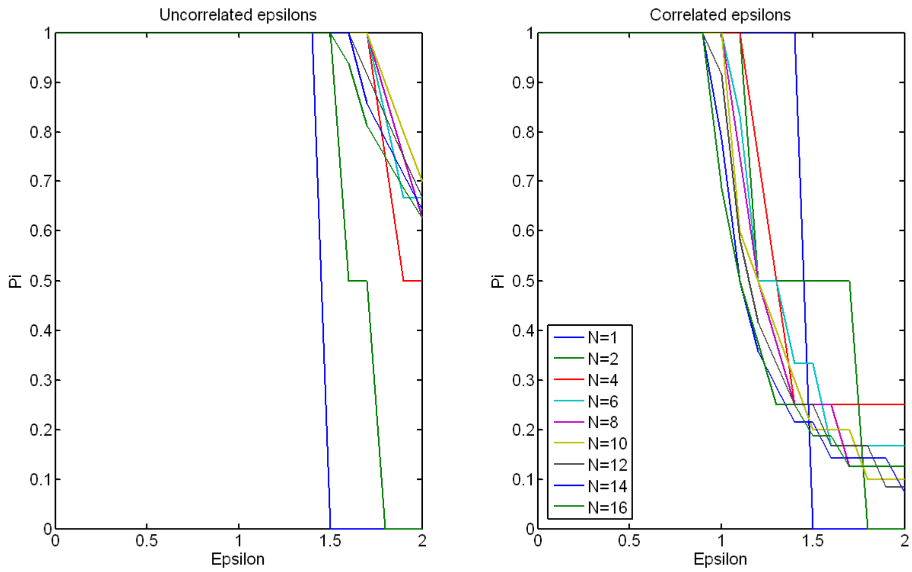


Figure 3.2. Effect of fertility on the optimal human capital portfolio, for different levels of risk ε

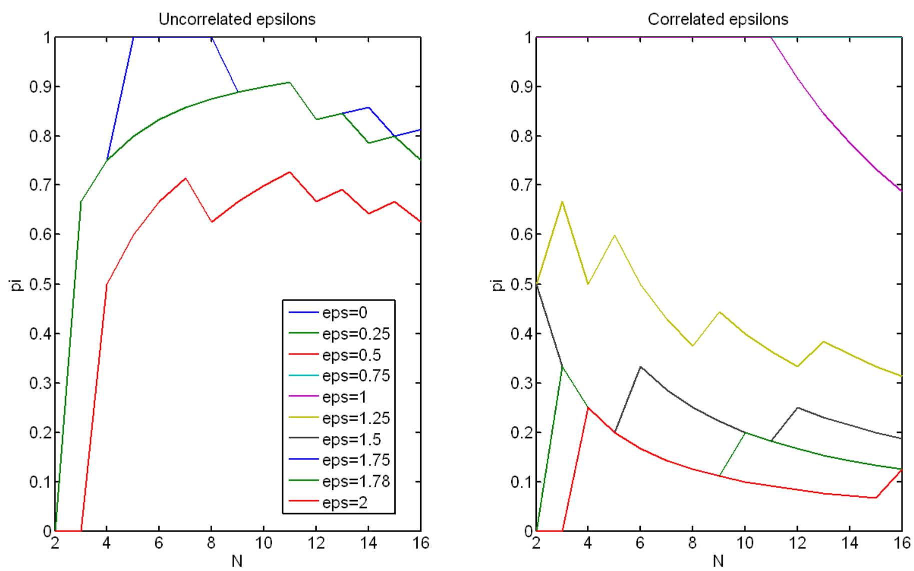


Figure 3.3. Effect of future urban income uncertainty on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

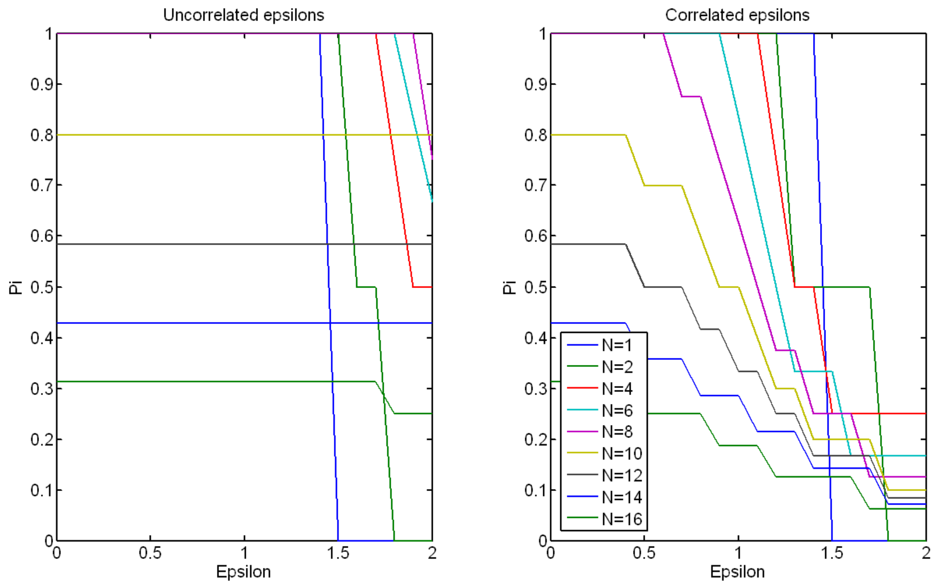


Figure 3.4. Effect of future urban income uncertainty on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

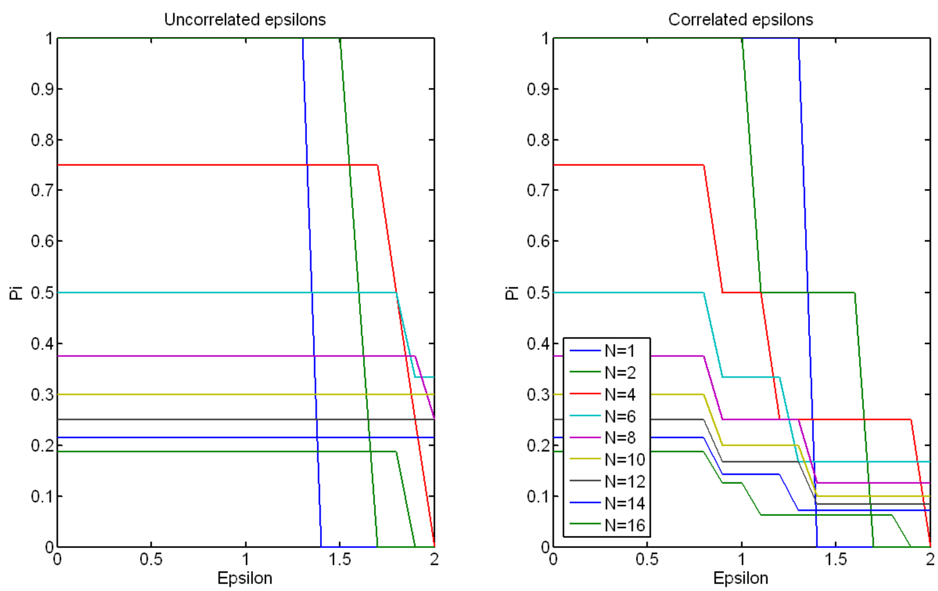


Figure 3.5. Effect of fertility on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

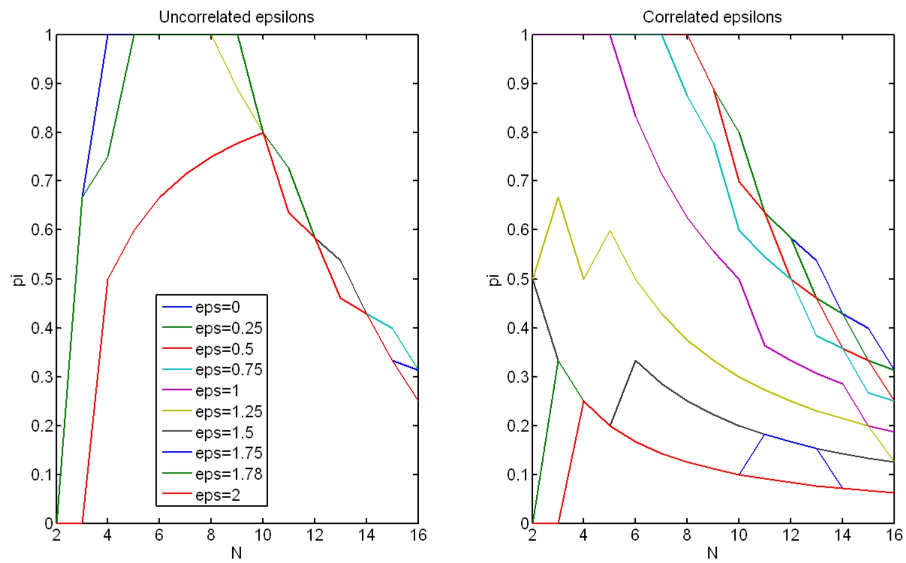


Figure 3.6. Effect of fertility on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

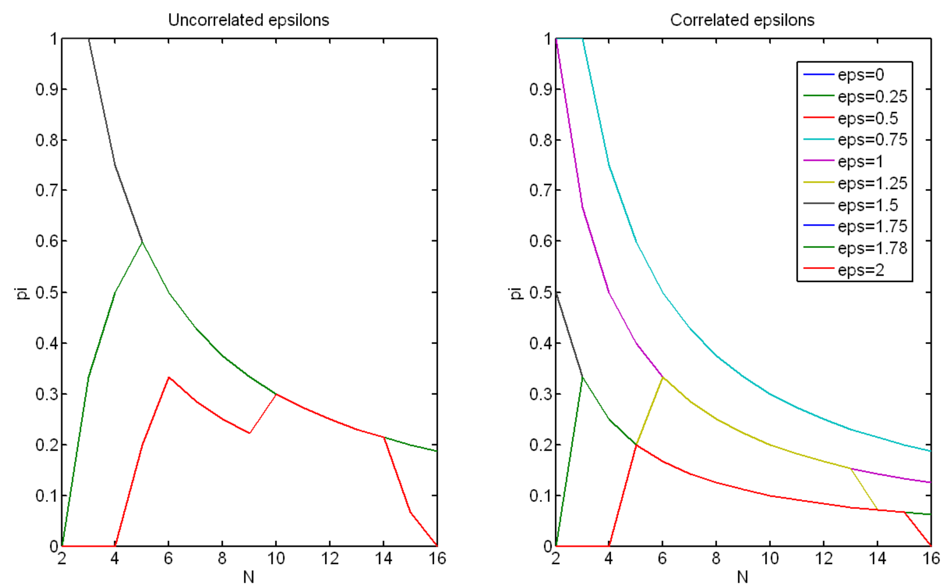


Figure 3.7. Effect of agricultural income on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

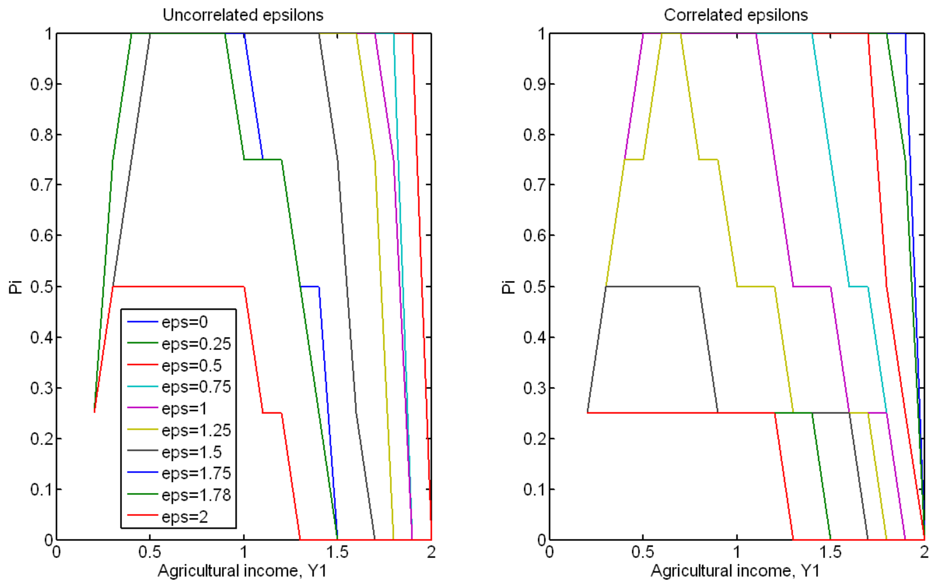


Figure 3.8. Effect of agricultural income on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

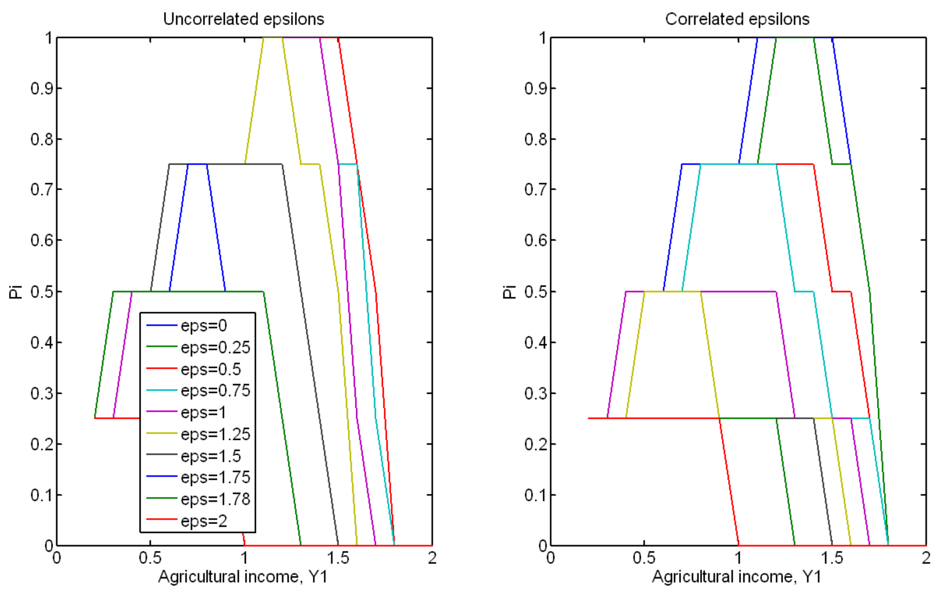


Figure 5.1. Income levels over average years of formal education among adult males in HH

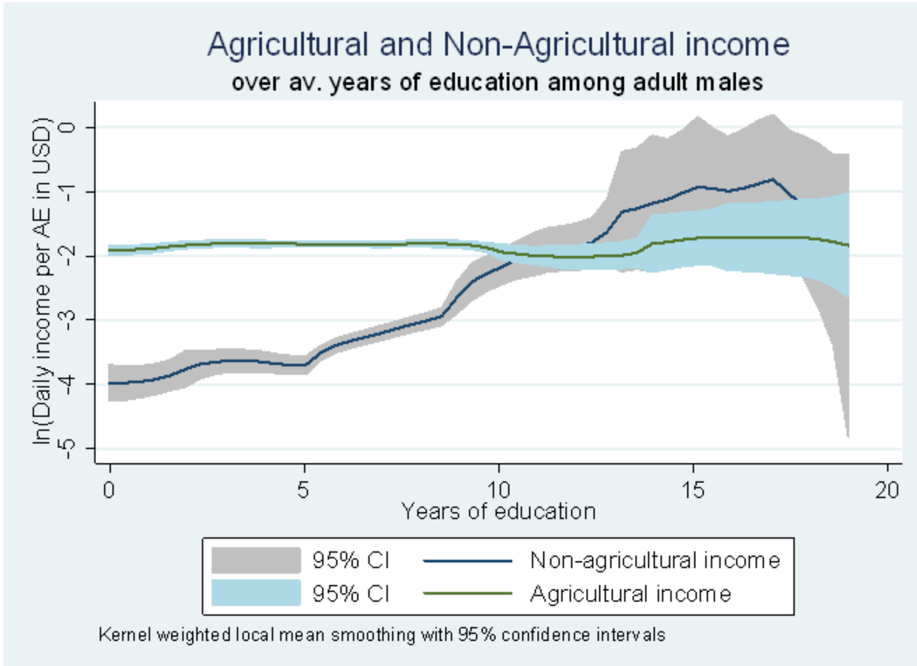


Figure 5.2. Proportion of formally educated sons over total number of sons in HH

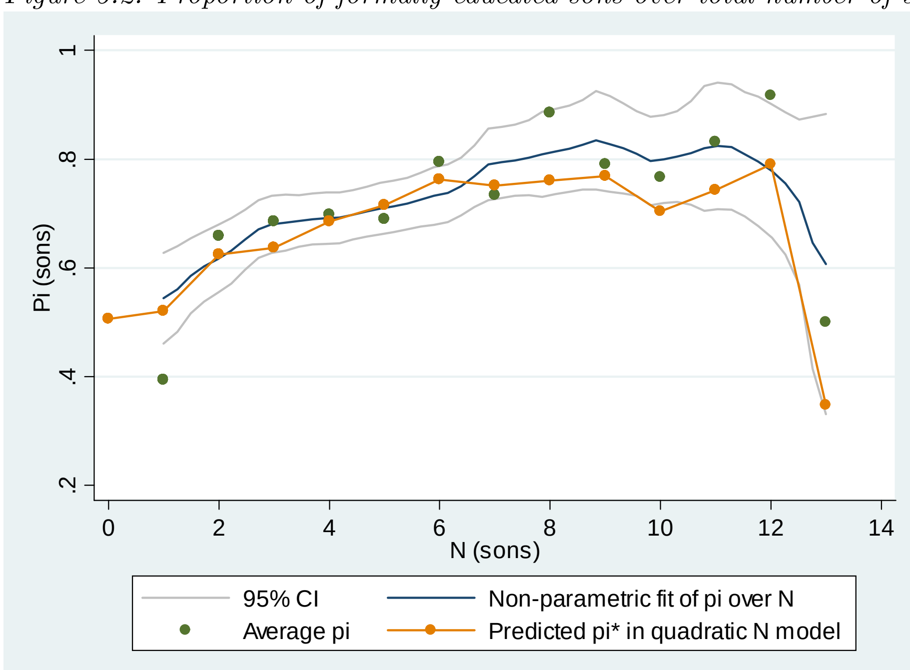


Figure 5.3. Proportion of formally educated sons over total number of sons in HH, split by HiEXP

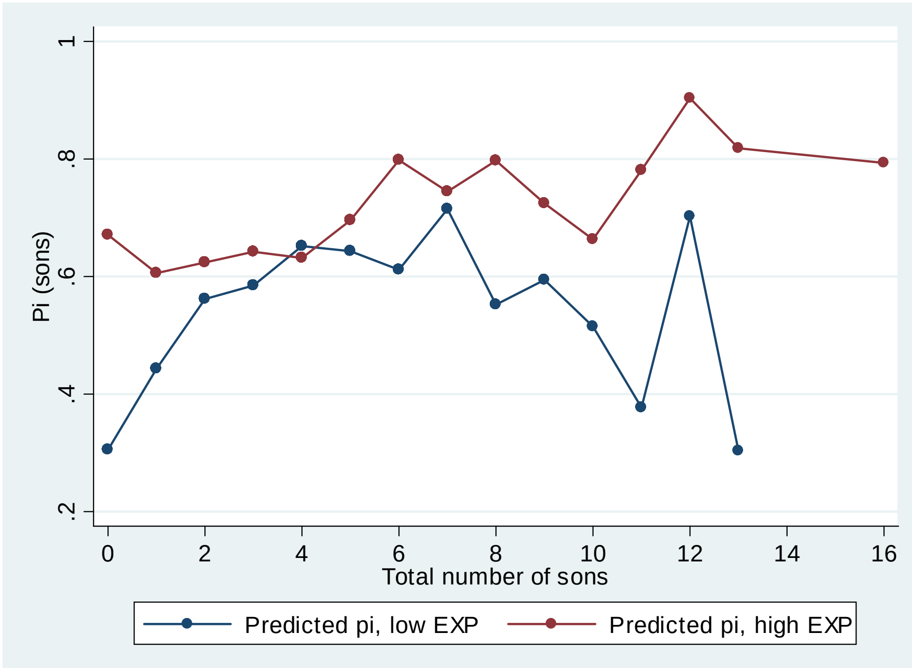


Figure 5.4. Actual π and predicted probabilitis of model (5)

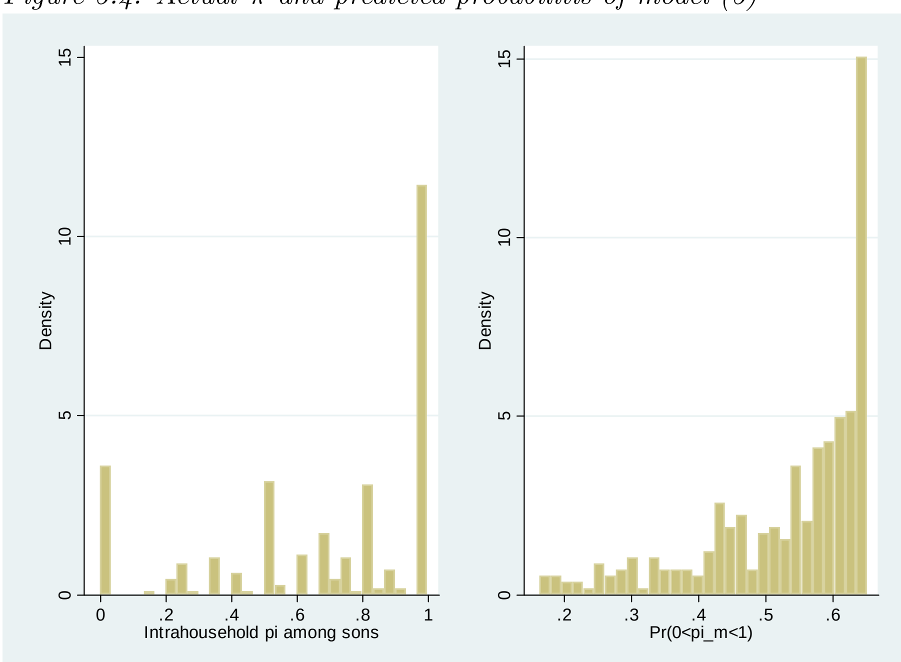
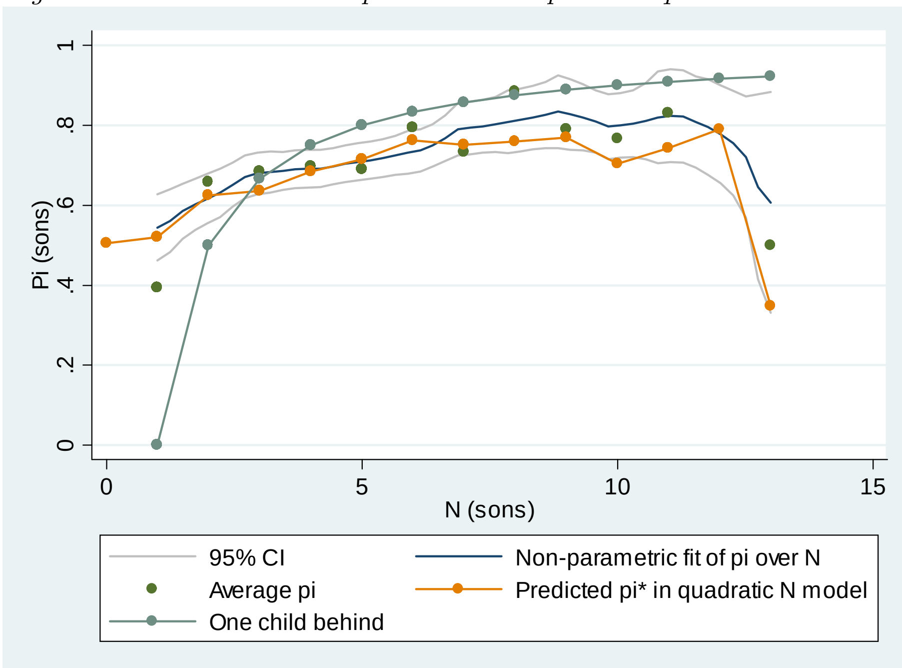


Figure 5.5. One-son-behind prediction compared to quadratic N model



9 Tables

Table 4.1. Summary Statistics

	mean	sd	min	max
KHDS II data				
Pi (sons)	0.681	0.342	0.000	1.000
Pi (daughters)	0.679	0.346	0.000	1.000
Total number of children	8.208	4.461	1.000	25.000
Total number of sons	4.090	2.555	0.000	16.000
Total number of daughters	4.118	2.778	0.000	16.000
KHDS I data				
Daily HH expenditure per AE in USD	0.366	0.200	0.072	2.129
Food share out of total HH expenditure	0.659	0.152	0.211	0.971
Land (ha)	2.244	1.867	0.121	12.222
Herd dummy	0.238	0.427	0.000	1.000
Number of income sources	3.597	0.940	1.000	6.000
Proportion of daughters	0.503	0.227	0.000	1.000
Household size, excl. children	-1.127	3.709	-18.000	6.000
Household head has primary education	0.340	0.474	0.000	1.000
Age of household head	50.414	14.215	17.000	95.000
Proportion of Mhaya in village	0.555	0.426	0.000	1.000
Proportion of Mnyambo in village	0.127	0.291	0.000	1.000
Proportion of Mhangaza in village	0.159	0.348	0.000	1.000
Proportion of Msubi in village	0.019	0.075	0.000	0.500
Proportion of Mzinza in village	0.011	0.031	0.000	0.150
Proportion of Kishubi in village	0.013	0.035	0.000	0.222
Proportion of other tribes in village	0.117	0.216	0.000	1.000
Tribal fractionalisation index	0.197	0.200	0.000	0.660
Population in village	3919	3501	1254	18526
Av. school distance in village	1.902	1.432	0.027	9.465
Av. school fee in village	0.398	0.149	0.231	1.389
Av. school uniform costs in village	4.253	1.095	2.418	7.579
Pr(migrant children remitting) in village	0.317	0.112	0.067	0.600
No. stud per math book	2.777	1.139	0.970	7.418
No. stud per kiswahili book	4.054	4.591	0.591	34.928
Proportion of A grade teachers in school	0.344	0.121	0.111	0.691
Proportion of B grade teachers in school	0.353	0.217	0.000	0.875
No. stud per classroom	48.890	8.476	29.757	70.103
Observations	365			

Note: There are only 353 (352) households with sons (daughters), respectively.

Table 5.2. Basic Tobit regressions of π

	Model (1)			Model (2)		Model (3)		Model (4)	
	All	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters
Total number of children, sons or daughters	0.020***	0.050***	0.001	0.058***	0.015	0.060***	0.014	0.063***	0.011
	(0.004)	(0.017)	(0.016)	(0.018)	(0.016)	(0.019)	(0.016)	(0.020)	(0.018)
Daily HH expenditure per AE in USD	0.249***	0.166	0.569**	0.183	0.561**	0.635**	1.529***	0.716**	1.456***
	(0.094)	(0.142)	(0.238)	(0.149)	(0.232)	(0.288)	(0.441)	(0.350)	(0.403)
Daily HH expenditure per AE, squared						-0.319**	-0.677***	-0.360**	-0.623***
						(0.148)	(0.235)	(0.174)	(0.201)
Av. school distance in village	-0.026*	-0.035	-0.041	-0.047**	-0.040	-0.045**	-0.036	-0.050**	-0.047
	(0.015)	(0.023)	(0.028)	(0.023)	(0.028)	(0.022)	(0.028)	(0.024)	(0.031)
Av. school fee in village	0.207	0.186	0.995**	0.106	0.508	0.052	0.383	-0.223	0.262
	(0.185)	(0.262)	(0.483)	(0.235)	(0.429)	(0.218)	(0.451)	(0.279)	(0.415)
Av. school uniform costs in village	0.011	0.037	0.009	0.030	0.017	0.024	0.004	0.025	0.008
	(0.016)	(0.030)	(0.033)	(0.039)	(0.037)	(0.039)	(0.038)	(0.039)	(0.042)
Pr(migrant children remitting) in village	0.546**	0.886**	0.543	0.502	0.219	0.507	0.227	0.457	0.393
	(0.212)	(0.385)	(0.377)	(0.378)	(0.489)	(0.382)	(0.498)	(0.417)	(0.464)
Proportion of daughters	-0.085	0.246*	-0.455***	0.225	-0.566***	0.230	-0.592***	0.254*	-0.472***
	(0.079)	(0.138)	(0.146)	(0.139)	(0.156)	(0.142)	(0.161)	(0.151)	(0.173)
Household size, excl. children	0.021***	0.026**	0.015	0.032***	0.021**	0.033***	0.019*	0.027**	0.014
	(0.006)	(0.013)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.013)	(0.012)
Household head has primary education	0.109***	0.271***	0.100	0.256***	0.067	0.253***	0.067	0.254***	0.098
	(0.034)	(0.058)	(0.092)	(0.057)	(0.093)	(0.057)	(0.094)	(0.066)	(0.089)
Age of household head	0.003	0.008***	0.004	0.007**	0.002	0.007**	0.002	0.006**	-0.000
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Constant	0.078	-0.369	0.106	-0.079	0.581	-0.141	0.501	-0.027	0.672
	(0.210)	(0.404)	(0.394)	(0.424)	(0.405)	(0.437)	(0.421)	(0.394)	(0.413)
School quality controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tribal controls	No	No	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Additional HH and village controls	No	No	No	No	No	No	No	Yes	Yes***
Observations	365	352	353	352	353	352	353	347	348

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5.3. Tobit regressions of π: testing model implications

	Model (4)	**Model (5)**	**Model (6)**	**Model (7)**	**Model (8)**	**Model (9)**	
	Sons	Sons	Daughters	Sons	Sons	Sons	Daughters
Total number of sons (daughters)	0.063***	0.141***	-0.012	0.163***	0.138***	0.120***	-0.039
	(0.020)	(0.043)	(0.048)	(0.048)	(0.047)	(0.039)	(0.049)
Total number of sons (daughters), squared		-0.007**	0.002	-0.009**	-0.007*	-0.005**	0.003
		(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)
Daily HH expenditure per AE in USD	0.716**	0.534	1.442***	1.247**	8.572***		
	(0.350)	(0.371)	(0.402)	(0.552)	(3.025)		
Daily HH expenditure per AE, squared	-0.360**	-0.154	-0.616***	-0.533*	-13.621***		
	(0.174)	(0.214)	(0.201)	(0.312)	(4.981)		
HiEXP				-0.028			
				(0.308)			
HiEXP x N				-0.078			
				(0.108)			
HiEXP x Nsquared				0.008			
				(0.008)			
Non-food share of total expenditure						2.042***	2.165*
						(0.698)	(1.153)
Non-food share of total expenditure, squared						-2.225***	-2.729*
						(0.839)	(1.412)
Av. school distance in village	-0.050**	-0.049**	-0.047	-0.045*	-0.056**	-0.049*	-0.049
	(0.024)	(0.023)	(0.031)	(0.024)	(0.028)	(0.025)	(0.031)
Av. school fee in village	-0.223	-0.260	0.237	-0.281	-0.145	0.086	0.626*
	(0.279)	(0.266)	(0.419)	(0.285)	(0.886)	(0.271)	(0.376)
Av. school uniform costs in village	0.025	0.029	0.008	0.032	-0.022	0.035	0.021
	(0.039)	(0.037)	(0.042)	(0.039)	(0.035)	(0.037)	(0.037)
Pr(migrant children remitting) in village	0.457	0.450	0.418	0.422	0.554	0.493	0.575
	(0.417)	(0.409)	(0.467)	(0.410)	(0.440)	(0.414)	(0.489)
Proportion of daughters	0.254*	0.311**	-0.443**	0.305**	0.111	0.260*	-0.328*
	(0.151)	(0.141)	(0.177)	(0.142)	(0.200)	(0.133)	(0.175)
Household size, excl. children	0.027**	0.027**	0.013	0.028**	0.018	0.015	-0.003
	(0.013)	(0.013)	(0.012)	(0.013)	(0.014)	(0.012)	(0.011)
Household head has primary education	0.254***	0.244***	0.096	0.238***	0.351***	0.248***	0.108
	(0.066)	(0.066)	(0.088)	(0.066)	(0.087)	(0.063)	(0.083)
Age of household head	0.006**	0.005*	-0.000	0.006**	0.005	0.005	-0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)
Constant	-0.027	-0.117	0.710*	-0.355	-1.152*	-0.359	0.489
	(0.394)	(0.384)	(0.419)	(0.436)	(0.609)	(0.383)	(0.449)
School quality controls	Yes	Yes	Yes*	Yes	Yes	Yes	Yes***
Tribal controls	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Additional HH and village controls	Yes	Yes	Yes***	Yes	Yes**	Yes	Yes***
Observations	347	347	348	347	262	347	348

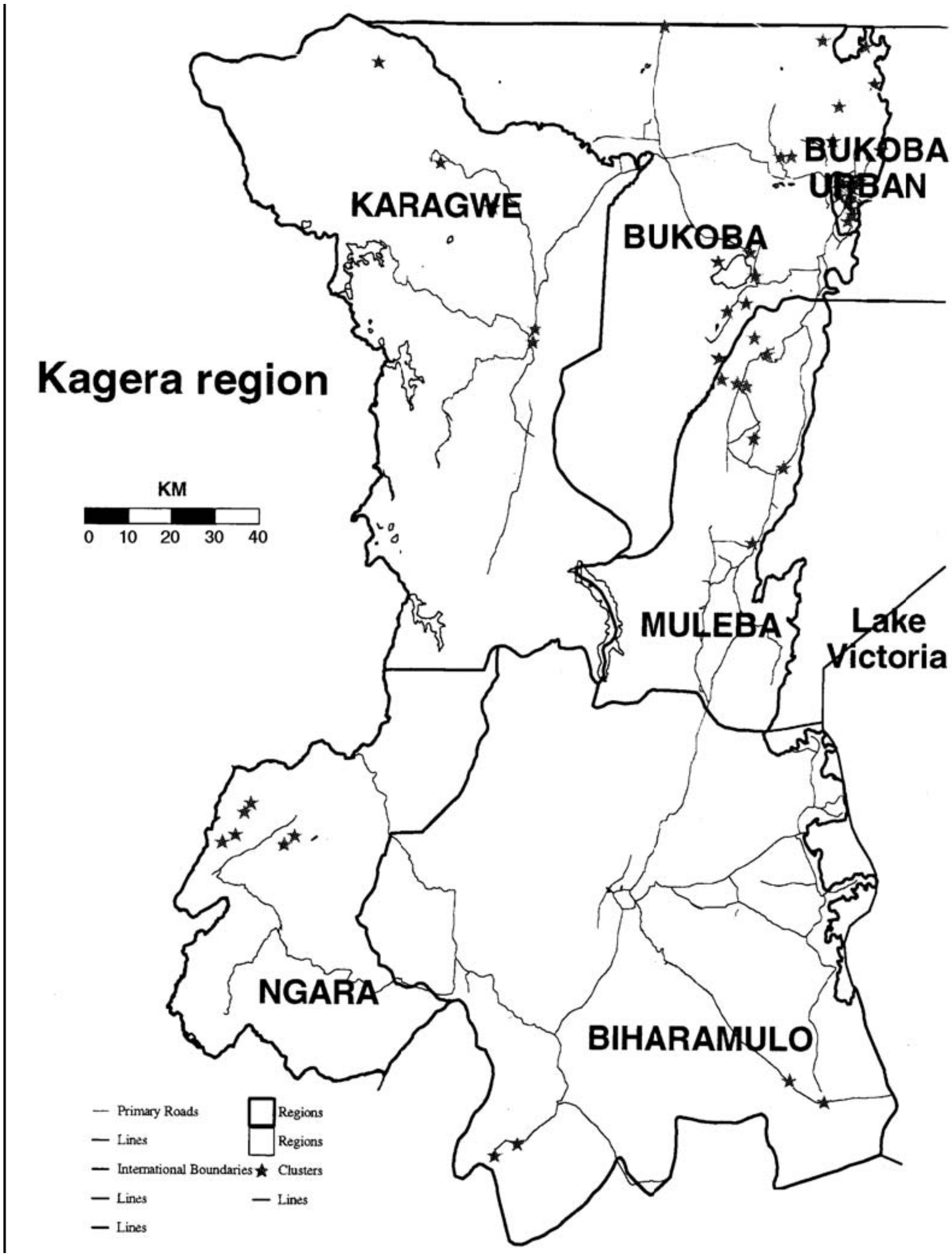
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5.5. Alternative econometric models for reduced form of π

	Model (5)	**Model (10a)**	**Model (10b)**	**Model (11)**	**Model (12)**	**Model (13)**
	Tobit	Tobit (het)	Tobit (het)	CLAD	Binomial	LPM
Total number of sons	0.141***	0.070**	0.088**	0.169*	0.334***	0.097***
	(0.043)	(0.035)	(0.038)	(0.089)	(0.087)	(0.022)
Total number of sons, squared	-0.007**	-0.003	-0.002	-0.010*	-0.010	-0.004**
	(0.003)	(0.002)	(0.003)	(0.006)	(0.006)	(0.002)
Daily HH expenditure per AE in USD	0.534	0.278	0.480	0.670	1.935*	0.333
	(0.371)	(0.355)	(0.360)	(0.896)	(1.020)	(0.207)
Daily HH expenditure per AE, squared	-0.154	-0.070	-0.198	-0.237	-0.860*	-0.093
	(0.214)	(0.176)	(0.182)	(0.764)	(0.519)	(0.122)
Av. school distance in village	-0.049**	-0.036*	-0.035	-0.037	-0.089	-0.025**
	(0.023)	(0.022)	(0.024)	(0.031)	(0.055)	(0.012)
Av. school fee in village	-0.260	-0.030	-0.018	-0.159	0.176	-0.039
	(0.266)	(0.160)	(0.183)	(2.001)	(0.679)	(0.154)
Av. school uniform costs in village	0.029	0.051	0.050	0.036	0.061	0.005
	(0.037)	(0.052)	(0.047)	(0.068)	(0.105)	(0.017)
Pr(migrant children remitting) in village	0.450	0.225	0.499	1.112*	0.278	0.215
	(0.409)	(0.385)	(0.434)	(0.666)	(0.948)	(0.208)
Proportion of daughters	0.311**	0.187	0.244	0.203	0.874**	0.218***
	(0.141)	(0.143)	(0.170)	(0.268)	(0.356)	(0.080)
Household size, excl. children	0.027**	0.017*	0.034***	0.008	0.080**	0.018***
	(0.013)	(0.010)	(0.013)	(0.022)	(0.033)	(0.006)
Household head has primary education	0.244***	0.101*	0.165***	0.370**	0.474***	0.123***
	(0.066)	(0.060)	(0.063)	(0.159)	(0.166)	(0.032)
Age of household head	0.005*	0.004*	0.005**	0.004	0.013**	0.003*
	(0.003)	(0.002)	(0.002)	(0.005)	(0.006)	(0.001)
Constant	-0.117	0.182	-0.233	-0.161	-1.412	0.112
	(0.384)	(0.440)	(0.417)	(0.907)	(0.998)	(0.179)
School quality controls	Yes	Yes	Yes	Yes	Yes	Yes
Tribal controls	Yes***	Yes	Yes	No	Yes	Yes
Additional HH and village controls	Yes	Yes	Yes	No	Yes	Yes
lnsigma						
Total number of sons		-0.167***				
		(0.030)				
Log (HH expenditure per AE per day)		-0.269	-0.059			
		(0.171)	(0.175)			
Household size, excl. children			0.077***			
			(0.024)			
Log (land)			-0.170*			
			(0.102)			
Constant	0.533***	-0.230	-0.511**			
	(0.036)	(0.218)	(0.236)			
Observations	347	347	347	352	347	347

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

10 Appendix A1: Map of Kagera and location of KHDS I clusters



Note. This map is copied from Development Research Group (2004).

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