Uncertain Returns and Children's Schooling in Tanzania

Ph.D Thesis

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October 16, 2008

Preface

This thesis has become a collection of papers about uncertain returns and children's schooling in Tanzania. This was not my intension when I embarked as a fresh Ph.D. student. However, under the supervision of Martin Browning, I have learned one main lesson - the insight is in the detail. He has kept me focused, asking the right questions at the right time, keeping my motivations and spirits high. I am deeply grateful for that.

Mette Ejrnæs, my second supervisor in the last phase of the Ph.D., has been an invaluable support, always available for questions, doubts and, not least, challanging discussions. It has been a true joy and an amazing privilege to be a student under this team of two.

During the course of my time as a Ph.D. student I have had my base at Centre for Applied Microeconometrics at Department of Economics at University of Copenhagen with periods visiting and working with Xavier Gine at the Development Research Group at the World Bank, the Economics Department at University of Essex who so kindly provided me with office space when needed, and at Institute for Fiscal Studies/UCL in London with the kind assistance of Prof. Richard Blundell and Prof. Andrew Chesher. Partcipating in, and not least learning from, these different research environments has been very productive and highly appreciated.

Finally, I would like to thank the entire group at CAM for great discussions, David Dreyer Lassen for a long and rewarding co-authorship and friendship; Fane Groes, my office and soul mate, for lots of fun, coffee and endless discussions; Alice Klynge and Mette Lunde Christensen for invaluable support and guidance; Bo Honoré for his suggestions and for always checking on me when in Copenhagen; Kathleen Beegle, Joachim DeWeerdt and Rikke Nørding Christensen for facilitating the use of Kagera data and for making our collection of the qualitative data financially possible with the support of the World Bank. Last, but not least, a special thank you to my dear family, friends and most of all, to my husband, Joao Miguel Ejarque, whose continuous support, challanging questions, love and blind belief in my abilities has made the world of research a lot more fun.

Introduction and Summary

Introduction

Classic human capital investment theory dictates that one should invest in education as long as the future discounted returns of such an investment are higher then the current direct and indirect costs. However, when it comes to primary education in developing countries, the investment decision is taken by parents on behalf of their children. This raises a problem of intergenerational contracts between parents and children. Parents cover the costs of investing in education of their children, but they face uncertainty about the level and their share of the future returns to such an investment.

Lack of primary schooling among rural children in developing countries is often attributed to credit constraints and child labour, implying that direct and indirect costs of sending children to school are high. Surprisingly few papers have considered the importance of the expected returns to parents from investing in the human capital of their children. However, in most developing countries parents rely fully on their children for old-age support and subsistence. Uncertainty about returns to education might therefore be an equally important factor in the human capital investment decision made by parents, as credit constraints and child labour has proven to be, because to parents these returns constitute a good part of their pension plan. This is the focus of this thesis.

When parents face uncertainty about the future returns to educating their children, they invest less in schooling. In chapter one, we find that in villages were there are stronger social norms guiding the intergenerational contract between parents and children, parents invest more in schooling than elsewhere. They face less uncertainty about their share in the children's future returns to schooling. When parents face uncertainty about the level of returns to education and when this uncertainty is uncorrelated across sectors, parents diversify their human capital investments. Most developing countres are characterised by a traditioal agricultural sector and more modern urban sector. Schooling tends to direct children towards future urban employment, whereas traditional on-farm learning-by-doing will direct children towards the agricultural sector. With such a sectoral divide in returns to education, the need for risk diversification can result in households keeping *some* of their children out of school. The finding that returns matter for the human capital investment decision should come as no surprise. The important contribution is that uncertainty about returns can have a strong influence on the optimal human capital investment decision of parents. Rural households in developing countries do not only diversify risk by diversifying current income sources both within the agricultural sector and between sectors. This result is of general importance because it shows how the need for risk diversification is fundamental and guides many aspects of life for households operating in an environment characterised by high risk, incomplete capital markets and virtually no social

security system.

Data from Tanzania have formed the basis for my empirical analyses. Rural Tanzania has proven a great choice for studying schooling because due to President Nyereres socialisation reform in the 1970s all villages have been endowed with a primary school. Access to school has therefore not been an issue that needed special attention. Furthermore, there has been no social unrest or ethnic conflicts in Tanzania for the past decades, which generally tends to have adverse effects on schooling of children. Finally, travelling to Tanzania and working with Tanzanians has been a true pleasure.

Summary of Chapters

This thesis consists of four chapters. The main focus of all chapters is the human capital investment decisions parents make on behalf of their children. Each chapter is in principle self-contained. However, chapter one, which is joint work with David Dreyer Lassen, differs from the remaining three chapters in the sense that it analyses the influence of the local environment through informal institutions on the seemingly 'private' decision of educating your own children. The last three chapters are all very closely related. In chapter two, I develop a simple human capital portfolio model which, in chapter three, is extended such that it can be tested on a cross sectional data set covering all of Tanzania. In chapter four, I use an extraordinary long panel data set from Kagera, a predominantly rural region in Northwestern Tanzania, to analyse households with completed fertility and completed schooling and thereby apply a more direct test of the human capital portfolio model against the standard explanations given in the child labour literature.

Chapter 1. Informal Institutions and Intergenerational Contracts: Evidence from Schooling and Remittances in Rural Tanzania (joint with David Dreyer Lassen)

This paper explores the role of informal institutions in facilitating intergenerational contracts governing investments in schooling and the payment of social security in the form of remittances. Investing in schooling of children is characterized by a fundamental problem of intergenerational contracting: parents cannot make a legal claim for return on, or even repayment of, the investment. In some cases, this inability can make parents choose less schooling (**?**) and instead rely on other modes of savings. In advanced economies, the state facilitates a political equilibrium where the middle-aged pay for compulsory schooling in exchange for receiving tax-financed pensions in old-age. However, in less developed economies intergenerational contracts are generally thought to be governed by informal institutions such as social norms. **?** and **?**, and many with them, point to the existence of social norms that can pressure children to support parents in old-age in exchange for investments in schooling done by the parents, paving

the way for investments to be made in the first place. An impression strongly supported by our qualitative field data from Kagera.

The role of social norms – and, more generally, informal institutions and the larger civil society – in enforcing the intergenerational contract associated with human capital investment is, to our knowledge, largely unexplored. In this paper, we provide a theoretical framework for and an empirical investigation of the relationship between the informal social setting and the fulfillment of the intergenerational contract. The key idea of our paper is simple: Parents invest in schooling for their children, partly with the aim of receiving a return on their investment. The expected return on the investment depends on the probability of receiving remittances from migrant children. If remittances are not paid, the child faces social sanctions from violating the norm of repayment. Such sanctions are more likely to be carried out in villages characterized by strong informal institutions. Thus, strong informal institutions increase the probability of receiving remittances, which increases the expected return on education. This, in turn, increases current investment in schooling.

To operationalize the role of social norms and measure the strength of informal institutions, we make one key assumption: informal institutions guiding and enforcing the set of social norms governing intergenerational exchange function better when a village is characterized by a higher degree of tribal homogeneity.

We find that village level tribal homogeneity is associated with both more schooling and, conditional on schooling, a higher probability of receiving remittances from relatives living elsewhere. This is consistent with the idea that informal institutions facilitate honouring the intergenerational contract. Households living in villages with a higher degree of tribal fractionalization choose less schooling for the children of the household, controlling for a wide range of household, school, and village characteristics. We also examine several possible, and possibly coexisting, explanations for the finding that tribal fractionalization is associated with less schooling. To discriminate among these, which include the role of urban networks, credit constraints, land availability and school characteristics, we rely on several additional sources of data, including our own qualitative data from focus group interviews in Kagera villages, collected partly for this reason. We find strong support for the hypothesis that the influence of tribal fractionalization on schooling do indeed run through higher levels of remittances in more homogenous villages with stronger informal institutions.

Chapter 2. Can Future Uncertainty Keep Children Out of School?

The most common argument for lack of primary schooling among children in developing countries is high direct and indirect costs of schooling, which cannot be overcome because households are liquidity constrained. Indirect costs of schooling are mostly thought of as foregone earnings associated with child labour, when children have to attend school rather than work. Although

liquidity constraints and child labour are valid explanations for why some children are not attending school, these explanations focus solely on the cost side of the investment decision and the role of children in ex-post risk coping. It seems reasonable that households in risk prone environments will, apart from their ex-post risk coping strategies, also consider the possibilities of ex-ante risk diversification. In this paper, I therefore ask the following question: Can future income uncertainty result in households keeping *some* of their children out of school as an optimal ex-ante risk diversification strategy?

I hypothesise that when there is uncertainty about future income of children and when parents rely on this income for their old-age support, diversifying the future income sources of children becomes an important means of ex-ante risk management. In rural areas, the basis for such a diversification is laid already in the human capital investment decision. Formal schooling will direct children towards future urban employment, whereas traditional on-farm learning-by-doing will direct children towards the agricultural sector. With such a sectoral divide in returns to education, the need for risk diversification can result in households keeping *some* of their children out of school.

This argument builds on insights from literatures other than the child labour and schooling literature. When focusing on a broader perspective of the rural household and not only on the direct and indirect costs of schooling of the individual child, it becomes clear that the following factors may also influence the joint human capital investment decision of children in a household. First, future income is generally uncertain and thus returns to education are uncertain. Second, in risk prone environments with very limited public pension schemes, children may not only play an important role in current ex-post consumption smoothing, but also function as future old-age security assets of their parents. Third, if there is uncertainty about the future income of children, ex-ante risk diversification is an important means of income smoothing. There is thus no apparent reason to assume that parents would consider the human capital investment decision of each child independently of his or her siblings. Rather, if children indeed are the old-age security providers, then parents should seek to optimize the portfolio of joint human capital investment decisions of their children, such that they balance future returns and risk exposure. Finally, work participation of children in household-based agricultural production systems may itself entail an important element of training and, as such, be part of a traditional education. In such a traditional rural environment, parents transfer specific human capital when working with their children, directing these towards future agricultural self-employment. Formal schooling, on the other hand, will direct them towards employment in the modern urban sector, where general human capital skills are needed.

I develop an illustrative portfolio model of the joint human capital investment decision of all children in a rural household, which incorporates these factors. The model is a two-period unitary household model, where parents in the first period decide on the optimal human

capital portfolio allocation of their N children, where the choice is between either general formal education (schooling) or specific traditional education (on-farm learning-by-doing). In the second period, parents depend on the income of their adult children for consumption. The formally educated children will earn income from the urban sector and the traditionally educated children will earn income in the agricultural sector. Second period income is uncertain.

The analytical results of the model, as well as the calibration results, show that future income uncertainty has a negative effect on the proportion of children sent to school. A relatively small degree of uncertainty, proxied by the income spread in survey data, is enough for the optimal portfolio choice of the average household to be less than full school enrolment, even in a world with perfect credit markets. This negative effect on the optimal human capital portfolio allocation can be surprisingly large, even in the presence of perfect credit markets. For the average household, the pure effect of uncertainty is so strong that actual school enrolment rates could, in principle, be explained solely by the existence of uncertainty. Thus, the roots of child labour and lack of schooling need not lie solely with incomplete credit markets and immediate gains from child labour, but could also be caused by the fact that rural households are not only concerned with securing their current, but also their future old-age income.

These findings have direct policy implications for educational policies, the aim of which tends to be full enrolment into primary school. Policies, which only act on the cost side of the human capital investment decision may be insufficient in terms of reaching full enrolment. It may well be necessary to supplement such policies with some that also act on the return side of the investment decision.

Chapter 3. Sibling Dependence, Uncertainty and Education: Findings from Tanzania

The purpose of this paper is to test the main prediction of the two-period human capital portfolio model in chapter 2 on standard cross-sectional data. The main prediction being that future income uncertainty has a negative effect on the proportion of children sent to school. However, it is, by definition, very difficult to get a good measure of future uncertainty, and thus virtually impossible to identify the actual effect of uncertainty on the optimal human capital portfolio of children in a household. An alternative is therefore to find other implications of the influence of future income uncertainty on the joint schooling decision which can be estimated in data and which are unlikely to be caused by other observationally equivalent explanations. One possibility is to take advantage of the natural sequentiality in schooling between younger and older siblings.

The two-period model is therefore extended to a three-period model, where older siblings are educated in the first period and workin the second and third period, whereas younger siblings are educated in the second period and work in the third period. Old-aged parents rely

on the income of children in the third period. This extension makes it possible to distinguish between the causes of sibling dependence in the joint human capital investment decision of parents. In a world of no uncertainty and no liquidity constraints, there would be no sibling dependence. However, as uncertainty and liquidity constraints are introduced, either of these can generate sibling dependence due to the need for risk diversification or due to sibling rivalry over scarce resources in the liquidity constrained household, respectively. The sequentiality in the schooling decision allows me to separate the implications of liquidity constraints versus risk diversification when looking at the relationship between younger and older siblings in the schooling decision. Calibrating, and partly simulating, the three period model yields testable empirical implications. There will be a positive effect of schooling of the older siblings on the schooling of the younger, when households are liquidity constrained, because the older cohort will be generating additional income. There will be a negative relationship if the overall schooling decision of all children in the household is primarily determined by a need for risk diversification.

Based on a nation-wide large scale cross-sectional household survey undertaken in Tanzania in 1994, I find evidence of sibling dependency consistent with risk diversification having a strong influence on the joint human capital investment decision of sons, but not of daughters. Results are considerably stronger among rural households compared to urban households. These results are consistent with the fact that most societies in Tanzania are patrilineal and therefore only sons are of importance for old-age security, and with the fact that only rural households have a credible option of educating their children traditionally through on-farm learning by doing. Sibling dependence in the schooling decision might therefore not only be caused by sibling rivalry for scarce resources, but can also be due to a need for risk management by diversifying future income sources. These findings have direct implications for educational policies, since lack of enrolment might not only be a matter of costs of schooling, but also of content in terms of a relevant curricula for future employment in the agricultural sector. In fact, when questioned about which subjects *should* be taught in primary schools, parents invariably allocate top rank to a hypothetical course in 'technical skills for agriculture and business'.

Chapter 4. Human Capital Diversifcation: Findings from Rural Tanzania

The purpose of this chapter is, just as chapter 3, to take the human capital portfolio model of chapter 2 to the data. However, the exercise in this chapter differs in the sense that the data set used is not standard household survey data, but rather a quite extraordinary panel data set, which is perfectly suited for testing the model in question. The data set is from a rural region in Northwstern Tanzania, Kagera. It is a panel data with an extraordinary long time horizon of 13 years between the first and the last wave and with information on all children of household heads, irrespective of their residence. This allows me to analyse households, which

in the last wave have completed their fertility as well as the education of all of their children, while the first wave gives me information of the socioeconomic status of the household at the time of making the schooling decisions. In addition, I have qualitative data based on focus group discussions with villagers from a quarter of the exact same villages as those surveyed for the panel data. These qualitative data are essential for getting a closer understanding of the influence of social norms on the household decision making, this is particularly important when the norms differ from ones own reference set.

The human capital portfolio model is calibrated using simple moments from the panel data, and model assumptions and empirical implications are all taken to the qualitative and quantitative data. By calibrating the model, I am able to separate implications of uncertain returns, *portfolio effects*, from implications of costs and liquidity constraints, *constraint effects* on the joint schooling decision. The key empirical implication of the human capital portfolio model is then that portfolio effects result in a positive relationship between fertility and schooling within a household, whereas constraint effects result in a negative relationship. 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 when consulting the qualitative data. All model assumptions and other implications are also consistent with the data.

Dansk Resumé

I mange udviklingslande er der mangel på almindelig grundskoleuddannelse blandt en stor andel af børnene. I Tanzania har under 70 % af den voksne befolkning fuldført 7 års skolegang. Dette er problematisk, da uddannelse og almen human kapital i et lands befolkning ses som en vigtig del af landets økonomiske vækst muligheder.

Der er selvsagt skrevet en del litteratur om hvorfor så mange børn ikke får de 7 års skolegang, de er berettiget og forpligtet til. Langt størstedelen af denne litteratur bygger på, at forældrene er fattige, uden videre lånemuligheder, og at de har brug for børnenes arbejdskraft til at generere ekstra indtægter til familien. Dette er uden tvivl én af årsagerne til at nogle børn ikke går i skole. Men det er en årsag, der udelukkende ser på omkostningssiden ved at investere i børns uddannelse. I denne afhandling fokuserer jeg på forældrenes afkast ved at investere i deres børns uddannelse.

De fleste ældre i udviklingslande er afhængige af deres børns støtte i alderdommen. Børnene er det tætteste de kommer på en pensionsopsparing. For at sikre denne pensionsopsparing bedst muligt er det derfor vigtigt for forældrene at sprede risikoen for at alle børnenes indtægtskilder fejler på samme tid. Den bedste form for risiko spredning i pensionsalderen opnås ved at have voksne børn med indtægtskilder fra forskellige sektorer, typisk ved at sikre sig at nogle børn arbejder i bysektoren i et lønnet job, mens andre børn tjener penge i landbrugssektoren. Slår høsten fejl i landbruget vil man altid kunne trække på børnene i bysektoren og omvendt, er bysektoren præget af høj arbejdsløshed vil man kunne leve af de subsistensafgrøder der dyrkes i landbrugssektoren. Et sådant behov for at sprede ens voksne børns indtægtskilder vil automatisk have en indflydelse på det uddannelsesvalg forældrene foretager på vegne af deres børn allerede i grundskolealderen.

Grundskolen i Tanzania, som i så mange andre udviklingslande, er præget af et stærkt fokus på den boglige viden. Børnene lærer foruden deres stamme modersmål også swahili og engelsk, de har matematik og moralundervisning. Skolen er således i høj grad møntet på at styrke de evner og færdigheder, der er nødvendige for at få et arbejde i den formelle bysektor. Selvom størstedelen af børnene bliver i landbrugsområderne hele deres liv, tilbyder skolen ikke undervisning i simple landbrugsteknikker eller specialiseret viden møntet på en fremtidig karriere som selvstændig landmand. Denne form for landbrugsuddannelse står forældrene i landdistrikterne traditionelt for. Børnene lærer hvordan man dyrker jorden og avler dyr ved at indgå som en naturlig del af familiens egen lille landbrugsproduktion.

I kapitel 1 ser vi på hvordan der i nogle landsbyer er mindre usikkerhed omkring de penge børn i byerne sender hjem fordi der er stærkere uformelle institutioner og sociale normer. Dette fører til at forældrene i disse landsbyer i gennemsnit sender flere børn i skole. I kapitel 2 udvikler jeg en simpel model for hvordan fremtidig usikkerhed omkring de voksne børns indkomster kan føre til at forældrene allerede i grundskole alderen beslutter sig for at uddanne

nogle børn traditionelt derhjemme i landbruget, mens andre bliver sendt i skole. Dette er således en alternativ forklaring på hvorfor ikke alle børn går i skole i udviklingslande. En komplementerende forklaring der fokuserer på usikkerheden omkring forældrenes forventede afkast fremfor omkostningen ved at sende børn i skole. I kapitel 3 og 4 tester jeg denne model på to forskellige datasæt. Dels et data sæt, der dækker hele Tanzania (kap. 3) og som gør det muligt at sammenligne husholdninger i landområderne med husholdninger i byområderne. Dels et datasæt som dækker et mindre område i Tanzania, men hvor man til gengæld har fulgt de samme husholdninger og alle deres børn i 13 år (kap. 4). Disse to datasæt gør det muligt at teste forskellige aspekter af modellens forudsigelser om risikospredning i uddannelsesbeslutningen. Resultaterne er konsistente med disse forudsigelser for sønner i landområderne, ikke for døtre og ikke for byhusholdninger, der af naturlige årsager ikke har samme mulighed for at uddanne deres børn traditionelt. Dette er et meget robust resultat idet de sociale normer dikterer at forældrene udelukkende kan forvente støtte fra deres sønner i alderdommen, gifte døtre tilhører helt og holdent svigerfamilien.

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Informal Institutions and Intergenerational Contracts: Evidence from Schooling and Remittances in Rural Tanzania*

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July 1, 2008

Abstract

This paper carries out a theoretical and empirical investigation of the role of informal institutions in facilitating intergenerational contracts governing investments in schooling and payments of pensions in the form of remittances. We show, using detailed household-level data from rural Tanzania, that informal institutions of social control, rooted in tribal affiliations, determine both the household's investment in schooling and the probability that it receives remittances from migrants. This is consistent with a framework in which households' expected returns in the form of remittances, which is determined partly by the prospects of social control over migrants, influence current investments in schooling.

Keywords: intergenerational contract, social compact, schooling, human capital, traditions, ethnicity, ethnic diversity, social capital, Tanzania, Africa
JEL codes: D130, O150.

*david.dreyer.lassen@econ.ku.dk and helene.bie.lilleoer@econ.ku.dk, respectively. We thank the World Bank's Social Development Department and Development Research Group as well as the Department of Economics at the University of Copenhagen for funding. We are grateful to Rob Chase and Rikke Nørding of the Social Development Department for valuable suggestions, to Joachim de Weerdt, Respichius D. Mitti, Antidius Rutayuga and Yvonne Swai, EDI-Africa, for their comments, hospitality and invaluable assistance with the field work, to Eliana La Ferrara for help with the SCPS data, and to Bob Bates, Martin Browning, Mette Ejrnæs, Andy Harris, Bo Honoré, Claus Pörtner and participants in seminars and conferences at CSAE (Oxford), Harvard, Institute for Fiscal Studies, University of Copenhagen, and the World Bank for comments and suggestions. The activities of CAM are supported by grants from the Danish National Research Foundation. All interpretations and errors are ours, and should not be attributed to the World Bank in any way.

1 Introduction

Investment in human capital in the form of schooling is one of the primary ingredients of economic growth. In all developed countries, basic schooling is provided for free or at low cost by the state, but both historically and in contemporary less developed economies, the most common form of investment in human capital is parental, or family, investment in schooling on behalf of children. Unlike other types of investments or saving instruments, however, investing in children is characterized by a fundamental problem of intergenerational contracting: parents cannot make a legal claim for return on, or even repayment of, the investment. In some cases, this inability can make parents choose less schooling (Ben-Porath, 1967) and instead rely on other modes of savings.

The basic problem is that children are not allowed to enter contractual agreements such as promising to provide for their parents in exchange for schooling investments made by the parents on behalf of their children. Becker and Murphy (1988) and Thompson and Ruhter (1979) argue that a possible response to this time inconsistency problem is for the state to provide schooling to young people and, at the same time, enforce old-age pensions such that the working population, when making investments in schooling, would be entitled to a share of the returns in the form of pensions paid out when they are old. This political equilibrium, denoted a social compact by Becker and Murphy (1988, p. 9), separates the individual investment from the individual return and makes enforcement a non-issue as both schooling and taxation is made compulsory by the state.[1] Recent analyses by Rangel (2003) and Boldrin and Montes (2005) provide a formal analysis of the Becker-Murphy argument, the latter focusing specifically on education and pensions, the former providing a general analysis of self-sustaining agreements over intergenerational goods.

Such intertemporal social compacts require a state sufficiently strong that it can credibly both raise taxes for (future) pensions and provide adequate schooling for children. However, a defining feature of less developed economies is that the provision of many services takes place through informal institutional arrangements, rather than the formal institutions embodied in developed economies. What happens when the state is not that strong? The result may be autarchy (Thompson and Ruhter, 1979) in which children's human capital is not used for savings at all, or under some circumstances, the result may be self-enforcing family equilibria based on tit-for-tat type strategies by children towards defecting adult children (Ehrlich and Lui, 1991; Cigno, 1993; Rangel, 2003). Becker and Tomes (1985) and Becker and Murphy (1988), and many with them, point to the existence of social norms that can pressure children

[1] Given that all other children are educated and parents will receive old-age support from the state, a free-riding problem emerges since parents could be tempted to have their own children working. See Thompson and Ruhter (1979) for a complete framework that includes also compulsory schooling and child labor laws as well as school leaving laws, and Goldin and Parsons (1989) for evidence from the U.S. in the 19th century.

to support parents in exchange for investments in schooling done by the parents or extended family on behalf of the children, paving the way for investments to be made in the first place, an impression strongly supported by our field data from Tanzania; for example, one respondent recalled a story where

> "In a neighboring village the father was neglected by the well-paid son that was living in the distant city Dar [es Salaam]. The father arranged a trip to go to him, but he was still betrayed. While he was in Dar, the father got assistance from others and visited the son's employer and he was granted a monthly lump sum that was deducted from the son's salary." [C13, Q8, translated].[2]

The case where the social compact is not enforced by the state is important, both historically and in the contemporary developing world, and the role of social norms – and, more generally, informal institutions and the larger civil society – in enforcing the intergenerational contract is, while frequently referred to, to our knowledge largely unexplored.[3] In this paper, we provide a theoretical framework for and an empirical investigation of the relationship between the informal social setting and the fulfillment of the intergenerational contract.

The key idea of our paper is simple: Parents invest in schooling for their children, partly with the aim of receiving a return on their investment. The expected return on the investment depends on the probability of receiving remittances from migrant children. If remittances are not paid, the child faces social sanctions from violating the norm of repayment. Such sanctions are more likely to be carried out in villages characterized by strong informal institutions. Thus, strong informal institutions increase the probability of receiving remittances, which increases the expected return on education. This, in turn, increases current investment in schooling.

To measure the strength of informal institutions, we start from the recent conceptualization of social capital. While social capital has come to mean many different things and is operationalized in many different ways, we follow Coleman (1988, 1990) in seeing social capital as different entities that "all consist of some aspect of social structures, and [...] facilitate certain actions of actors [...] within the structure." (Coleman, 1988, S98). As noted by Bates (1999, 2000), ethnicity is one such structure. Ethnic or tribal affiliation, like kinship, carries with it promises and obligations and provides, through traditions and social norms, what Coleman calls a structure.

To operationalize the role of ethnicity in informal institutions, we use a tribal fragmentation index to capture the degree of population heterogeneity along tribal lines at the village

[2] Cluster 13, item 8, translated from notes in Swahili, as are following quotes.

[3] For example, The Department for Economic and Social Affairs of the United Nations note in their 2005 Annual Report on the social situation of the world "[t]he manner in which the intergenerational contract is currently honoured varies across societies. In most developing countries, intergenerational support is sustained within a wide kinship network and sometimes through community interaction, while in developed countries the State mediates and/or supports the contract to varying degrees." (UN 2005, p. 82)

level. There is considerable evidence that such heterogeneity is associated with less success in overcoming collective action problems and providing public goods (Alesina and La Ferrara, 2005). In our setting of sub-Saharan Africa, this is an appropriate measure of informal institution strength, as insurance and the provision of services with a public element typically are organized through informal institutions grounded in kinship or tribal associations rather than in the weak or developing state. Based on this, we make one key assumption: informal institutions guiding and enforcing the set of social norms governing intergenerational exchange function better when a village is characterized by a higher degree of tribal homogeneity. This assumption, discussed in detail below, is widely supported in experimental and empirical work on the role of identity in overcoming collective action problems.

We investigate the effect of village level tribal fragmentation on schooling and remittances using two different data sets from Tanzania, both collected in the early 1990s. One covers the entire of Tanzania, another, with very detailed data on migrants and remittances, covers the Kagera region, a rural region by Lake Victoria in the Northwestern part of the country. We find that village level tribal homogeneity is associated with both more schooling and, conditional on schooling, a higher probability of receiving remittances from relatives living elsewhere. This is consistent with the idea that informal institutions facilitate honouring the intergenerational contract. Households living in villages with a higher degree of tribal fractionalization choose less schooling for the children of the household, controlling for a wide range of household, school, and village characteristics. This is the case in both data sets. In our preferred specification on the Tanzania-wide data set, increasing tribal fractionalization by one standard deviation decreases the probability of a child being in school by approximately six percentage points. In our preferred specification on the Kagera data, increasing tribal fractionalization from its minimum to its maximum level decreases the probability of observing remittances in the past six months by eight percentage points.

We identify the effect of tribal fractionalization on investment in schooling and remittances by examining the potential endogeneity of the tribal composition of villages, the possibilities of spurious effects, which could arise if tribal fractionalization is correlated with other between-village differences, and the selectivity of youngsters migrating to different places. Ethnic land settlement in East Africa is largely determined by stable historical patterns (Miguel and Gugerty, 2005; Miguel, 2004) and we show that residential mobility in and out of the villages in our sample is very limited and unrelated to tribal fractionalization and school characteristics, and that results are independent of mobility issues. Further, we compare a wide range of socioeconomic, demographic, and school quality variables across homogenous and diverse villages, both for the entire distribution of tribal fractionalization and for villages in the lowest and highest quintile of fractionalization, respectively, and find tribal fractionalization to be orthorgonal to all potentially confounding variables. Finally, we compare migrants residing

in similar environments to each other, rather than migrants in the major cities with migrants in nearby villages.

We examine several possible, and possibly coexisting, explanations for the finding that tribal fractionalization is associated with less schooling. To discriminate among these, which include the role of urban networks, credit constraints, land availability and school characteristics, we rely on several additional sources of data. In addition to the Tanzania-wide data set, we use supplementary data on social capital and inequality available for a subset of the sampled households. As a supplement to the detailed Kagera region data, in order to learn more about the causal path from tribal fractionalization to schooling and remittance, we use our own data from group interviews in Kagera villages, collected partly for this reason. Finally, we rely on the large anthropological and economic literature on tribes and kinship, and migration, respectively.

The paper links with several entwined strands of literature. As noted above, a number of papers examine implicit intergenerational contracts. Thompson and Ruhter (1979), Parsons (1984), Becker and Murphy (1988), and Ehrlich and Lui (1991) all consider some variant of the intrafamily intergenerational contract. Thompson and Ruhter (1979) and Becker and Murphy (1988) focus on the role of the state in facilitating intergenerational contracts in the absence of binding contracts with children, Parsons (1984) analyzes intergenerational transfers within the economic framework of the family, and Ehrlich and Lui (1991) consider self-enforcing agreements in an overlapping generations framework, though with a focus on fertility. Two recent papers, Rangel (2003) and Boldrin and Montes (2005) provide the game-theoretic foundations for the discussion in Becker and Murphy (1988). Rangel analyzes the general case of (as he calls them) forward and backward intergenerational goods, while Boldrin and Montes provide a focused analysis of the role of the state in providing both education and pensions. We know of only one paper that explicitly links tribal affiliation to the obligations to remit: Based on field work in the Luapula province in Zambia (Bates, 1976), Bates (2000) argues that ethnicity empowers the elders with political control over land rights that are of crucial importance for migrants wishing to return, but he does not consider the investment motive in education.

Second, the paper contributes to what is sometimes called the new economics of labor migration (Lucas and Stark, 1985; Stark, 1991; Lucas, 1997), by explicitly linking migration behavior and the decision to remit with schooling decisions. Lucas (1997, p. 750), summarizing the large literature on internal labor migration in developing countries, concludes that "it seems plausible that education is part of an intertemporal arrangement; the family educates members in order for them to migrate and gain urban entry, ultimately to repay the family from town."[4] As noted by Lucas, however, a difficulty with such an intertemporal arrangement

[4] A large literature has investigated the various motives for remittances. Cox and Rank (1992) find support for the exchange motive, Lee, Parish, and Willis (1994), and Lillard and Willis (1997, 2002) find support for the

is enforcement; however, "to some extent, trust, tradition and altruism make the family a natural enforcement unit." While the economic literature on migration and education has rarely looked beyond the household, Lucas (1997) notes that a third level of factors, denoted contextual effects in the demography literature (e.g. Hugo, 1981; Findley, 1987; Bilsborrow et al. 1987), comprises the influence and composition of the sending community upon migration decisions. Such contextual effects remain largely unexplored in both theoretical and empirical economics studies of migration-related issues, though some work has been done mainly in the context of migration networks (Winters et al. 2001) and on the role of relative deprivation as a cause of migration (Stark, 1991). This paper looks at how context – informal institutions and, to a lesser extent, social capital – affects education and remittances. Lucas and Stark (1985) show that the prospects for inheritance matter: for example, sons of families with larger herds remit more, as families have a better bargaining position in this case. In our empirical work, we also control for institutions governing inheritance when estimating the effect of informal institutions on remittances.[5]

Third, as ethnicity is part of the broader concept of social capital, the paper contributes, from a developing country perspective, to the mainly U.S.-centered literature on the effects of social capital on schooling decisions. Coleman (1988, 1990), who shares credit for introducing the term 'social capital,' examined the role of social networks (or fabric) in lowering the risk of high school dropout, and Goldin and Katz (1999) argue that the expansion of higher secondary education in the United States before WWII was influenced to a considerable extent by social capital. They measure social capital by the resources allocated by local communities to primary schooling. As such, they consider only one part of the intergenerational contract, as do Miguel and Gugerty (2005) in their careful analysis of how ethnic diversity hinders voluntary school financing in Kenya.

Finally, the paper contributes, though from a different angle, to the literature on the effects of ethnic diversity on public policy outcomes.[6] Easterly and Levine (1997) note, examining a cross-section of countries, that economic growth is negatively related to the degree of ethnolinguistic fractionalization. Alesina, Baqir and Easterly (1999) find that less funds are allocated to local public goods provision in more racially diverse municipalities in the U.S., and Miguel and Gugerty (2005) argue that it is the relative inability to impose sanctions across ethnic groups

repayment of implicit loan-hypothesis in South-East Asia, while Raut and Tran (2005) reject the loan motive in favor of a reciprocity motive. Cox and Fafchamps (2008) provide a recent survey.

[5] Collier and Gunning (1999, p.78-9) notes on the African experience that "[l]ineage rules of inheritance enforced intergeneration transfer payments. The kin group was able to enforce adherence to each particular rule through the threat of exclusion from the entire package of benefits." Bates (1999, 2000) provides a general overview; see for example Snyder (1997) for specific evidence on the *Iraqw* of northern Tanzania, and Gulliver (1971) for an in-depth study of how kinship and tribal affiliation shaped interaction in Tanzania before independence.

[6] A separate literature has considered the effects of ethnic diversity on the risk of conflict and internal warfare. Bates (1999) provides an introduction to both topics.

that can hinder cooperation and voluntary contributions to local public goods, illustrating their point by a careful analysis of primary school funding in rural Kenya. While the existing literature has examined the effect of ethnic diversity on cooperative or public outcomes, such as public goods provision, we consider the effects of fractionalization on a seemingly 'private' decision: Investment in children's schooling.

The next section introduces the Tanzanian setting, including impressions from our group discussions, and section three sets up a simple model for how tribal fractionalization influences household decisions on schooling through its effects on the efficacy of social sanctions. Section four presents the data, and section five considers empirical issues related to analysis, including identification. Section six reports results and section seven examines alternative explanations. Section eight concludes.

2 Schooling and pensions in Tanzania: The setting

2.1 Education and Pensions in Tanzania

In the 1970s, under then-President Nyerere's Education for Self-Reliance program, official estimates put gross school enrolment rates for 7-13 olds at 95 %. By 1993, following years of economic decline, the official estimate was 70 %, well above our estimate of 55 %, based on data from rural areas only.[7] Compulsory schooling was re-introduced in 2001 by then-President Mkapa, and free primary schooling, funded mainly by donor agencies, has boosted enrolment rates; some concerns persist, however, about the quality of primary education.[8] The first wide-spread funded pension system was introduced in 1997 as part of a comprehensive social insurance legislation, but pension payments remain low and most people are reliant on the family in old-age and in case of economic hardship.

2.2 Impressions from group discussions

Our empirical observation that tribal fractionalization, through informal institutions and social norms, affects schooling can, as noted above, have many different explanations. To help us identify potential alternative explanations for the observed association between tribal fractionalization and schooling, to distinguish among hypotheses that are observationally equivalent in the reduced form econometric work and, if possible, to assist us in evaluating the relative merit of these hypotheses, we conducted a series of group discussions and semi-structured interviews in twelve KHDS villages in the Kagera District in Northwestern Tanzania in 2005, working

[7] See Buchert (1994) on the education in Tanzania. Numbers are from Gibbon and Raikes (1995).

[8] Milton Nkosi: "Tanzania looks beyond free schooling." BBC News Africa, July 15, 2005.

with the team that collected a new round of KHDS data in 2004.[9]

The quantitative data employed in the empirical analysis dates back to the early 1990s, while the group discussions were conducted in 2005. The main change in the intervening period is the re-introduction of compulsory schooling noted above, and all groups invariably stated that primary schooling has become common for everyone, which was not the case before. Respondents also argued that this to some extent also has diminished the value of primary schooling, and increased the need for secondary schooling.

When asked to discuss the value of schooling, a standard reply was that schooling is for the benefit and development of the child, but a frequent additional explanation was often given: one man argued that "if you sow maize, you don't only want to look at the flower, you also want to harvest" [Cluster 19, item 2]. Generally, (primary) schooling is seen as a better investment than giving the child land, as "it is better to give education than to give a shamba, with education a child can buy himself many shambas." [Cluster 4, item 2]. A major motivation for schooling is to make the child self-reliant and thus no longer a financial burden to the parents, but there was also a clear expectation in the villages that formal education, in particular secondary schooling, leads to migration and, not least, remittances. When asked to rank profiles of children with different educational levels, less educated children and children staying nearby were expected to help with household chores (washing clothes, field work) while educated children, in particular those with secondary schooling, were expected to remit cash.

In general, (older) boys would receive priority in schooling investments, as girls by Tanzanian custom become part of their husband's family, and returns on education, as a result, will not accrue to the household; there was some disagreement about the latter point, though. In particular, girls were portrayed as more caring for their family, and examples were given of daughters favouring their parents over her husband's parents. At the same time, pregnancy was often mentioned as a reason both for girls dropping out of school and, as a result thereof,

[9]Documentation is found in Lassen and Lilleør (2008). Discussions were carried out in twelve villages, selected among the KHDS villages to achieve a balance between high and low fractionalization villages. We did two rounds of pre-testing of the focus group discussion (FGD) questionnaire, one in a high TF village and one in a low TF village, with subsequent adjustments to the questionnaire. The final questionnaire (available in Lassen and Lilleør, 2008) is a mixture of open-ended and exploratory questions, group assessments of likelihoods (e.g. for migrating and remitting for types of children), and closed form factual questions. In addition to the questionnaire, a roster of participants was taken as they arrived. We also set up procedures for reporting of the results so as to ensure a uniform reporting across villages

A typical 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). In high TF villages selection was done so as to have members from more than one tribe present in the FGD (in Kagera, one tribe villages almost always means Haya villages, and the Hayas are often the majority tribe in more mixed villages as well; see Reining, 1967, for an in-depth study of the Haya.) All sessions were conducted with the same facilitator and the same note taker. Following each session, a subjective evaluation of the degree of overall participation, the degree of equal participation and the degree of knowledge of the participants was carried out.

for not investing in secondary schooling for girls in the first place.

According to the participants of the group discussions, the degree of sanctions or 'measures' (as they were invariably called by respondents) which can be taken against children failing to remit or help out as they are expected to varies considerably. Sanctions range from having the clan reprimand the non-remitting child [e.g. cluster 2, item 8] over imposing fines, or cursing children, to reducing the amount or the quality of land to be inherited. The most serious, and most common, sanction is to deny non-remitting children inheritance in the form of land, including access to burial grounds. In one group discussion, a respondent provided an example of a parent selling off his land when his children in Dar Es Salaam did not send remittances; as a result, the children began remitting [cluster 23, item 8]. Is such a threat credible, given that major inheritance decisions are taken after the parents' deaths? Respondents in one village agreed with the statement by one man that "the community may [...] intervene if the father can say it before his death" [cluster 4, item 8 and field notes]. When asked whether it would make a difference if a non-remitting child comes from a good cooperation village (associated by respondents primarily with homogeneous villages) as opposed to a poor cooperation village (associated with heterogeneous villages), the general response was that children from good cooperation villages should expect stronger measures: "those from villages with good cooperation will get stronger measures, because it is easy for the members to sit and discuss on the measures to be taken, while it is difficult for the village without good cooperation because it is difficult to reach the consensus." [cluster 8, item 8]. In another village, respondents stated that "all the measures depend on how the parent decides with blessings of the clan, in case they belong to the strong one" [cluster 7, item 8]. These statements support the notion that social sanctions can indeed be used as an enforcement tool by parents, especially with the help of their fellow clan/tribe members, and that this is likely to be more pronounced in tribally homogenous villages.

3 Schooling, remittances, and informal institutions

Our approach is to follow the literature on the economics of labor migration in looking at household, or broader family, strategies in devising implicit intertemporal agreements that govern the allocation of resources towards investment in education, and the link to migration and payment of remittances to the household when the migrant begins earning money in town.[10] We begin from a standard model of educational choice (e.g. Baland and Robinson,

[10] Thus, we focus on one particular set of strategies within a broader set of possible family strategies. Lucas (1997) provides an overview of studies linking migration with fertility, marriage, and risk spreading, issues we do not consider here. Regarding fertility, we find below that household sizes across homogenous and heterogenous villages are essentially identical, suggesting that it is not fertility as an omitted variable that is the cause of our findings.

2000) without any altruism. Parents make a choice between child labor and schooling in the first period, when the child is a part of the household. In our model, formal education in the form of schooling increases the probability of getting a high wage job in the urban sector. In the second period, the child, now called the migrant, enjoys consumption on its own and can choose whether or not to remit a share of its labor income to the household, which makes economic decisions in the second period. As noted by Lucas and Stark (1985), when remittances are not based on altruism alone, or at all, enforcement of the implicit intertemporal contract becomes a key issue. This enforcement is provided through the family, the tribe and the urban network (Ben-Porath, 1985) by appealing to norms, traditions and trust as well as to promises for inheritance, possibilities of land allocations upon returning to their rural home, and access to burial grounds.

In the model, the impact of informal institutions on remitters' behavior is thus based on two key assumptions: First, that non-remitters are subject to social sanctions and, second, that the efficacy of these sanctions decreases in the degree of tribal fractionalization. The first part of the argument is widely supported by anthropological and recent economic studies. Migrants are expected to remit and those who do not face sanctions upon returning to their village, for example by being denied access to land or access to burial grounds (Gugler, 1968; Connell et al., 1976; Bates, 1976, 1990, 1999; Collier and Gunning, 1999) or by receiving a reduced or no inheritance (Lucas and Stark, 1985; Bernheim et al. (1985), La Ferrara, 2007); while the exact sanctions used can differ between regions and among tribes, inheritance and access to family burial grounds was mentioned repeatedly in the group discussions as the primary instrument available to families for controlling migrants' behavior. We model such measures or sanctions as being applied without cost, which is a good approximation to the situation in rural East Africa, where disputes are often over burial rights or access to land and sanctions are relatively low-cost actions. Further, as is well known from the experimental literature, people readily apply sanctions in e.g. public goods games even if dispensing such sanctions are costly to them.

The second assumption also has support from a wide range of studies. Bates and Shepsle (1997) investigate the impact of ostracism on non-contributers to public goods in games featuring overlapping generations, and argue that such ostracism functions better within than across ethnic groups. In a similar way, Bates (1999) argues that identity generally, and ethnicity specifically, serves to facilitate beneficial economic interactions that would otherwise not have taken place and he argues that it is precisely the ability of clans or tribes to levy and uphold social sanctions that sometimes makes ethnicity a creative force in sub-Saharan Africa. Miguel and Gugerty (2005) and Miguel (2004) present empirical evidence from East Africa that more tribally fractionalized communities are less able to secure voluntary payments for local public goods, and they attribute this to the fact that social sanctions function less effectively across

tribal groups.[11]

More direct evidence comes from Miguel and Posner (2006) who, based on cross-country evidence, suggest that ethnic salience is higher in more homogenous places. If this is true also within countries, it confirms why ethnic homogeneity is important for facilitating social sanctions: if tribal or ethnic salience is low in heterogenous places, upholding norms and social sanctions related to remittances is difficult, while tribal affiliations are very much a part of daily lives in homogenous places. In a similar spirit, Ross and Weisner (1977) argue that the strength of networks in the sending community affects the scope for sanctions. Recent experimental evidence also supports the idea that the detrimental effect of ethnic diversity on public goods provision is through a lack of shared social norms and an inability to carry out social sanctions. Habyarimana et al. (2007) experimentally test competing explanations for the lack of success in providing public goods in heterogenous groups. They carry out the test in a heterogenous community in Kampala, and find no support for preference-based and team-work explanations, but conclude that ethnically homogenous communities "possess both norms and networks that facilitate the sanctioning of community members who fail to contribute to collective endeavors." (Habyarimana et al. 2007, p. 722). Further, they find that players cooperate more under the threat of sanctioning, that enforcers punish players when enforcement is costly, that they punish defecting co-ethnics more than defecting non-co-ethnics and that this is particularly true when a co-ethnic defects in a game with another co-ethnic. This supports our assumption that villagers of another tribe are less likely to participate in the sanctioning of a non-remitter.

Finally, this assumption is also supported in our own data, to which we return in more detail below: Survey evidence from 69 villages reveals that a village-level average of 'trust in family members' is negatively correlated with tribal fractionalization, as is a village-level average of 'trust in fellow tribesmen'.[12] This supports our measure of lack of cooperation potential, the validity of which could be weakened if intragroup relations strengthen as inter-group differences become more pronounced.

[11] In formal models of these issues, the relation between ethnicity and punishment strategies in the forms of social sanctions is rarely modelled directly but rather assumed, as we do below. In a related setting, however, La Ferrara (2003) considers a microfounded model of credit in a dynastic environment, where punishments for failure to repay loans are levied on dynastic descendants, endogenously making repayment an equilibrium response.

[12] p-values for the correlations are .006 and .154, respectively. Data from the SCPS, described in the section on data below. We also find 'unity of the village', 'spirit of participation in the village' and 'group functioning' to be significantly negatively correlated with tribal fractionalization across the 69 villages, findings which are confirmed in our group interviews where participants generally agreed that villages with one tribe (homogenous villages) had better cooperation than mixed tribe villages, and that villages with good cooperation were generally thought to be better able to 'sit down and discuss' appropriate measures to be taken against non-remitters (field notes, cluster 19).

3.1 The model

The household lives for two periods, 1 and 2, and receives exogenous income A in each period. The household H has a life time utility function, with a concave Bernoulli utility function v over income. The household has a representative child, and we model the choice of schooling as a continuous variable $b \in [0,1]$, where $b = 1$ is full time schooling, for example through to a completed secondary school degree, and $b = 0$ implies no schooling.[13] The costs of education, and subsequent migration, including uniform costs, school fees and relocation expenses, are denoted e. Schooling increases the chance of getting a formal sector job. Denote by $p(b)$ the probability of getting a formal sector job as a function of human capital accumulation; we assume that the probability of becoming employed depends positively on the level of schooling such that $p' > 0$. Child labor yields a wage w^T per efficiency unit. This wage is normalized to one.

The household wishes to maximize expected lifetime utility, subject to the costs of educating children and subject to the determination of the level of remittances taking place in the second period. Hence, the household's maximization problem is

$$\begin{aligned} & \max_{b \geq 0} v(A + (1-b) - be) + Ev(A, R; b) \qquad (1) \\ Ev(A, R; b) &= p(b)\, v(A + R) + (1 - p(b))\, v(A) \end{aligned}$$

where R is the level of remittances determined by the migrant in the second period.

In the second period, the migrant M gets a formal sector job, with wages w^H, with probability $p(b)$, or an informal sector job, with wages $w^L < w^H$, with probability $1 - p(b)$. If he gets a formal sector job or other employment with high wages, he is expected to remit a part of his earnings to the household. If he does not obtain a high income, he is not expected to remit. We model this in the following simple way: Expected sanctions are a function of remittances $R \geq 0$ and carry a utility cost to the migrant, denoted $\psi\left(\bar{R} - R\right)$, where $\psi(0) = 0$ (if remittances equal $\bar{R}$), $\psi' > 0$. This is the first assumption referred to above. However, in practice the ability of the rural community to 'sit down and discuss appropriate measures' depends in part on the civil society of the rural village. We model this by including the term $q(TF)$, where q is the probability that such measures are implemented and $q' < 0$ captures that this probability decreases in the degree of tribal fractionalization; hence, with probability $1 - q$ measures are not implemented and utility cost is zero, and if no measures are taken, expected utility cost is zero. This is the second assumption referred to above.

[13] We abstract from the household's choice of education for the *group* of children; modelling this empirically using a count data model yields similar results. In practice, there is wide variation in the years of completed schooling. In the Kagera data, migrant children report years of completed schooling and there is positive support for the full range of school years from 1 to 11.

Based on this, the migrant solves

$$\max_{R\geq 0} p(b)\left[u\left(w^H - R\right) - q(TF)\,\psi\left(\bar{R} - R\right)\right] + (1 - p(b))\,u\left(w^L\right)$$

In that case, the first order condition[14] for an interior solution R^* becomes

$$u'\left(w^H - R^*\right) = q(TF)\,\psi'\left(\bar{R} - R^*\right) \text{ if } R^* > 0 \tag{2}$$

and for the corner

$$u'\left(w^H\right) > q(TF)\,\psi'\left(\bar{R}\right) \text{ if } R^* = 0. \tag{3}$$

The first order condition implicitly defines optimal remittances R^* as a function of tribal fractionalization, TF. Knowing the level of remittances in the second period given a high wage income, parents now solve (1). We assume that there is an interior solution to this problem, characterized by the first order condition[15]

$$v'(A + 1 - b(1+e))(1+e) = p'(b)\left[v(A+R) - v(A)\right]. \tag{4}$$

We can now determine the effect of the community's ability to sanction non-remitters, characterized by the tribal fractionalization of the village, on the amount on schooling as

$$\frac{db}{dTF} = \frac{db}{dR}\frac{dR}{dTF}. \tag{5}$$

Straightforward differentiation of (2) and (4) yields[16]

$$\frac{db}{dR} > 0 \text{ and } \frac{dR}{dTF} < 0$$

[14] The second order condition for a maximum is

$$u''\left(w^H - R^*\right) - q(TF)\,\psi''\left(\bar{R} - R^*\right) < 0$$

which is satisfied if $\psi'' > 0$ or not too negative. We assume this to be the case.

[15] Again, the second order condition for a maximum is that $v''(A + 1 - b(1+e))(1+e)^2 + p''(b)\left[v(A+R) - v(A)\right] < 0$ which is the case for example if $p'' \leq 0$.

[16] The expressions are, respectively,

$$\frac{db}{dR} = \frac{-p'(b)\,v'(A+R)}{v''(A+1-b(1+e))(1+e)^2 + p''(b)\left[v(A+R) - v(A)\right]} > 0$$

and

$$\frac{dR^*}{dTF} = \frac{-q'(TF)\,\psi'\left(\bar{R} - R^*\right)}{u''\left(w^H - R^*\right) - q(TF)\,\psi''\left(\bar{R} - R^*\right)} < 0.$$

which yields

$$\frac{db}{dTF} = \frac{db}{dR}\frac{dR}{dTF} < 0. \tag{6}$$

Thus, increasing tribal fractionalization decreases the risk of being sanctioned by the community, which decreases remittances sent. Households, recognizing this, respond by spending less on education in the first period. If $R = 0$ in the corner solution, there is no return on the investment b and, in the absence of altruism and schooling laws, the optimal choice of b is zero.[17]

In sum, this simple model predicts a reduced form causal relationship between village level tribal fractionalization and schooling decisions. However, as noted in the introduction, there exists a number of potential explanations that could account for such an empirical relationship between tribal fractionalization and schooling. To discriminate between these competing explanations, we utilize the additional structure provided by the model in the decomposition (5) to test the hypothesis that the causal relation from tribal fractionalization to schooling is based on the intergenerational contract, whereby social norms and the scope for social sanctions govern payment of remittances, which in turn influences the household's decision to invest in schooling in the first place. We defer the investigation of alternative explanations to section six, below.

4 Data

We employ several data sets from Tanzania to investigate the hypothesis that tribal fractionalization affects schooling decisions, and that it does so through the intergenerational contract. This section describes the quantitative data, which consists of several large-scale household surveys.

4.1 Quantitative data sources

Our main sources of data are two large-scale household data sets from Tanzania, both collected in the early 1990s. One is a nationally representative cross-sectional survey of 5184 households from 1993-94, the Human Resource Development Survey (HRDS); the other is a detailed regional four wave panel survey of over 800 households in 51 clusters, the Kagera Health and Development Survey (KHDS), carried out in the Kagera region of Northwestern Tanzania from 1991-1994 at six month intervals.[18,19] Both data sets sample rural households with school-aged

[17] Compulsory schooling laws were considerably strengthened in Tanzania in the late 1990's, after the period from which our data stems. Our group interviews confirm much more widespread education than 10 years before.

[18] Both data sets are collected by the World Bank as Living Standards Measurement Surveys (LSMS). They can be downloaded from http://www.worldbank.org/lsms/

[19] Kagera borders on Rwanda and experienced a large inflow of Rwandan refugees following the 1994 genocide (see Center for the Study of Forced Migration, 2003). Our village-level measures are based on the first wave of the survey, carried out in 1991-92, and are not affected by the mid-1990s refugee situation in Tanzania.

children, but only the KHDS includes information on migrant children. We use the HRDS data set whenever feasible, as it is both a much larger data set and nationally representative.

Our main empirical investigation is based on the HRDS, and this data set also allows us to test three out of four alternative explanations referred to in the introduction. However, when investigating our hypothesized causal path, that the negative effect of TF on schooling stem from lower levels of remittances and weaker intergenerational contracts between migrant children and their parents, we have to use the more detailed regional survey as well as our qualitative data, both from Kagera. In the KHDS, extraordinary care was devoted to collecting data on children of the household living elsewhere. This includes their geographical location, level of education, employment status and, not least, their level of remittances. This is unusual for household surveys, which typically collects information only on current household members.

Finally, we also make use of a third data set, the Social Capital and Poverty Survey (SCPS) collected in 1994-95 in most of the rural HRDS clusters.[20] It is therefore possible to merge HRDS and SCPS data at the village level, although the households surveyed are not identical. We use the SCPS data for analyzing and testing some of our alternative explanations.

4.1.1 Sampling

The sampling in the HRDS is based on the sampling frame of the National Master Sample collected by the Tanzanian Bureau of Statistics. It uses all the 222 clusters of the National Master Sample, 100 of which are rural villages while 122 are enumeration areas in urban settings. Within each cluster, 20-25 households were sampled at random, see Ferreira and Griffin (1996).

KHDS was originally collected to measure the impact of adult mortality and morbidity on the welfare of individuals and households. Kagera was chosen mainly because it was the epicenter of the East African AIDS epidemic. The sampling of KHDS therefore focused on oversampling households with high probability of adult mortality. This resulted in a two-stage stratified random sample, where the stratification was done over agronomic zones at the cluster level and over joint morbidity and mortality status at the household level. This resulted in 51 clusters of 16 households in each, out of which 14 households were characterized as 'sick' and 2 households as 'well' during the enumeration. 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 produce consistent estimates and allow for valid inference (Wooldridge, 2002). We test for differences in results between 'well' and 'sick' households when using the KHDS data and find no effects.

[20] SCPS was also collected by the World Bank, but not as part of the LSMS set-up.

4.1.2 Tribal fractionalization measure

We measure the strength of informal institutions by the degree of tribal fractionalization. We focus on tribal affiliation rather than clan membership, as we have no data on the latter and recognizing, with Horowitz (1985, p.60), that "[t]here is no bright line to be drawn between kinship and ethnicity, especially in societies where the range of recognized family relationships is wide and the importance of kinship ties is great." For a village k, the value of the tribal fractionalization index TF is given by

$$TF_k = 1 - \sum_{h \in H_k} \theta_{hk}^2$$

where θ_{hk} is the population share of tribe h in village k, and H_k is a partition of tribes in village k such that the tribal shares sum to one in each village. The tribal shares θ_{hk} are village level estimates based on individual household responses in HRDS; while the empirical analysis below concentrates on households with school age children, the estimates of the tribal shares are based on the entire, substantially larger, HRDS sample. Figure 1 shows the distribution of villages with respect to the fractionalization measure, both in total and for rural and urban areas separately.

< Figure 1 here >

In the empirical specification below, we follow the recommendation by Vigdor (2002) by including also tribal population shares on their own. Excluding tribal shares would imply the behavioral restriction that all tribes have the same propensity to invest in education, regardless of the tribal composition of their village. It could be the case that some tribes, possible for reasons of tradition or degree of modernization, are more prone to investing in formal education, and we capture this by including the individual shares.[21] As we note below, the individual tribal shares are jointly strongly significant, also if we include the TF index.

5 Empirical specification and identification

The simple model above yields several testable empirical predictions, two of which stem directly from the first order conditions for schooling (4) and for remittances (2), respectively. These first order conditions can be directly translated into reduced form regressions.

Empirically, we model the household's choice of education based on (4) as a binary variable, which equals one if a school-aged child is enrolled in or has completed primary school, zero

[21] Some tribes have more traditions for migration, a necessary part of education paying off (Connell et al. 1976, ch. 2) while there are also differences between tribes in their propensity to carry out punishments (McElreath, 2004).

otherwise.[22] The reduced form is estimated as a standard logit model, where a child is enrolled if the optimal b from equation (4) is greater than or equal to the equivalent of seven years of primary schooling, $\underline{b}$. We know from the first order condition that b can be characterized as a function of direct and indirect schooling costs, household income in period 1 and period 2, the urban employment probability function and tribal fractionalization through future remittances. To the extent possible, these variables, or their close proxies, are included in the regression model, along with a range of control variables, $\mathbf{X}$, which have been found to affect the choice of schooling or might control for some of the unobserved future variables. Our main estimating equation, the schooling regression, is given by

$$prob(b \geq \underline{b}) = \Lambda(\alpha_0 + \alpha_1 e + \alpha_2 w^T + \alpha_3 A_1 + \alpha_4 TF + \boldsymbol{\beta}\mathbf{X}). \tag{7}$$

Based on the model, our hypothesis is that $\alpha_4 < 0$. The estimation of (7) is based on a sample of all children of household heads between 7-17 years of age[23] drawn from the Tanzania-wide HRDS data set. Households base their schooling decision on their expectations about future remittances. This implies that there are two underlying conditions which must hold for the schooling first order condition, and thus the reduced form regression above, to be valid. First, an underlying assumption of the model is that the probability of formal employment must be increasing in b, i.e. $p'(b) > 0$. Second, the degree of tribal fractionalization must have a negative effect on remittances, $\frac{dR}{dTF} < 0$. Both of these conditions relate to second period variables for the migrant child. These are necessary, but not sufficient, conditions to identify the model. To investigate these second period relations, we turn to the KHDS data with its detailed information about migrant children.

We investigate the assumption that $p'(b) > 0$ by simply regressing the probability of formal employment on the level of schooling of the migrant along with controls for age, gender, and geographical location, $\mathbf{W}$. We focus on formal employment which guarantees the migrant a monthly wage as the distinction between unemployment and self-employment (e.g. as petty-trader) or informal jobs is often very blurred in developing countries. We find this to be the case – primary schooling increases the chances for formal sector employment in a strongly significant way, as does secondary schooling.[24]

The second condition which must be satisfied for our main regression to be a valid reduced form of the model relates remittances to the degree of tribal fractionalization; the migrant's

[22] School enrolment reflects the long run decision of the parents, whereas recent school attendance is subject to temporary fluctuations in household resources. Enrolment is also preferred over school attainment to ensure a reasonable link between schooling decisions and current income levels.

[23] Since school enrolment is often delayed, we widen the official school age with two years from 7-17 rather than 7-17 years. We are not including foster children, or other children not directly related to the household head, as their intergenerational contracts will be different. The sample is drawn from the Tanzania-wide data set, HRDS. Results are replicated using the KHDS data with the same sample selection.

[24] Results are enclosed as table A.3.

first order condition (2) implies that $\frac{dR}{dTF} < 0$. This translates into a regression of the level of remittances on employment status, and the probability that sanctions for non-remitting migrants are invoked, which depends on the time invariant variable TF. We estimate this as a censored (or corner-solution) Tobit model, since we frequently observe remittances equal to zero. The censored Tobit is set up in terms of a latent variable, where the optimal amount of remittances for each individual is

$$R_i^* = \delta_0 + \delta_1 w_i^H + \delta_2 TF + \boldsymbol{\gamma}\mathbf{Z}_i + u_i,$$

where $\mathbf{Z}$ is a set of control variables, including individual, household and village characteristics. The model predicts that $\delta_1 > 0$ and that $\delta_2 < 0$. A necessary identification condition of the model is thus that we do not reject $\delta_2 < 0$. In principle, R_i^* can be negative if the migrant would like to receive remittances from the family, but since this is not the migrant's decision to make and we do not observe such wishes, R_i^* is censored at the corner solution zero; in the data, we observe $R_i = \max(0, R_i^*)$. The conditional expectation of R given our explanatory variables is then a composite measure of the probability of remitting and the expected value of remittances, given that the migrant child is remitting.

$$E(R|w^H, TF, \mathbf{Z}) = prob(R > 0|w^H, TF, \mathbf{Z})E(R|w^H, TF, \mathbf{Z}, R > 0) \tag{8}$$

We will primarily model the level of remittances as a Tobit model, which assumes homogeneity and normality about the error term u_i for the δ-estimates to be consistent. To get additional insights into the nature of remittances, we use a hurdle model, which is a decomposition that essentially corresponds to a joint result of a probit model of the probability of remitting and a linear regression of the conditional expectation of the level of remittances in the uncensored part of the sample.

5.1 Identification

In the regression analysis below, we estimate investment in schooling and payment of remittances on tribal fractionalization. For the resulting estimates to be interpreted as causal effects, we need to consider identification of the empirical model. First, the tribal fractionalization of a village could be endogenous to school quality or variables related to this. Second, estimates of α_4 in (7) could represent effects of other slow-moving village level variables on schooling and remittances rather than TF having an effect of its own.

Regarding the first concern, we can rely on the historical fact that there has been relatively stable tribal settlement patterns in rural Tanzania since the mid-1970's. Most villages in rural Tanzania were established well before colonial rule ended, and from the mid-1970's up to the

early 1990's, which is when the surveys that we employ were collected, mobility was limited in Tanzania, though not non-existent, as has been the case in neighboring Kenya (see Miguel, 2003). The villagization program, *Ujamaa*, carried out in the mid-1970's, forced some rural residents to move to other, often newly constructed, villages and in the following period rural mobility has been severely restricted, to have increased only recently. This, in itself, suggests that migration into *rural* communities, which are the focus of our investigation, has been limited.

This is confirmed by data from the SCPS, where respondents were asked to rate whether they perceived migration into their community as high. We code a village to have high frequency of migration if more than a third of the respondents in the village think so. Even with this generous definition, only nine percent of villages were classified as having a high frequency of migration. There is no significant difference in the migration pattern across more and less heterogenous villages, and excluding the high frequency villages from the analysis below does not change results, see bottom panel of table 1 below.

Regarding the second concern, which is also related to possible alternative explanations to which we return in section seven, we include a wide range of village level controls in the estimating equations. As a more direct and transparent preliminary investigation, in table 1 we compare the most homogenous quintile of HRDS/SCPS villages with the most heterogenous quintile across a number of variables that could be related to tribal fractionalization. Correlations across the full sample yields similar results, but the comparison in table 1 facilitates interpretation. The table reports mean values for the characteristics for the two groups of villages, as well as the difference and the resulting t-test values.

< Table 1 here >

The table suggests a well-balanced sample for household expenditure and hectares of land owned with respect to tribal homogeneity, but household size (and thus fertility) is significantly higher in low TF villages. As for our alternative explanations, there is also support for some of these. There is no direct evidence that perceived school quality is consistently higher in low fractionalization villages, nor are there any significant differences in term of schooling expenditure or school distance between high and low TF villages. Only among school supplies do we find a very marginal difference in favour of low TF villages. This is as expected and found by Miguel and Gugerty (2005) for Kenya. There is more support for the informal credit and land scarcity explanations. In low TF villages, 21 per cent of the households report that if they faced a sudden credit need of approximately 100 USD, then they would first ask their family, friends or relatives for assistance, as opposed to pawn shops, local traders, banks or credit cooperatives. This is almost 10 percentage points higher than in high TF villages and the one sided t-test is also clearly significant with a p-value of 0.04. Likewise, 43 per cent of

households in low TF villages report that land is very difficult to obtain (although there is no significant difference in number of ha of land owned), and 26 per cent of households that it is mainly acquired through inheritance.[25] These numbers are also significantly higher than in low TF villages. This shows the importance of also testing the significance of these different variables in the schooling regression along with TF. Including these variables as controls will ensure that their effects on schooling are captured separately from any effect of TF.

6 Results

6.1 Schooling, informal institutions and tribal fractionalization

The results from the estimation of the relationship between school enrollment and tribal fractionalization (equation (7)) is shown in table two, with standard errors corrected for clustering at the village level in parentheses. Model 1 includes a constant, the tribal fractionalization index, TF, and controls for the tribal population shares at the village level. This simple model shows that there is a significantly negative effect of TF on the probability of a child being enrolled in school; model 2 adds regional controls, which does not affect the estimated effect of TF; in any case, the magnitude of this estimated effect is likely to be biased due to omitted variables.[26]

Model 3 includes a set of key explanatory variables, some originating from the theoretical discussion above, some being standard controls in the literature on school enrolment. These include the household expenditure level as a measure of the household's resources,[27] and measures of direct and opportunity costs of schooling. The latter are present if a household owns land, has direct agricultural income, or has a herd, in which case the need for (possibly, part time) child labor is higher, increasing the opportunity cost of educating children formally.[28] Additionally, distance to school matters as children who spend more time travelling to school are less available for part-time work, such as fetching water or caring for younger siblings. Furthermore, we include prospects of non-agricultural employment (measured by the proportion of the adult village population in formal or informal employment).

[25] As several group discussants noted, parents have an obligation to give their children either a shamba (a plot of land) or an education (and sometimes both). If land is scarce, the only possiblity for giving your children a piece of land is by subdividing your own shamba, which would show up in the data as a smaller average shamba size.

[26] The corresponding summary statistics are shown in Table A1 in the appendix

[27] The effect of household incomes on the child labor vs. schooling choice is not unambiguous. See Baland and Robinson (2000) and Rogers and Swinnerton (2004).

[28] Land and herd ownership can influence the choice of education in other ways as well. As noted by Lucas and Stark (1985), households with inheritable assets receive more remittances. In our framework, household assets can be used in the bargaining over remittances to increase the flow of funds from migrants to parents, increasing the expected return on schooling.

< Table 2 here >

Finally, model 4 includes school quality indicator variables to control for the effects identified by Miguel and Gugerty (2004) that ethnically diverse communities in Kenya are less successful in securing voluntary contributions for funding primary schools, which could conceivably affect perceived quality of such schools. In our case, however, including school quality variables affects the estimated effect of TF only marginally, echoing the small differences across homogenous and heterogenous villages observed in table 1.

The estimated coefficients on tribal fractionalization are reasonably stable across the specifications, and the TF coefficient is negative and significant at the 5 % level throughout. Based on model 4 in table 2, the marginal effect of increasing tribal fractionalization equals -0.23; thus, increasing tribal fractionalization by one standard deviation (.26 in our sample) lowers the probability of being in school by 6 percentage points. The remaining explanatory variables all have the expected sign, but a few are insignificant. The level of household expenditures has a positive significant impact on the schooling decision, but it is reduced when the main income source is agricultural and children thus are needed for help; a similar conclusion comes from the negative effect of the household having a herd. Furthermore, girls are enrolled in school more often than are boys, while a greater distance to school, measured as the average at the cluster level, decreases school enrollment.

Table 3 shows results divided by gender. The effect of TF on schooling is larger for girls than for boys, as there is more variation in the schooling of girls, but both estimated effects are significant and sizeable. Additionally, we see that it is the education of girls that drives the result on income. The education of girls thus seem to be somewhat more of a luxury decision, made when there are funds for it. This is confirmed by the group interviews, where the education of boys is always preferred over the education of girls, partly because the education of girls is perceived to be associated with more risk for two reasons: first, girls might get pregnant when attending school (especially secondary school) and subsequently drop out; second, once married, the obligations of a woman lie primarily with her husband's family and not her own. Her parents can therefore not expect or demand assistance from her, but only hope for it.

< Table 3 here >

As for the marginal effects of TF on the schooling probability of girls and boys, the effects remain significantly negative and of the same order of magnitude; the probability of school attendance of girls is reduced by almost 25 percentage points and of boys by 20 percentage points when moving from a complete homogenous village to a heterogenous village. The results are thus robust to choice of specification.

The result that increasing tribal fractionalization decreases the probability of school enrollment is the first step in showing how informal institutions influence the intergenerational

contract. We now turn to the second step, examining in more detail the more specific partial derivatives predicted by the decomposition of the reduced form relationship.

6.2 Remittances and tribal fractionalization

Out of the 714 rural households observed in the first wave of KHDS, 76% of all households received remittances within the past 12 months of the interview, and 52% of all households have received remittances from Children Living Elsewhere (CLE), i.e. individuals about whom we have additional information such as educational background and economic activity. There is a significant positive difference between remittances sent from children with primary education or more and children without education, confirming that households are rational when expecting remittances to increase with education; we return to this below.

We also find that there are significant positive differences in the proportion of households receiving remittances in low TF villages compared to high TF villages; this is the case both for all remittances received and for remittances from children. In the most homogenous villages, the average proportion of households receiving remittances is 76%, and 53% of households receive remittances from their children, compared to average proportions of 69% receiving from anyone and 47% receiving from children in the most heterogenous villages. This is supportive of our second assumption, and is confirmed in the regression analysis below.

For the regression analysis, we focus on the migrant's decision to remit to a household in his or her village of origin. For sample migrants who live within the region of Kagera, 12 % ($n = 1309$) remitted in the past six months of the survey, while for migrants living outside of Kagera, 22 % ($n = 554$) remitted. However, migrants living nearby often assist families in various ways beyond, or instead of, monetary remittances, types of assistance which are substitutes for monetary transfers, but not captured by the survey used here. Thus, including nearby migrants with faraway migrants can bias results related to monetary remittances. As a consequence, we focus on the sample of migrants outside of Kagera, as they do not have the opportunity of providing in-kind assistance to the same extent. At the same time, there is ample evidence that migrants, and in particular migrants to faraway towns, are a selective sample (Stark, 1991). While we do control for available individual characteristics, it remains likely that migrants leaving Kagera are different from those staying put on a number of, possibly unobservable, dimensions. This provides another reason for focusing on the sample of migrants outside of Kagera.

Table 4 relates the payment of remittances by migrants to characteristics of the individual CLE, the recipient household, and the village of the recipient household, see equation (8) above[29]. As noted in the introduction, most of the economic literature on remittances has fo-

[29] The corresponding summary statistics are shown in table A2 in the appendix.

cused on sender and recipient characteristics, while some work in demography has also included a limited selection of village-level characteristics.[30] We base our choice of control variables on the standard of the remittances literature (see, e.g., Vanwey, 2004), but include also additional village level characteristics that can be thought to influence the intergenerational contract, including various inheritance rules and traditions.

< Table 4 here >

In the sample of migrant children living outside Kagera, 78 % choose the corner solution of no remittances in the first wave (equation (3) above). This number increases in subsequent waves due to the very short time span of six months between each wave. The censoring means that OLS estimation will produce inconsistent estimates, but the OLS results reported in table 1, model 1, nevertheless provide a benchmark for more complex models, and, furthermore, assists us in assessing the appropriateness of subsequent specifications below. For now, we simply observe that the negative estimated effect of TF is statistically significant.

In reality, remittances are either positive (interior solutions) or zero in the corner solution. Model 4.2 present results from a Tobit model, which allows for corner solutions in a natural way. In this specification, the estimate on TF is negative and strongly significant, consistent with parents in more heterogenous villages expecting remittances to be lower. The overall effect is not big: Increasing TF from the minimum to the maximum in the sample, 0 to .66, increases the (latent variable) amount paid by 1100 shillings, the equivalent of USD 2.40; note, however, that this is the amount sent within the last six months, meaning of course that the total return is much larger. The low magnitude of the (latent variable) estimate reflects the substantial mass point at zero. If we look at the two marginal effects separately, we find that the marginal effect conditional on paying is indeed quite small, while the effect of TF on the probability of receiving a positive amount (which can be calculated from the probit model, described below), as compared to zero, is reasonably large; increasing TF from 0 to .66 decreases the probability of observing positive remittances by 8 percentage points.

The results on controls are also of interest. First, we note that having a formal sector job and completed primary or secondary education strongly increases the probability of sending remittances. We obviously encounter the problem that TF can have influenced schooling in the first place, as demonstrated above, but our estimate of the direct effect is not greatly affected by the in- or exclusion of the schooling variables. The main effect of excluding the schooling variables is that TF becomes significant at the 1% level.

In addition, girls remit more than boys (but see below), and households with more land receive more remittances. Households in communities with mutual aid among farmers, possibly

[30] Denoted "contextual effects" in the demography literature, such village level characteristics often include history of migration or village level measures of economic conditions.

representing higher social capital or cooperation in general, receive more remittances. This is consistent with remittances being sent not to alleviate household idiosyncratic income shocks, but rather to be in good standing with the community. The same interpretation can be applied to the result that households in communities that have experienced inheritance disputes in the past year receive higher remittances: if inheritance rules are not fully agreed upon, it can be important to maintain a good relationship with the household (see also Lucas and Stark, 1985). Overall, remittance patterns differ somewhat between tribes, and in general remittances decrease from the first wave to the subsequent three, reflecting that in the first wave respondents were asked about receiving remittances in the past 12 months, while subsequent waves asked about remittances in the past six months.

6.3 Robustness

In model 3, table 4, we model the sending of remittances as a binary decision, equal to one if remittances are sent and zero otherwise. We estimate this using a probit model; again, TF enters in a negative and statistically significant way. This specification also allows us to assess the appropriateness of the Tobit-model. Under the assumption of normality, $\gamma \equiv \beta/\sigma$ where γ is the coefficient on TF in the probit specification, β the corresponding coefficient in the tobit specification and σ the standard error of the tobit (see, e.g., Wooldridge, 2002, p. 521). Using the estimation counterparts, we find that $\hat{\gamma} = -.98$ and that $\hat{\beta}/\hat{\sigma} = -10.48/11.10 = -.94$, which does not suggest misspecification of the tobit model. As another check, we note that the share of observations with positive remittances ($= .13$) multiplied by the tobit estimate on TF (-10.48) yields -1.36 which is quite close to the OLS estimate of -1.07, as should be the case under assumptions of joint normality under censoring from below at zero (Wooldridge, 2002).[31]

In model 4, table 4, we estimate an OLS model conditional on remittances being positive. The size of the estimated coefficient is roughly as in model 4.1, but the standard error somewhat larger as the number of observations has dropped by almost a factor of 10. Models 4.3 (probit) and 4.4 (OLS conditional on sending) together approximate a hurdle model, which allows for the effects of the explanatory variables to differ between the qualitative choice of choosing no or positive remittances, and the quantitative choice of choosing the amount of remittances.[32] We find that TF affects negatively both the decision to send remittances at all and the decision on how much to send, conditional on sending, which accords well with the corner solution structure of the model; the estimated coefficients suggest, as discussed above, that the quantitatively

[31] Additional specification checks for heteroscedasticity were carried out based on the probit model. We found little evidence of heteroscedasticity, and in the few case where some was present, notably primary education and formal sector jobs, it did not affect results.

[32] Alternatively, we could have modelled the continuous sending decision by a truncated regression model; this strengthens results on TF somewhat, but have no other effects.

important effect is on sending vs. non-sending rather than on the amount sent. While the smaller sample of the conditional OLS model requires careful comparisons, some variables are seen to affect the decisions whether to send and how much to send in different ways. In particular, girls tend to send at a much higher frequency than boys, but they send smaller amounts; thus, the sign on girls is positive in the binary sending model, while it is negative, albeit insignificant, in the model of how much to send. While beyond the scope of this paper, the hurdle model suggests that the factors affecting the act of sending remittances at all, which signals a willingness to send, can be different from the factors determining the amount sent.

7 Alternative explanations

A number of alternative explanations for the observed reduced form results exist: First, consider the role of urban networks. Urban networks can be important by helping arriving migrants get housing and work, and networks can also monitor migrants and remind them of their obligations towards those at home. Thus, strong urban networks increase the expected return on schooling and migration. If the functioning of urban networks is better when they are rooted in more homogenous villages, stronger urban networks, rather than a higher risk of sanctions, could explain the observed relationship between TF and schooling. We cannot observe the number of migrants in a city that come from a particular village, but one direct test for the influence of home village tribal fractionalization through urban networks is to model the probability of getting a formal sector, high paying job as a function of TF directly. While we find that schooling dramatically increases the probability of getting a formal sector job, as discussed above, we find no significant direct effects of TF (table A.1). Respondents in the group discussion were generally sceptical of urban networks acting on behalf of village households, arguing for example that securing remittances is not an objective of the network, and that information about individuals' behavior is generally not available [Cluster 2, item 8].

Second, from our group interviews it became clear that ethnically homogenous villages are often associated with being ancestral villages, where land is scarce, whereas heterogenous villages could be of more recent and uncertain origin and have a higher degree of land availability. Therefore, if parents are faced with the choice of either giving their child a plot of land or an education (cf. note above), the relative cost of providing children with a shamba would be lower in villages where land is available, which may happen to be where tribal fractionalization is high. We cannot observe village age in our data, but we do observe individual and average land holdings. In table 1, we saw that average shamba sizes were approximately equal across homogenous and heterogenous communities, and we control for household land holdings in regressions. For the detailed Kagera data, the bivariate relationship is in fact the opposite: more homogenous villages also have larger land holdings, which would tend toward choosing

less schooling for the children of the household.[33] Table 5 shows results from including into the main specification additional explanatory variables. While the first column reproduces our main choice of specification from table 2, columns 2 and 3 include, respectively, a measure of limited land availability and an indicator variable for land being mainly inherited. Neither of these are significant, and interactions with TF does not suggests any such effects.

< Table 5 here >

Third, living in an tribally homogenous village can increase the probability that a household hit by a negative shock receives assistance from fellow villagers, as part of an informal insurance system. At the same time, it can facilitate cooperation on sending children to school or funding migration for educated children. While a full investigation of the relationship between credit availability, insurance and tribal fractionalization is beyond the scope of this paper, we do have some evidence on (the lack of) a relationship between these. From table 1 we see that there are marginally better informal credit opportunities in the most homogenous villages compared to the most heterogenous villages, but as seen in model 4, table 5, this result does not carry over to a regression framework; the effect of informal credit availability is itself insignificant in the schooling regression, and does not affect the estimated effect of TF.[34] Furthermore, we could not find evidence to suggest that the effect of TF on schooling depends on the availability of credit opportunities; interacting TF with household expenditures (our equivalent of A_1 in the model) did not yield any results. As already mentioned, the other part of the intergenerational contract, the payment of remittances, was not affected by the existence of local insurance arrangements, measured by the availability of mutual aid among farmers in a village, even if the latter itself in some specifications did appear to be associated with higher remittances.

Finally, tribal fractionalization could be correlated with school quality, as suggested by Miguel and Gugerty (2005) in the case of Kenya. Better school quality would increase the demand for schooling, due to an expectation of better schooling outcome and thus urban labour market prospects. As we noted above, tables 1 and 2 show that school quality does not appear to be associated with tribal fractionalization and, furthermore, does not affect the estimate of the effect of TF on school enrolment decisions.

[33] Gulliver (1961) suggests that rural land scarcity in colonial times provided a catalyst for change of inheritance rules. Less available land meant that sons had a harder time acquiring land on their own, which led to pressure on, and in turn change of, past inheritance norms by which brothers were the first to inherit. In turn, this created incentives for sons to influence the division of the inheritance, in part by remaining in good standing with the home village.

[34] In addition, group interview respondents in all villages strongly disagreed with the idea that families would jointly raise money for funding migration for particular children; this was simply unheard of.

8 Discussion

The intergenerational contract has two components: investment in schooling and payment of pensions. While intergenerational contracts in developed economies are generally managed by the state, in developing economies with weaker state structures and less fiscal capacity, intergenerational contracts are generally thought to be enforced by traditions and social norms, often rooted in tribal or ethnic affiliations. The analysis presented in this paper takes a comprehensive approach to analyzing intergenerational contracts in developing economies, including decisions on both schooling and pensions (in the form of remittances), joined together by and enforced through tribal identity.

Our findings are at odds with the notion that all traditional institutions are a hindrance to development. In rural Tanzania, it is exactly traditional institutions that help overcome enforcement problems inherent to the family bargaining underlying educational choice, migration, and remittances. If such traditions weaken, and social structures lose some of their power, the move towards more education and, ultimately, a higher standard of living, could be delayed or impaired if other institutions do not take their place. Therefore, while informal institutions would not necessarily be a part of the first best solution in a fully modernized state, they may be able to correct, at least partially, distortions arising from underdeveloped credit markets. insufficient social insurance systems and lack of fiscal capacity.

At the same time, the interconnection between tribal or ethnic identity and the provision of schooling and pensions suggests that successful government involvement in, say, basic schooling, can have implications for the informal provision of pensions as well as patterns of tribal affiliations. Conversely, policies directed at national identity or unity can have consequences for the provision of both schooling and pensions. This is important as the weakening of traditional institutions are sometimes an independent policy initiative of national governments. In Tanzania, in particular, there has been consistent efforts since the 1960's to create a nation state to replace tribal communities. While this effort has been successful in many ways (Miguel, 2004), including creating a strong national identity, the results of this paper suggest that tribal affiliation still has implications for the daily lives of Tanzanians, an impression strongly supported by our group interviews. A main reason for this, of course, is that existing authority structures such as tribes and elders do not simply sit around and wait for their authority to be challenged by government strategies aimed at replacing traditional allegiances. As noted by Bates (1999), in some parts of sub-Saharan Africa the notion that villagers must be buried in the place they were born is actually quite recent, dating from the 1970's when youth began to question the elders' authority and, hence, the reason to remit and stay on good terms with the rural community. Similarly, Snyder (1997) reports that the continuation of religious rituals among the Iraqw of northern Tanzania is closely linked to the legitimacy of political authority;

if the role of the religious ritual is weakened, so is the elders' authority which involves allocating land and settling disputes.

We see the results of this paper as a testimony to the fact that ethnicity, and more broadly identity, can sometimes help create and support important economic transactions which would otherwise not be realized due to weak formal institutions or underdeveloped markets. The absence of ethnic affiliation would not necessarily imply that more beneficial transactions would be undertaken; rather, as noted by Carr and Landa (1983), or Greif (1993) in the context of Mediterranean traders in fourteenth century Europe, existence of an ethnic identity can help sustain exchange where there would otherwise be none.

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Table 1: Differences across homogenous and heterogenous communities

Cluster means	Low *TF*	High *TF*	Difference	*t*-test	*p*-value
HRDS variables					
Household size	6.47	5.94	.52	1.84	.07
Hhd expenditures per a.e.	.80	.89	.09	1.05	.30
Land (ha)	12.21	10.59	1.62	0.91	.37
School expenditures	6.66	5.83	.83	0.67	.51
Distance to school	1.61	1.77	.16	0.57	.57
School quality variables					
Teachers good/adequate*	.73	.80	.07	1.40	.91
School supplies g/a*	.42	.36	.06	0.95	.17
Environment g/a*	.54	.50	.04	0.72	.23
Swahili lessons g/a*	.83	.90	.07	1.39	.91
English lessons g/a*	.56	.63	.07	1.47	.93
Math lessons g/a*	.73	.82	.09	1.88	.97
SCPS variables					
High migration freq.	.06	.10	.04	0.64	.52
Informal credit*	.21	.12	.09	1.82	.04
Limited land availability*	.43	.22	.21	2.03	.02
Land mainly inherited*	.26	.15	.11	2.01	.03

Note: Numbers may not add up due to rounding. Differences and t-test statistics are absolute numbers. The t-tests have 43 d.f. and are assumed to have equal variances. # clusters in low TF is 23 and in high TF is 22. *p-values are for one-sided hypothesis testing of better school quality, better informal credit opportunities and less access to land, respectively, in low TF villages. Sample is based on rural HRDS and SCPS clusters.

Table 2: School enrolment and tribal fractionalization

School logits	(1)	(2)	(3)	(4)
TF	-0.641***	-0.688**	-0.848**	-0.777**
	(0.238)	(0.282)	(0.343)	(0.339)
Age			2.018***	2.029***
			(0.140)	(0.140)
Age^2			-0.069***	-0.070***
			(0.006)	(0.006)
Birth order			-0.050	-0.043
			(0.036)	(0.036)
Girl			0.261***	0.262***
			(0.085)	(0.086)
Daily HH expenditure per AE ($)			1.083***	1.144***
			(0.412)	(0.427)
Agriculture is main income			0.239	0.235
			(0.320)	(0.331)
HH exp*Agricultural income			-0.771*	-0.805*
			(0.448)	(0.461)
School expenditure, cluster av.			0.000	-0.007
			(0.027)	(0.027)
School distance, cluster av.			-0.237***	-0.238***
			(0.087)	(0.088)
Household has herd			-0.332***	-0.345***
			(0.104)	(0.107)
Total number of children			0.064***	0.063***
			(0.022)	(0.022)
Land (ha)			0.008	0.009
			(0.006)	(0.007)
Land^2			-0.000	-0.000
			(0.000)	(0.000)
Tribal population shares	no	yes***	yes***	yes***
Region controls	no	yes	yes**	yes**
School quality controls	no	no	no	yes*
Observations	3826	3826	3826	3826
Pseudo R-squared	0.005	0.019	0.285	0.288

Robust standard errors in parentheses, corrected for clustering at the village level.
*** p<0.01, ** p<0.05, * p<0.1.
Results on included constant term not reported.

Table 3: School enrolment and tribal fractionalization by gender

School logits	(1) All	(2) Girls	(3) Boys
TF	-0.776**	-0.893**	-0.702**
	(0.339)	(0.413)	(0.357)
Age	2.029***	1.931***	2.162***
	(0.140)	(0.207)	(0.178)
Age^2	-0.070***	-0.066***	-0.075***
	(0.006)	(0.009)	(0.007)
Birth order	-0.038	-0.049	-0.022
	(0.036)	(0.047)	(0.047)
Girl	0.263***		
	(0.086)		
Daily HH expenditure per AE ($)	1.144***	1.254***	1.147*
	(0.427)	(0.481)	(0.646)
Agriculture is main income	0.235	0.020	0.522
	(0.331)	(0.366)	(0.545)
HH exp*Agricultural income	-0.805*	-0.911*	-0.828
	(0.461)	(0.526)	(0.708)
School expenditure, cluster av.	-0.007	-0.003	-0.010
	(0.027)	(0.036)	(0.026)
School distance, cluster av.	-0.238***	-0.256**	-0.213**
	(0.088)	(0.117)	(0.092)
Household has herd	-0.346***	-0.442***	-0.270*
	(0.107)	(0.164)	(0.138)
Total number of children	0.061***	0.064*	0.055**
	(0.022)	(0.035)	(0.026)
Land (ha)	0.009	0.015*	0.004
	(0.007)	(0.009)	(0.008)
Land^2	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Constant	-12.443***	-11.227***	-13.695***
	(0.947)	(1.228)	(1.269)
Tribal population shares	yes***	yes***	yes***
Region controls	yes**	yes	yes***
School quality controls	yes*	yes	yes*
Observations	3826	1895	1931
Pseudo R-squared	0.288	0.286	0.298

Robust standard errors in parentheses, corrected for clustering at village level. *** p<0.01, ** p<0.05, * p<0.1.

Results on included constant term not reported.

Table 4: Remittances and tribal fractionalization

	1	2	3	4
	OLS	Tobit	Probit	OLS
	log(remit)	log(remit)	remit n/y	log(remit)
TF	-1.07**	-10.48**	-0.98**	-1.11
	(0.49)	(5.17)	(0.47)	(0.68)
Formal sector job	1.15***	5.73***	0.54***	0.25*
	(0.17)	(0.89)	(0.09)	(0.14)
Completed primary school	0.48***	7.41***	0.67***	0.19
	(0.13)	(1.32)	(0.12)	(0.14)
Completed secondary school	1.04***	8.38***	0.76***	0.48***
	(0.34)	(1.55)	(0.16)	(0.16)
Girl	0.36**	3.27***	0.31***	-0.18
	(0.14)	(0.94)	(0.09)	(0.15)
Age	0.08***	1.04***	0.09***	0.19***
	(0.02)	(0.23)	(0.02)	(0.06)
Age^2	-0.00***	-0.01***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
(mean) hhsize	-0.02*	-0.07	-0.01	0.02
	(0.01)	(0.10)	(0.01)	(0.02)
Daily HH expenditure per AE ($)	-0.08*	-0.89	-0.09	0.14
	(0.05)	(0.55)	(0.06)	(0.14)
Agriculture is main income	-0.04	0.98	0.11	-0.68**
	(0.13)	(0.86)	(0.09)	(0.27)
Log(Land (ha))	0.20**	1.56***	0.15***	0.11
	(0.08)	(0.57)	(0.06)	(0.10)
Household has herd	-0.01	-0.07	-0.01	-0.01
	(0.01)	(0.05)	(0.00)	(0.01)
Mutual aid among farmers	0.18	1.56*	0.14	0.02
	(0.12)	(0.89)	(0.09)	(0.16)
Community population size	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Inheritance disputes past 12m	0.22*	1.32*	0.13*	-0.01
	(0.11)	(0.76)	(0.07)	(0.18)
Can wife inherit land	0.16	1.24	0.11	0.10
	(0.12)	(0.75)	(0.07)	(0.15)
Funeral arranged by family or clan	-0.24*	-1.70*	-0.16*	-0.04
	(0.14)	(0.97)	(0.09)	(0.13)
Tribe of HH head§	0.000	0.015	0.008	0.087
Village level tribal shares§	0.000	0.000	0.000	0.005
Religion§	0.499	0.394	0.315	0.219
Survey wave§	0.006	0.002	0.001	0.350
sigma^hat		11.10***		
		(0.32)		
Sample	Full	Full	Full	remit > 0
Observations	2875	2875	2852	346
R-squared	0.161	0.116	0.219	0.290
No. of clusters	40	40	40	39
log likelihood		-1843.0	-822.9	

Robust standard errors corrected for clustering at village level in parentheses.
A constant was included but is not reported.
*** p<0.01, ** p<0.05, * p<0.1
§ Reports p-values for F-tests that all variables within category are zero.

Table 5: Alternative explanations

School logits, HRDS sample	(1)	(2)	(3)	(4)
TF	-0.776**	-0.781**	-0.786**	-0.765**
	(0.339)	(0.339)	(0.341)	(0.351)
Limited land availability		-0.186		
		(0.242)		
Land mainly inherited			-0.357	
			(0.600)	
Member of major tribe in cluster				0.015
				(0.157)
Informal credit				
Tribal population shares	yes***	yes***	yes***	yes***
Region controls	yes**	yes**	yes**	yes**
School quality controls	yes*	yes*	yes*	yes*
Observations	3826	3826	3826	3826
Pseudo R-squared	0.288	0.288	0.288	0.288

Robust standard errors in parentheses, corrected for clustering at village level. *** p<0.01, ** p<0.05, * p<0.1.

Regressions included additional control variables as in table 2, model 4: Age, Age^2, Birth-order, Gender, HH expenditure, agriculture income, school expenditure, school distance, herd, no. of children land holdings, interaction terms and a constant.

Table A1. Summary statistics for HRDS sample

Variable	Mean	SD	Min	Max
TF	0.345	0.264	0.000	0.903
Age	11.558	3.142	7.000	17.000
Birth order	2.366	1.954	0.000	16.000
Girl	0.495	0.500	0.000	1.000
Daily HH expenditure per AE ($)	0.724	0.490	0.054	5.213
Daily HH expenditure per AE, squared	0.764	1.630	0.003	27.177
Agriculture is main income	0.893	0.309	0.000	1.000
HH exp*Agricultural income	0.637	0.495	0.000	4.863
School expenditure, cluster av.	6.118	3.413	1.718	19.281
School distance, cluster av.	1.471	0.989	0.185	5.417
Household has herd	0.386	0.487	0.000	1.000
Total number of children	5.068	2.856	0.000	19.000
Land (ha)	15.203	17.916	0.000	190.000
Adequate/good teachers	0.747	0.435	0.000	1.000
Adequate/good headmaster	0.814	0.389	0.000	1.000
Adequate/good school supplies	0.383	0.486	0.000	1.000
Adequate/good environment	0.549	0.498	0.000	1.000
Adequate/good self-reliance	0.774	0.418	0.000	1.000
Adequate/good Swahili	0.865	0.342	0.000	1.000
Adequate/good English	0.573	0.495	0.000	1.000
Adequate/good mathematics	0.768	0.422	0.000	1.000
Adequate/good moral classes	0.724	0.447	0.000	1.000
Limited land availability	0.324	0.355	0.000	1.000
Land mainly inherited	0.205	0.178	0.000	0.733
Informal credit	0.183	0.172	0.000	0.600
Member of major tribe in cluster	0.777	0.416	0.000	1.000
Observations	**3826**			

Data source: HRDS

Table A2. Summary statistics KHDS sample

	mean	sd	min	max
Log(remittances)	0.969	2.655	0.000	12.553
TF	0.172	0.198	0.000	0.660
Formal sector job	0.243	0.429	0.000	1.000
Completed primary school	0.379	0.485	0.000	1.000
Completed secondary school	0.153	0.360	0.000	1.000
Girl	0.330	0.470	0.000	1.000
Age	28.741	9.354	15.000	68.000
HH size	8.398	4.841	1.000	36.000
Mutual aid among farmers	0.722	0.448	0.000	1.000
Daily HH expenditure per AE ($)	0.439	0.682	0.000	9.023
Agriculture is main income	0.793	0.405	0.000	1.000
Log(Land (ha))	0.669	0.772	-2.109	4.123
Household has herd	1.929	6.733	0.000	94.000
Community population size	3195.621	3078.783	525.000	18526.000
Catholic	0.552	0.497	0.000	1.000
Muslim	0.175	0.380	0.000	1.000
Protestant	0.183	0.387	0.000	1.000
Inheritance disputes past 12m	0.558	0.497	0.000	1.000
Can wife inherit land	0.357	0.479	0.000	1.000
Proportion of Mhaya in village	0.665	0.396	0.000	1.000
Proportion of Mnyambo in village	0.090	0.255	0.000	1.000
Proportion of Mhangaza in village	0.095	0.274	0.000	1.000
Proportion of Msubi in village	0.022	0.088	0.000	0.500
Proportion of Mzinza in village	0.007	0.024	0.000	0.150
Proportion of Other tribes in village	0.163	0.292	0.000	1.000
Proportion of Kishubi in village	0.015	0.041	0.000	0.222
Funeral arranged by family or clan	0.703	0.457	0.000	1.000
Observations	**2875**			

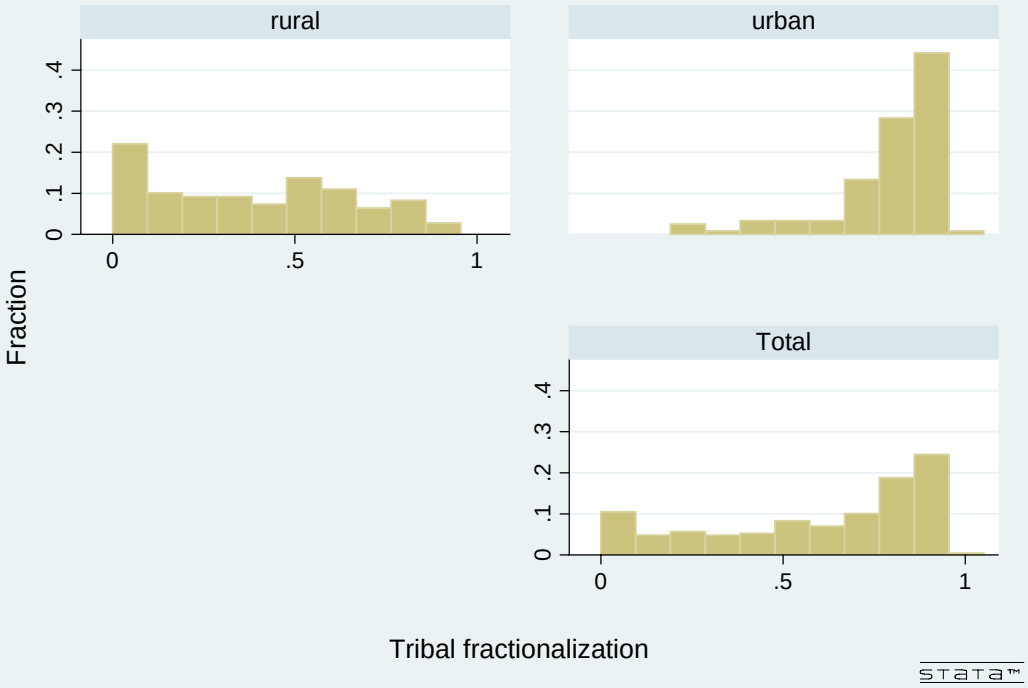
Table A.3. The effect of education on formal sector employment.

	1	2	3
Some primary school	0.461*	0.480**	0.394
	(0.243)	(0.243)	(0.257)
Completed primary school	1.185***	1.196***	1.074***
	(0.267)	(0.266)	(0.287)
Completed secondary school	2.288***	2.295***	2.129***
	(0.293)	(0.293)	(0.330)
Age	0.268***	0.266***	0.270***
	(0.055)	(0.054)	(0.056)
Age^2	-0.003***	-0.003***	-0.004***
	(0.001)	(0.001)	(0.001)
Girl	-0.680***	-0.681***	-0.726***
	(0.144)	(0.145)	(0.148)
TF		-0.236	0.012
		(0.463)	(0.600)
Village level tribal shares	No	No	Yes
Survey wave	Yes	Yes	Yes
Place of residence	Yes***	Yes***	Yes***
Observations	2723	2723	2723

Robust standard errors in parentheses. Constant included, but results not reported.

*** p<0.01, ** p<0.05, * p<0.1, Data source: KHDS

Figure 1: Tribal fractionalization in rural and urban clusters



Can Future Uncertainty Keep Children Out of School?

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July 18, 2008

Abstract

There is little doubt in the literature, that poverty and liquidity constraints can drive children out of school and into child labour in developing countries. But are there other important explanations for low primary school enrolment rates? The child labour and schooling literature often ignores that uncertainty about future returns results in a need for risk diversification, that children function as old-age security providers when there are no available pension systems, that the human capital investment decision of one child is likely to be influenced by that of his/her siblings, and that rural parents face a choice of investing in either specific or general human capital of their children. In this paper, I investigate the effects of future income uncertainty on the joint human capital investment decision of children in a household. I develop and calibrate a simple illustrative human capital portfolio model and show that existing levels of uncertainty can indeed result in less than full school enrolment within a household, even in a world of perfect credit markets. The paper thus offers an alternative explanation for why it might be optimal for rural parents not to send *all* of their children to school.

Keywords: Schooling, child labour, specific human capital, traditional education, intergenerational transfers, old-age security, uncertainty, income source diversification, liquidity constraints

Chapter 2 of PhD thesis

1 Introduction

Primary school enrolment rates are low in many developing countries, and generally lower than what policy makers aim for. This is problematic since schooling and human capital is central for economic development. In the economic literature on child labour and schooling, the main explanation for this lack of schooling is the inability of parents to borrow against the future enhanced earnings of children in order to finance their schooling today, e.g. Baland and Robinson (2000), Ranjan (2001), Edmonds (2007). Most rural households live in a high risk environment with incomplete credit and insurance markets, and virtually no social security system. Faced with poverty or periodic income short falls, households have to resort to informal insurance mechanisms to smooth consumption. It is often argued that one important mechanism is adjusting the labour supply of children as a means of ex-post risk coping. Liquidity constrained households thus borrow on the human capital market rather than on the incomplete financial capital market. The focus on the constraints and costs side of the human capital investment decision and on the use of child labour as a means of ex-post risk coping is the essence of the explanations given in the child labour and schooling literature on why enrolment rates are low and child labour widespread. Although these are valid explanations for why some children are kept out of school in rural areas of developing countries, they might not constitute the full explanation. It seems reasonable that households in risk prone environments will, apart from their ex-post risk coping strategies, also consider the possibilities of ex-ante risk diversification.

In this paper, I therefore ask the following question: Can future income uncertainty result in households keeping *some* of their children out of school as an optimal ex-ante risk diversification strategy? I hypothesise that when there is uncertainty about future income of children and when parents rely on this income for their old-age support, diversifying the future income sources of children becomes an important means of ex-ante risk management. In rural areas, the basis for such a diversification is laid already in the human capital investment decision. Formal schooling will direct children towards future urban employment, whereas traditional on-farm learning-by-doing will direct children towards the agricultural sector. With such a sectoral divide in returns to education, the need for risk diversification, due to future income uncertainty, can result in less than full enrolment into primary schools among siblings being an optimal human capital investment strategy for the household. I find that this is the case even if there are perfect credit markets and schooling is the most profitable human capital investment choice for the individual child.

My main argument, that uncertainty and thus the need for risk diversification influence the joint schooling decision of children in a household, primarily grew out of insights from literatures other than the child labour and schooling literature. These literatures will all be reviewed in turn below, but the key points follow here. When focusing on a broader perspective of the rural household rather than on the direct and indirect costs of schooling of the individual

child, it becomes clear that the following factors may also influence the joint human capital investment decision of children in a household. First, future income is generally uncertain and thus returns to education are uncertain. Second, in risk prone environments with very limited public pension schemes, children may not only play an important role in current ex-post consumption smoothing, but also function as future old-age security assets of their parents. Third, if there is uncertainty about the future income of children, ex-ante risk diversification is an important means of income smoothing. There is thus no apparent reason to assume that parents would consider the human capital investment decision of each child independently of his or her siblings. Rather, if children indeed are the old-age security providers, then parents should seek to optimize the portfolio of joint human capital investment decisions of their children, such that they balance future returns and risk exposure. Finally, work participation of children in household-based agricultural production systems may itself entail an important element of training and, as such, be part of a traditional education. In such a traditional rural environment, parents transfer specific human capital when working with their children, directing these towards future agricultural self-employment. Formal schooling, on the other hand, will direct them towards employment in the modern urban sector, where general human capital skills are needed.

Building on these insights from the literature, I develop an illustrative portfolio model of the joint human capital investment decision of all children in a household. The model is a two-period unitary household model, where parents in the first period decide on the optimal human capital portfolio allocation of their N children, where the choice is between either general formal education (schooling) or specific traditional education (on-farm learning-by-doing). In the second period, parents depend on the income of their adult children for consumption. The formally educated children will earn income from the urban sector and the traditionally educated children will earn income in the agricultural sector. Second period income is uncertain. In the model I abstract from liquidity constraints and child labour in order to focus on the pure effects of future income uncertainty on schooling. My purpose is not to argue against the influence of poverty and credit constraints on schooling, but rather to complement these existing explanations by analysing the human capital investment decisions of siblings jointly and from an ex-ante risk management perspective. I wish to emphasise that the model is only applicable to rural households where children can be engaged in traditional agricultural production. Child labour is thus viewed solely as work participation in familiy-based farming. The analysis should not be applied to children working as wage workers or otherwise under hazardous or exploitative conditions.[1]

The analytical results of the model show that future income uncertainty has a negative

[1] See Edmonds (2007) for an overview of which types of economic activities working children engage in. Based on cross-country UNICEF data sources, he estimates that 8% of children are engaged in wage work outside the household.

effect on the proportion of children sent to school. However, this is a qualitative result and it does not indicate whether existing levels of uncertainty could potentially keep some children out of school purely due to future risk diversification, even if households are not liquidity constrained in any way. The model is therefore calibrated using numerical values based on household averages from a national household survey undertaken in Tanzania. As opposed to two recent papers, which have also introduced uncertainty about the returns to schooling[2], I am able to show that a relatively small degree of uncertainty taken from a simple income spread measure is enough for the optimal portfolio choice of the average household to be less than full school enrolment, even in a world with perfect credit markets. Existing levels of uncertainty can indeed result in parents only sending some, but not all children to school. This negative effect on the optimal human capital portfolio allocation can be surprisingly large, even in the presence of perfect credit markets. For the average household, the pure effect of uncertainty is so strong that actual school enrolment rates could, in principle, be explained solely by the existence of uncertainty. Thus, the roots of child labour and lack of schooling need not lie solely with incomplete credit markets and poverty, but could also be caused by the fact that rural households are not only concerned with securing their current, but also their future old-age income. Future income uncertainty may constitute a very important element in the schooling decisions of households and the need for future income source diversification and ex-ante risk management can have direct implications for the optimal composition of a household's human capital portfolio of children. This adds a new perspective to the child labour debate, which has previously been centered around the need for ex-post consumption smoothing in the liquidity constrained household. These findings have direct policy implications for educational policies, the aim of which tends to be full enrolment into primary school. Policies, which only act on the cost side of the human capital investment decision may be insufficient in terms of reaching full enrolment. It may well be necessary to supplement such policies with some that also act on the return side of the investment decision.

Before turning to the details of the model, the next section looks at how this paper links with existing papers on schooling and child labour, uncertainty about income, intergenerational transfers and sibling dependence. The model is presented in section 3. Three different types of preference structures are considered in slightly lengthly detail, mainly to ensure that prudence is not generating the results. However, there is no indication of this being the case and the use of standard CRRA preferences is probably the most appropriate choice. Calibration results are shown in section 4, and section 5 concludes.

[2] See Pouliot (2005) and Estevan and Baland (2007). Although the latter focuses on mortality risk of young adults, this is in some sense also a source of uncertainty about returns to schooling seen from the parental point of view. However, as Estevan and Baland (2007) argue, young adult mortality risk may in regions of sub-Saharan Africa dominate the intrinsic uncertainty associated with returns to education.

2 Related Literature

As mentioned above, the idea that uncertainty and risk diversification can influence the joint schooling decision of all children in a household grew out of insights from literatures on uncertainty, income and consumption smooting and risk diversifiation, on retuns to specific versus general human capital, on sibling dependency, and on intergenerational transfers and children as old-age security assets. Drawing on these literature, a broader basis is formed for analysing the human capital investment decisions of a household as a whole, rather than for the individual child.

2.1 Income and consumption smoothing

It is well-known that most rural households in developing countries live in a high risk environment with incomplete credit and insurance markets, very limited public pension schemes and virtually no social security system. In such an environment, children may provide an important source of informal insurance, consumption smoothing and future old-age security. That is, they may play an important role both as providers of additional sources of income, when anticipated income of parents is low in old-age; and in the risk management strategies of the household aimed at shielding consumption from income variations. These strategies are generally two-fold; ex-ante risk management through income smoothing or ex-post risk coping through consumption smoothing, see e.g. Morduch (1995) and Dercon (2002), and for a more detailed analysis see Fafchamps (2003). I return to the role of children as old-age security providers in section 2.6 below.

Ex-ante, households smooth income by diversifying their income sources, labour supply and investments. The farm household diversifies income sources in part by diversifying the household labour supply between on-farm and non-farm economic activities, but also by diversifying the on-farm investments and production portfolio between a variety of crops, land holdings and animal stock. Examples of widespread use of on-farm/non-farm diversification of labour supply are found in Reardon (1997), C.B. Barrett and P.Webb (2001) and Dercon and Krishnan (1996). Morduch (1990), Rosenzweig and Binswanger (1993), and Dercon (1996) all show that both the composition of agricultural investments and the production portfolio are influenced by the degree of income variability faced by a farm household. This results in lower profitability when income variability is high, because production portfolios with less risk exposure and lower returns are chosen in high risk environment.

Ex-post, households shield consumption from idiosyncratic income shocks by obtaining credit, depleting of assets and buffer stocks, readjusting the labour supply of household members, and seeking assistance from the extended family or other informal risk sharing arrangements, see Kotlikoff and Spivak (1981), Townsend (1994) and Udry (1994). However, as

Townsend (1994) showed, households are generally uninsured against covariate income shocks at village level, typically due to adverse weather events. Under such circumstances, spatial diversification of the extended family becomes an important informal insurance arrangement through intergenerational transfers and remittances, see Rosenzweig (1988), Rosenzweig and Stark (1989), and Appelbaum and Katz (1991).

Income and consumption smoothing mechanisms thus have important implications for the allocation of labour and the investment portfolios of a household. The child labour literature reviewed below has a strong emphasis on the role of children in achieving ex-post consumption smoothing through increased child labour rather than schooling. However, the child labour literature is virtually silent, when it comes to analysing the role of children in the ex-ante income smoothing strategies of a household through future income diversification and informal insurance possibilities, as suggested in the fertility literature, see below.

2.2 Child labour and schooling

There is, by now, an impressive number of articles in the child labour and schooling literature, so many that various literature surveys have already been undertaken, see for example Basu (1999), Andvig (2000), Brown, Stern, and Deardorff (2003), Bhalotra and Tzannatos (2003) and Edmonds (2007). I will therefore not even attempt at making an exhaustive review of the literature, but rather focus on the subjects that this paper links with directly.

In general, the literature on child labour and schooling has focussed on one major reason for children being sent to work: binding credit constraints which tend to go hand-in-hand with poverty. Households are not able to cover the current costs of schooling. Most of the literature is based on the intertemporal human capital investment model by Ben-Porath (1967). He simply suggests that each individual must invest in an additional year of education as long as the increase in the discounted future earnings is larger than the current direct costs (e.g. school fees) and indirect costs (foregone earnings) of schooling. It is assumed that the individual can borrow against his/her future earnings to finance each additional year of schooling at perfect capital markets.

However, in developing countries, financial capital markets are far from perfect and the banking sector is almost non-existent. Credit sources are therefore often informal social networks or local moneylenders with high interest rates, see Udry (1994) and Deaton (1997, ch.6.3). Such credit sources seldom provide a plausible means of financing long term human capital investments, although they can be used for smoothing consumption in the short run when faced with income shocks.

Basu and Van (1998), Baland and Robinson (2000) and Ranjan (1999, 2001) all analyse, theoretically, how liquidity constraints can increase child work and reduce schooling because parents are unable to reduce current consumption by the direct and indirect costs of schooling

due to poverty and they are unable to borrow against the future earnings of their children. The fact that parents cannot borrow against the future income of their children, arise for two reasons. One is the incomplete credit market, which limits intertemporal transfers. The other is the problem of agency, or what Baland and Robinson (2000) model as insufficient levels of altruism between parents and children, which limits intergenerational transfers, see also Parsons (1984), and Becker and Murphy (1988). The agency problem arises from the fact that parents cannot strictly enforce repayment of the educational expenses when children become adults and experience returns to the human capital investments made by parents when young. However, although the theoretical papers, and in particular Baland and Robinson (2000), focus on these two main reasons for child labour and lack of schooling, the corresponding empirical literature has virtually only focussed on the effect of binding credit constraints and poverty. Few papers have analysed the link between child labour and intergenerational transfers, I will return to this below.

Although there is general agreement, theoretically, about the negative effects of poverty and credit constraints on schooling, causal effects and not mere correlations are hard to identify empirically. Some studies have found the expected negative correlations between credit constraints, poverty and schooling, but this is at best suggestive evidence consistent with theory, see Jacoby (1994), Jensen and Nielsen (1997) and Bhalotra (2007) for examples on household data, and Krueger (1996) and Dehejia and Gatti (2002) for cross-country evidence. Yet, other studies have found mixed evidence, no significant correlations or even significantly positive correlations between income or wealth and child labour, see Coulombe and Canagarajah (1998), and Ray (2000). Bhalotra and Heady (2003) emphasise that there can be a 'wealth paradox' in relation to child labour, which arise when there are imperfections in the land and labour markets. If the demand for labour cannot be met, farm households may have to use own labour resources, including those of their children.

A second group of studies have analysed the relationship between poverty and child labour over the full income range. They all find that it can be highly non-monotonic, locally. Edmonds (2005) and Bhalotra (2007) base their theoretical set-up on the notion from Basu and Van (1998) that only households which cannot afford otherwise in terms of subsistence, send their children to work. Edmonds (2005) finds that there is 'dramatic non-linearity' in the relationship between child labour and household expenditure in the neighbourhood of the poverty line. The expected negative relationship generally only appears for households above the poverty line. Bhalotra (2007) finds that sons in Pakistan do indeed engage in wage-work because of subsistence poverty. Rogers and Swinnerton (2004) take a theoretical approach and use the model in Baland and Robinson (2000) to show that rising incomes can lead to more child labour. This happens when income rises enough to reduce old-age transfers from adult children to parents, but not enough for the credit constraints not to bind and thus for parents to send

their young children to school purely out of altruism. The result is that the relationship between income and child labour may be 'neither monotonically decreasing nor continuous'. All three papers show that there is an overall negative relationship between income and child labour, but local estimates can very well produce a positive or insignificant relationship due to local non-monotonicities.

A third group of studies have focussed on estimating the effect of exogenous transitory variations in income on child labour and schooling. By choosing such an estimation strategy, these studies come closer to identification of a causal relation between child labour and income and, thus, of the possible effect of credit constraints and consumption smoothing. Jacoby and Skoufias (1997), Jensen (2000) and Beegle, Dehejia, and Gatti (2006) all estimate the effect of current transitory income shocks, either due to adverse weather or accidental unanticipated crop loss (e.g. due to insects or fire), on human capital investment or child labour. They find clear indications of self-insurance strategies resulting in a reduction of human capital investments and/or increasing levels of child work. These adverse effects of income shortfalls are contributed to the lack of ex-post consumption smoothing possibilities on the local incomplete credit market. Edmonds (2006) propose an alternative way of estimating the effects of credit constraints on child labour and schooling. He uses the timing of a fully anticipated age-dependent increase in income, pensions. If credit markets are complete, the announcement of a permanent increase in income should have an immediate effect on schooling. If credit markets are incomplete and households face borrowing constraints, the effect on schooling will only occur after the increase in income has actually taken place. He finds indications of credit constraints, especially in rural areas.

The literature on how poverty and/or credit constraints affect child labour and schooling decisions concentrates on the need for ex-post consumption smoothing to overcome income fluctuations and current uncertainty. However, in this paper, I argue that the ex-ante need for risk diversification might also be an important factor in the allocation of children's time between schooling and work. If schooling is considered an investment, any future uncertainty about its return should have an impact on the decision to invest.

2.3 Uncertainty about future returns

A recent issue of Labour Economics (vol 14, issue 6) was devoted to research on education and risk. Although the papers focus on education in the context of a developed country, several points stand out. It is noted that even though investments in human capital are often thought of in the same way as investments in financial or physical capital, the concept of risk in returns or future uncertainty is often missing in the discussion of schooling decisions, e.g. Hogan and Walker (2007). And, importantly, Cunha and Heckman (2007) point to the fact that ex-ante, not ex-post, returns are what agents act on, when making their schooling decision.

In the literature on child labour and schooling in developing countries, very few papers have looked at the effect of future uncertainty. Fitzsimons (2007) estimates the effect of future uncertainty in parental income, predicted by past rainfall variability, on education choices of children. Appelbaum and Katz (1991) analyse a similar problem theoretically. Both papers find negative effects of future uncertainty in parental income on schooling when credit markets are incomplete. Pouliot (2005) uses the Baland and Robinson (2000) model to show that when there is incomplete insurance and uncertainty about returns to education, then the level of child labour will be inefficiently high, even when there are perfect credit markets and no poverty (positive bequests from parents to children in old-age). However, Pouliot (2005) does not consider the effects of uncertainty on schooling and child labour, when parents rely on the income of their children for old-age support, nor does he consider how much uncertainty is necessary for child labour to dominate schooling. Estevan and Baland (2007) argue that only high mortaility rates among adult children can generate enough uncertainty for parents to alter their human capital investment decision.

Although this paper is closely related to the models of Pouliot (2005) and Estevan and Baland (2007), it differs in two fundamental ways. First, because the negative effect of uncertainty of schooling is established not only analytically, but also numerically by calibrating the model using household survey data showing that existing levels of income variation is indeed enough to predict strong negative effects of uncertainty on schooling. Second, because the effect of future uncertainty on schooling is analysed for the full set of children at household level.

2.4 Siblings

Allowing for sibling dependency and portfolio effects, which can yield very different predictions compared to one-child models and, not least, provide an alternative explanation for sibling differences. There is a variety of papers analysing sibling differences in educational attainment and child labour. These papers are roughly grouped by two different approaches. One group focus on explaining positive birth order effects on schooling. Different explanations, which are not simply attributed to parental preferences, have been given. If the household faces credit constraints, older children might have to work to help finance the education of the younger siblings, see Willis and Parish (1993), Emerson and Souza (2002) and Manacorda (2006). The birth order effects could also be due to the fertility decision being ruled by the genetic endowment of the last born child. If the youngest child is high-ability, Ejrnæs and Pörtner (2004) argue, then parents are more likely not to have additional children compared to a situation where the youngest child is low ability. This results in a higher probability of schooling among the youngest children. Edmonds (2006b) argue that older siblings (lower birth order) have a comparative advantage over the younger ones in household production and therefore are less likly to be sent to school.

The other group of papers focus on explaining sibling differences in general. Horowitz and Wang (2004) also point to the fact that there might be heterogeneity in the ability of children, which can lead to one child having a comparative advantage over other children in the accumulation of human capital. Dahan and Gaviria (2003) show that differences can also arise, even for completely identical siblings, as long as households are credit constrained and there are increasing returns to human capital investment (e.g. due to sheepskin effects of school diplomas). Their model has a clear empirical implication, very poor households will not be educating any children, middle income households will be educating some and rich households will be educating all children. Their findings from Latin America are broadly consistent with this prediction of the model. Morduch looks at, what he terms, 'sibling rivalry', see Garg and Morduch (1998) and Morduch (2000). He argues that the competition for resources within the household is gender specific and finds that moving from an all-brothers to an all-sisters household can be beneficial in terms of schooling (in Tanzania) or health (in Ghana). Bommier and Lambert (2004) follow up on this and propose a test for whether such dependency among siblings is due to competition for resources or a result of more complicated interactions between siblings, say as being substitutes or complements for each other in the household production function or in the parental utility function. Their empirical findings are in favour of a model with interaction, although their test does not allow them to identify where these interactions originate from.

In the majority of these papers, sibling differences stem from poverty or binding credit constraints and the need for ex-post consumption smoothing. Only Bommier and Lambert (2004) discuss the possibility that sibling differences could arise due to explicit dependencies, rather than dependency arising because of a common credit constraint.

By analysing the joint human capital investment decision for all children in a household, I allow for dependency among siblings. The dependency in the model of this paper stems purely from the need for future irisk diversification. Uncertainty about future returns affects the optimal human capital portfolio choice of the household in their balancing of risk exposure against the level of returns. If there is no uncertainty about future returns, the model collapses to a model of N identical and independent children for whom the educational choice will all be the same and thus directly resembles standard child labour models in the literature.

2.5 Specific vs. general human capital

In some of the early economics literature on child labour and schooling, one can still come across more positive aspects of child labour. For instance, in their classic survey, Rodgers and Standing emphasise that '(...) it is important not to confuse schooling with education. Many other activities contribute to education, and some forms of economic activity are among them.' and '(...) work itself may be an important component of "education" especially in household-based

production systems (...)", Rodgers and Standing (1981, p.10 & p.33, respectively.). Bonnet (1993) notes that work participation is part of a traditional educational process in Africa and that this traditional education may offer the best survival prospects for the future, i.e. also better than formal education. Here Bonnet, implicitly, touches upon two different aspects of why children are working. One is the social anthropological aspect of work participation being an important component of the traditional education and the 'socialisation' of a child; the other is the economic aspect focusing on the returns to traditional education compared to formal education.

In the social anthropological literature, there is a clear distinction between traditional education based on indigenous knowledge, and formal education based on Western principles. In traditional education, children learn by participating in the work of, in the early years, their mothers and, later for the boys, in the work of their fathers, Bradley (1993). Child labour is regarded as the accumulation of specific human capital through learning-by-doing; it is a way of 'socialising' the child, i.e. of adapting it to its environment and teaching it the life skills necessary for survival, Andvig (2000). African parents term it 'responsibility training', Agiobu-Kemmer (1992). However, it should be emphasised that this type of traditional education is concentrated in rural areas and less applicable to children in urban areas. Bekombo (1981) notes, 'the productive activity of a child living in a rural and traditional environment is a means of social integration and cannot be likened to paid work.' But in a modern urban environment, 'when children's work is no longer integrated into an educational system it becomes a "deviant" and "delinquent" activity (...)', Bekombo (1981, p.114).

Bock (1998, 2002) takes the analysis of the educational element in child work particiption one step deeper. He notes that parents are faced with a choice, when allocating their children's time to different tasks. Some tasks are more complex than others and therefore have a higher learning potential. Parents thus have to make the trade-off between letting their children do simple (often boring) tasks with low learning but an immediate return, or letting them do more difficult tasks with high learning, more supervisional needs and only future returns in the form of higher specific human capital. Child work may therefore not always bring immediate returns as it is generally assumed in the recent economic child labour literature, but might even be costly and time consuming for parents, the stronger the educational element. Bock emphasises that there is a trade-off between task complexity and immediate output within traditional education and that parents are well aware of the need for generating learning opportunities for their children to ensure future agricultural returns.

According to the social anthropological literature, the introduction of formal education based on Western principles has not been unproblematic in Africa. The traditional concept of knowledge was suddenly questioned. Western knowledge is seen as de-contextual and rational, rather than ethical, Daun (1992). It is argued that Western education has induced unfavourable

changes in the behaviour of students away from the African sense of collective concern towards Western individualism, it has weakened the gerontocracies, threatened the continuation of traditional values and way of life, and resulted in brain drain of the rural villages, see for instance Schildkrout (1981), Daun (1992) and Odora (1992). Equally problematic, though, is the perceived lack of returns of schooling, Rodgers and Standing (1981) and Bonnet (1993). Agiobu-Kemmer (1992) notes that where traditional education hardly ever left an individual jobless, formal Western education entails a risk of future urban unemployment. If this is, indeed, the perception or even the reality of formal education in rural Africa that it 'broadens your mind, but it does not tell you how to survive' as an African commentator puts it[3], then local reservations toward schooling and a continued emphasis on traditional specific learning is fully understandable.

The economics literature on returns to schooling confirms that there are limited or even no returns to formal education in simple traditional agricultural production systems. A key contribution in this area is Rosenzweig (1995). He argues that there has to be 'productive learning opportunities' for schooling to result in positive returns. When the production tecnology is simple, schooling does not increase productivity. Children accumulate the necessary human capital through specific experience when working along side their parents, Rosenzweig and Wolpin (1985). This is typically the case in traditional agricultural household-based production systems, where best practises have been known for and passed on by generations, Rosenzweig (1996). Returns to formal education are only positive, when new complex technologies are introduced, creating an environment for productive learning opportunities. 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. 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 and show that on-farm returns to education are low, but off-farm returns can be high. This results in a shift of educated labour resources within the farm household away from farm activities and towards non-farm economic activities. Likewise, Fafchamps and Wahba (2006) find that on-farm child labour drops and schooling attendance increases with urban proximity, which they interpret as a reflection of local labour market possibilities. They note that 'participation in subsistence work - primarily farming - may be seen as a beneficial activity by parents, probably because it teaches important skills to children', (Fafchamps and Wahba (2006)).

From this dispersed literature on the training component in on-farm child work, there are two main points to emphasise; first that child labour may be an important element in a traditional educational system, which emphasises the accumulation of specific human capital

[3] Agiobu-Kemmer (1992, p.7)

through experience; and second that returns to specific human capital might match or even be higher than returns to general human capital acquired through formal schooling in traditional rural environments. These two points seem largely ignored in the child labour literature, only Bommier and Lambert (2000) and de Vreyer, Lambert, and Magnac (1999) have followed the line of thought of distinguishing between specific and general human capital to explain delayed enrolment into primary schools and sibling differences in educational attainment. Surprisingly, child work is generally modelled purely as an additional current income source, e.g. Basu and Van (1998) and Baland and Robinson (2000) and the papers, which have followed in their wake. Bommier and Dubois (2004) even go one step further and introduce disutility of labour among children without adding the investment aspect[4]. These approaches are highly relevant, when considering disturbing images of hazardous and exploitative child labour or even simple wage work. Less so, when considering children engaged in traditional agricultural work on the familiy-run farms or household plots. Indeed, the vast majority of the many working children in Sub-Saharan Africa are engaged in these household-based production systems, see Bhalotra and Tzannatos (2003).

In this paper, there is a clear distinction between traditional and formal education that is between specific human capital aimed at the agricultural sector and general human capital aimed at the modern urban sector. Child labour is thus seen as an educational alternative to formal schooling with different future prospects. My purpose is not to argue against the importance of child work in overcoming poverty, credit constraints and income shocks, but simply to point to the fact that the role of children and their economic activities might be more complex than that in a traditional agricultural environment.

2.6 Intergenerational transfers and children as old-age security

A central assumption in the portfolio model in section 3 is that parents depend on the income of their children for old-age support. This assumption is based on the fertility literature, and supported by empirical literature on intergenerational transfers.

In the fertility literature, the argument for having children often extends beyond a pure consumption argument of parents deriving utility from having children, just as they derive utility from consuming goods. This is especially the case, when analysing fertility decisions of households faced with considerable risk, incomplete credit and insurance markets and highly inadequate or no public pension or social security schemes. In such an environment, it is often argued that children may function as security assets. Generally, the old-age security aspect of children is emphasised and Nugent (1985) is, by now, a classic reference on the subject. Children may also function as security assets in terms of insurance, because their future income sources represent additional risk diversification possibilities, in particular Appelbaum and Katz (1991)

[4]They also do not consider the possibility that children might experience disutility of schooling.

emphasise the risk diversification aspect, but Cain (1981, 1983) and Pörtner (2001) also discuss the insurance role of children. In the fertility literature, children are thus naturally considered as part of the ex-ante risk management strategies of a household. If children indeed play the role of security assets, this is likely not only to affect fertility, but also the human capital investments in these children.

In the child labour and schooling literature, the old-age security motive for investing in the general human capital of children, has often been dismissed due to agency problems, see e.g. Udry (2004). That is, it is impossible for parents and children to engage in an intergenerational enforceable contract of parents financing the human capital investments of children in return for future old-age transfers, Parsons (1984) and Becker and Murphy (1988). Thus, unless there are high degrees of altruism between parents and children, old-age support is not seen as a motive for human capital investments, e.g. Baland and Robinson (2000).

Nugent (1985) is aware of the problems of agency, in what he terms, loyalty of children to their parents in old-age. He claims, however, that there is scope for loyalty training, which, he argues, is facilitated by cultural norms in traditional societies. Norms is often argued to be an effective means of overcoming agency problems, see for instance De Vos (1985) and Lucas and Stark (1985), but also chapter 1 of this thesis for a more recent discussion[5].

Despite possible agency problems, there is ample empirical evidence that intergenerational transfers from children to parents do occur, e.g. Lee, Parish, and Willis (1994) and Lillard and Willis (1997, 2002). And some suggestive evidence that such transfers are in fact part of an informal old-age support system, Nugent and Gillaspy (1983) and De Vos (1985). More recent studies achieve better identification of this informal support system, because they show that the introduction of public security schemes, at least partially, crowd out private transfers, see Cox and Jimenez (1992) for evidence from Peru, and Jensen (2003) for even more robust evidence from South Africa. It therefore seems resonable to assume that parents rely on some support from their children in old-age, although they might not be able to fully control it.

Recently, a few theoretical papers on child labour and schooling have acknowledged the importance of future intergenerational transfers for the human capital investment decisions today. Rogers and Swinnerton (2004) use the link between schooling and expected future transfers from children to parents to show that the relationship between child labour and parental income need not be monotonically decreasing, see above. Chakraborty and Das (2005) argue that there is positive relationship between life expectancy and human capital investment, because only parents that actually reach old-age will be able to benefit from their educational investments in their children. Raut and Tran (2005) suggest that if intergenerational transfers

[5] There is some discussion in the literature on intergenerational transfers about whether transfers from children to parents occur as pure repayments of human capital investments, due to altruism or simply because social norms dictate it, see e.g. Lucas and Stark (1985), Altonji, Hayashi, and Kotlikoff (1997) and more recently Raut and Tran (2005). This is a separate question, beyond the scope of this paper.

are simply an alternative means of financing schooling, then parental investment in eduaction is socially optimal. Although, if intergenerational transfers are based on altruism and reciprocity, then some parents will underinvest in their children's human capital and their is scope for policy intervention. Their findings, using Indonesian data, support the latter hypothesis. These three papers are the first attempts at establishing a link between the literatures on child labour and intergenerational transfers. By adding uncertainty about future income of children to the equation, this paper is an additional contribution to such a link.

3 Theoretical Framework

The model developed in this paper differs from most of the models in the existing child labour literature in four ways. First, the model introduces uncertainty about the future returns to education, i.e. about children's future income. Second, parents rely on the future income of their children for old-age support. This gives parents a clear incentive to choose an optimal human capital portfolio of their children in terms of balancing returns and risk exposure, given their degree of risk aversion. Third, the model is not a one parent - one child model of human capital investment, but rather a one parent - N children model, where the human capital investment decision of children is modelled jointly, thus allowing for sibling dependence. Fourth, there is a clear distinction between general human capital acquired through schooling and specific human capital acquired through work experience. Child labour is thus modelled as an educational alternative, which directs children towards future agricultural income sources, whereas formal schooling directs children towards future urban income sources.

A theoretical framework is designed, which emphasises the effect of future uncertainty and the need for risk diversification on the allocation of children between schooling and labour in a household. To exhibit clearly what the effects of uncertainty and risk diversification are, I begin by abstracting from the conventional explanations for child labour and low school enrolment. That is, I assume that credit markets are perfect, such that households do not face any liquidity constraints, and that there are no agency problems between generations, such that parents can rely on full old-age support from their children. Later both liquidity constraints and child labour are introduced allowing me to compare model predictions under different scenarios.

The basic model set-up gives a general understanding of how uncertainty can affect the human capital investment allocation. By specifying a simple preference structure and the sources of uncertainty, it is possible to arrive at closed form solutions. It is straightforward to show analytically that uncertainty about future returns can have a negative effect on schooling both in a one-child model and for N children. However, the question of interest is whether the negative effect is large enough for the model to predict lower levels of schooling given realistic levels of uncertainty about children's future income. In section 4, the model is therefore

calibrated using data driven numerical values for a variety of different preference structures and under different scenarios.

3.1 The basic model

The model is a two period unitary household model, where parents function as a unified sole decision maker. There is no discounting of the future and no interest rate on savings or credit. 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.[6]

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 thus 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[7]. 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

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

[6] 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.

[7] 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.

where π is the proportion of children, which parents have chosen 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 $(1-\pi)N$.[8] The total amount of educational expenses is $(1-\pi)Ne^a + \pi Ne^b$, where e^a is 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 considered both non-negative.[9]

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 question is: can this alone result in less than full school enrolment among siblings, i.e. a model prediction of $\pi < 1$ solely due to uncertainty.

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 of all children, which is given by the income of children in the agricultural sector $(1-\pi)Ny_2^a$, and the income of children in the urban sector πNy_2^b. Children are thus 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 $\alpha > 0$. In principle, $\alpha \in [0;1]$, but in the following I will assume that $\alpha \in]0;1[$ to ensure that there is a positive, but diminishing marginal effect of having more children on second period income. When $\alpha = 0$, children share all their income with their parents. When $\alpha = 1$ children share only a fraction $1/N$ of their income with their parents, resulting in parents receiving the equivalent of one full income from their children in total. If there is only one child in the household that child will be the sole breadwinner of the family in the second period and is forced to share his/her full income with the parents, irrespective of the size of α.

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 first order condition with respect to s is

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

[8] For analytical simplicity, π is written as continuous in the theoretical model, but it will be treated as discrete in the calibrations and in the empirical model.

[9] 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.

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

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

where

$$E[N^{1-\alpha}(y_2^b - y_2^a)U'(c_2)] = E(N^{1-\alpha}(y_2^b - y_2^a))EU'(c_2) + cov(N^{1-\alpha}y_2^b, U'(c_2)) - cov(N^{1-\alpha}y_2^a, U'(c_2))$$

Uncertainty about second period income results in two covariance terms, both negative, between the second period income variables, y_2^a and y_2^b, and marginal utility, $U'(c_2)$. These terms will, when they are strong enough, pull the optimal portfolio allocation, π^* away from each of the two corner solutions. Uncertainty in the agricultural sector will have a positive effect on π^* because it will increase the right hand side of the first order consition for π and pull towards the $\pi^* = 1$ corner solution. Uncertainty in the urban sector, on the other hand, will have a negative effect on π^* because it will decrease the right hand side of the the first order condition for π and thus pull towards the $\pi^* = 0$ corner solution.

In the following, I assume that there is no covariant uncertainty between second period income from children in the urban sector and children in the agricultural sector. This allows me to simplify the problem by normalising uncertainty about income from the agricultural sector to zero, and thus solely focus on the effect of uncertainty of urban income on the optimal proportion of children in formal schooling. Going back to the first order condition for π, equation (4), this means concentrating on the covariance term, which can reduce the right-hand side of the first order condition and thus reduce the optimal π^*. That is, focusing on the somewhat more relevant question of what can result in an optimal π^* below 1, rather than what can result in an optimal π^* above 0.

This is not to say that there is no uncertainty in the agricultural sector, but rather that uncertainty associated with income transfers from distant migrant children in the urban sector is higher. These migrant children may face higher income levels, but also relatively more variation, since the urban labour market entails a 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 income transfers 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[10]. The uncertainty, that parents face about income transfers from migrant

[10] The uncertainty could thus also, in effect, be an intergenerational agency problem between parents and

children in urban sector is modelled as a simple mean-preserving spread. Each migrant child can either get a good (typically formal sector) job or not, where the probability of a good draw in the urban labour market is given by $p = 0.5$. Migrant children in good jobs have an urban income of $y_2^b = \mu + \varepsilon$, whereas migrant children without good jobs have an urban income of $y_2^b = \mu - \varepsilon$.[11] This means that 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 $Var(y_2^b) = \varepsilon^2$. Given this specification of uncertainty, the first order condition for π rewrites (4) as

$$N(e^b - e^a)U'(c_1) = N^{1-\alpha}(\mu - y_2^a)EU'(c_2) + cov[N^{1-\alpha}y_2^b, U'(c_2)] - 0$$

where the specification of the covariance term will depend on the degree of risk correlation in the urban labour market outcome. The expected total income transfers from all the πN children, which have gone to the urban sector, is simply $E(\pi N^{1-\alpha}y_2^b) = \pi N^{1-\alpha}\mu$, independent of the degree of risk correlation among migrant siblings. But the variance of their expected total income, $Var(\pi N^{1-\alpha}y_2^b)$ and the covariance above, $cov(N^{1-\alpha}y_2^b, U'(c_2))$ will both depend on the degree of risk correlation in urban income.

I consider the two extremes where income transfers from siblings in urban employment are either perfectly correlated or uncorrelated. Reality is likely to lie somewhere in between. When there is perfect risk correlation among siblings in urban employment, all siblings will either have a good draw and then their income transfers will amount to $\pi N^{1-\alpha}(\mu+\varepsilon)$, or they will all have a bad draw 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 there is no risk correlation among siblings, they all face the same urban labour market lottery irrespective of the labour market outcomes of their siblings. 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 uncertainty in the agricultural sector and the urban sector do not covary, house-

migrant children. Their degree of success is harder to monitor and lack of family control increases 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. In chapter 1, we analyse the effect of such sanctions on the demand for formal schooling.

[11] I do not explicitly consider a mortality risk of young adults as in Estevan and Baland (2007). However, the model could easily be extended to include such risk, but if mortality risk is exogenous to choice of education, it would simply just add a higher level of uncertainty in both the agricultural and urban sector. The qualitative findings of the model would not change.

holds will have an incentive to diversify their human capital investments to reduce future risk exposure. If the need for diversification is strong enough, this will have a negative impact on the proportion of children sent to school in the optimal human capital portfolio of the household.

3.2 Specification of preferences

The choice of preference structure and degree of risk aversion is crucial for the model predictions. In the following, analytical results are derived for the quadratic utility function to allow for risk aversion without prudence. Prudence is introduced later, first by introducing a very small cubic term in the quadratic utility function, and second simply by looking at a standard CRRA utility function, which incorporates both risk averison and prudence. Analytically, a model with quadratic preferences is much more tractable than CRRA preferences, making it possible to arrive at an analystical solution for π and to look at its derivatives. Numerically, however, there is no difference in tractability, and, CRRA preferences are likely to be a more realistic preference structure. An additional benefit of CRRA preferences is that only one parameter needs to be determined exogenously, the relative degree of risk aversion, γ. The model is calibrated for all three types of preferences in section 4, but the reported results will be mainly on the model predictions based on CRRA preferences.

3.2.1 Quadratic utility

It seems plausible to expect households in developing countries to be both risk averse and prudent. However, to keep these two matters apart and to ensure that results are not driven by prudence in the preference structure, but only by risk aversion, assume for now that the utility function is quadratic and thus that the third derivative is zero, i.e. no prudence. This implies that there is certainty equivalence in the marginal utility, $E(U'(c_t)) = U'(E(c_t))$, since marginal utility is linear in c_t. Define

$$U(c_t) = Mc_t - \frac{1}{2}\gamma {c_t}^2 \tag{5}$$

for both periods. M is the bliss point of maximum consumption. So utility increases in c_t, $U'(c_t) = M - \gamma c_t > 0$, but at a decreasing rate, $U''(c_t) = -\gamma < 0$ and $U'''(c_t) = 0$. It should be noted that the quadratic utility function does not belong to the class of CRRA or CARA utility functions, but has the rather awkward feature of increasing absolute risk aversion, when the consumption level increases. I will return to this below.

Given the quadratic utility function, the first order condition for s simply rewrites as

$$M - \gamma c_1 = M - \gamma E c_2$$

so the perfect credit market ensures that consumption in period 1 equals the expected consumtion in period 2. From this it is also clear that in this simple model, endogenous N would result in an infinite number of children in each household as long as second period earnings are higher than first period education expenditures. Thus, since the choice of schooling is the focus of this analysis, and not the fertility choice, N is modelled as an exogenous variable.

The first order condition for the proportion of children in schooling, π under perfect risk correlation becomes

$$N(e^b - e^a)(M - \gamma c_1) = N^{1-\alpha}(\mu - y_2^a)(M - \gamma E c_2) - \gamma\pi N^{2-2\alpha}\varepsilon^2$$

and the equivalent equation under no risk correlation among siblings in second period urban income is given by

$$N(e^b - e^a)(M - \gamma c_1) = N^{1-\alpha}(\mu - y_2^a)(M - \gamma E c_2) - \gamma\pi N^{1-2\alpha}\varepsilon^2$$

Thus, only the covariance terms differ for these first order conditions for π. Under perfect risk correlation $cov(Ny_2^b, U'(c_2)) = -\gamma\pi N^{2-2\alpha}\varepsilon^2$, and under no risk correlation $cov(Ny_2^b, U'(c_2)) = -\gamma\pi N^{1-2\alpha}\varepsilon^2$, see appendix A1.

The first order conditions are given by two equations in two unknowns, s and π, which can be solved for analytically. When there is perfect risk correlation among siblings in urban employment, the optimal educational allocation for the household in period one will be

$$\pi^*_{cor} = \frac{\Delta\left(N^\alpha 2M - \gamma(N^\alpha Y_1 + Ny_2^a - N^{1+\alpha}e^a)\right)}{\gamma\left[N\Delta^2 + 2N\varepsilon^2\right]} \tag{6}$$

where $\Delta = (\mu - y_2^a) - N^\alpha(e^b - e^a)$. The corresponding choice under no risk correlation among urban employed siblings is

$$\pi^*_{uncor} = \frac{\Delta\left(N^\alpha 2M - \gamma(N^\alpha Y_1 + Ny_2^a - N^{1+\alpha}e^a)\right)}{\gamma\left[N\Delta^2 + 2\varepsilon^2\right]} \tag{7}$$

If formal education is more costly than traditional education, but also sufficiently more profitable in expectation such that $\Delta > 0$, then π^* will always be positive, the question is if it will ever be less than unity. From equation (6) and (7), it is clear that $\pi^*_{cor} < \pi^*_{uncor}$, the optimal allocation of children into formal education will always be lower when there is perfect risk correlation, compared to no risk correlation, among urban employed siblings. The optimal choice of savings will differ correspondingly, $s^*_{cor} > s^*_{uncor}$. Only when there is no uncertainty, $\varepsilon = 0$, or only one child in the household, $N = 1$, will $\pi^*_{cor} = \pi^*_{uncor}$. It should be noted that if $\varepsilon = 0$ and $N = 1$, then this model collapses to a standard model of human capital investment used in the child labour literature. Since there are no liquidity constraints or agency problems,

the model will always predict full school enrolment when there is no uncertainty, irrespective of the number of children in the household as long as returns to formal education are higher than returns to agricultural education that is as long as $\Delta > 0$.

The real question of interest here is whether uncertainty alone is enough to drive π below unity even under perfect credit markets. From the analytical solutions for π^*,(6) and (7), it is clear that an increase in uncertainty measured by ε or similarly an increase in the variance of urban income, ε^2, will always have a negative effect on the optimal proportion of children in formal education, π^*. Under perfect risk correlation among siblings in the urban labour market, the derivate is given by

$$\frac{\partial \pi^*_{cor}}{\partial \varepsilon^2} = -\frac{2N\Delta(N^\alpha 2M - \gamma(N^\alpha Y_1 + Ny_2^a - N^{1+\alpha}e^a))}{\gamma\left[N\Delta^2 + 2N\varepsilon^2\right]^2} < 0$$

and under no risk correlation by

$$\frac{\partial \pi^*_{uncor}}{\partial \varepsilon^2} = -\frac{2\Delta(N^\alpha 2M - \gamma(N^\alpha Y_1 + Ny_2^a - N^{1+\alpha}e^a))}{\gamma\left[N\Delta^2 + 2\varepsilon^2\right]^2} < 0$$

However, although the partial derivative of π^* with respect to ε is clearly negative and stronger uncer perfect risk correlation than in the uncorrelated case, it is uninformative about the size of ε necessary for the model to predict an optimal π^* below unity. To answer such question, numerical solutions are needed, for this see calibration results in section 4.

Another partial derivative of interest is the effect of belonging to a household with more children, compared to one with less, on the optimal proportion of children in school, all else equal. Given the portfolio approach in setting up the model, intuition says that the optimal proportion of children in school should be reasonably constant for varying levels of N once N is large enough to allow for some flexibility in the somewhat discrete π^*. E.g. for $N = 2, \pi^*$ can only take the follwoing three values $[0, \frac{1}{2}, 1]$. Irrespective of the degree of risk correlation, the derivates cannot be signed, indicating either a non-monotonic relationship or simply a not very strong relationship. The partial derivatives with respect to N is given by

$$\begin{aligned}\frac{\partial \pi^*_{cor}}{\partial N} &= \frac{\alpha\Delta'(2N^\alpha M - \gamma(N^\alpha Y_1 - N^{1+\alpha}e^a)) - \Delta''\gamma N y_2^a + \Delta\gamma N^{1+\alpha}e^a}{\gamma N\left[N\Delta^2 + 2N\varepsilon^2\right]} \\ &\quad - \frac{\Delta(2N^\alpha M - \gamma(N^\alpha Y_1 + Ny_2^a - N^{1+\alpha}e^a))(\Delta^2 - 2\alpha N^\alpha(e^b - e^a)\Delta + 2\varepsilon^2)}{\gamma\left[N\Delta^2 + 2N\varepsilon^2\right]^2} \lesseqgtr 0\end{aligned}$$

under perfect risk correlation, and under no risk correlation by

$$\begin{aligned}\frac{\partial \pi^*_{uncor}}{\partial N} &= \frac{\alpha\Delta'(2N^\alpha M - \gamma(N^\alpha Y_1 - N^{1+\alpha}e^a)) - \Delta''\gamma N y_2^a + \Delta\gamma N^{1+\alpha}e^a}{\gamma N\left[N\Delta^2 + 2\varepsilon^2\right]} \\ &\quad - \frac{\Delta(2N^\alpha M - \gamma(N^\alpha Y_1 + N y_2^a - N^{1+\alpha}e^a))(\Delta^2 - 2\alpha N^\alpha(e^b - e^a)\Delta)}{\gamma\left[N\Delta^2 + 2\varepsilon^2\right]^2} \lesseqgtr 0\end{aligned}$$

where both $\Delta' = (\mu - y_2^a) - 2N^\alpha(e^b - e^a)$ and $\Delta'' = (\mu - y_2^a) - (1+\alpha)N^\alpha(e^b - e^a)$ are positive. These partial derivatives are of particular interest when compared to the ones produced by a similar model with liquidity constraints. Liquidity constraints are likely to create sibling rivalry over the limited resources, as suggested by the literature reviewed above, and one should expect a clear negative effect of coming from a household with more children compared to one with less when both households are liquidity constrained, see section 3.3.

Finally, the model can also easily be extended to show the recently much debated empirical result of non-monotonicity in income[12]. Since the model only applies to rural households, it is reasonable to assume that the earning abilities of children working in the agricultural sector in the second period are positively correlated with the income generated by their parents in the same sector in the first period. Such a positive relationship can be expected partly because parents transfer specific human capital to their children when educating them traditionally, and partly because children entering the agricultural sector would typically be endowed with parental farm land or other local land with similar characteristics and thus similar earning potentials, see Rosenzweig and Wolpin (1985). By simply defining second period agricultural income as a function of parental first period income, such that $y_2^a = f(Y_1), f' > 0$, non-monotonicity between proportion of children in school and parental first period income is generated. The partial derivative of π with respect to Y_1 becomes ambiguous.

$$\begin{aligned}\frac{\partial \pi^*}{\partial Y_1} &= \frac{-f'(Y_1)(2N^\alpha M - \gamma(N^\alpha Y_1 + N f(Y_1) - N^{1+\alpha}e^a) + \gamma N\Delta) - \gamma N^\alpha \Delta}{\gamma\Phi} \\ &\quad + \frac{2N\Delta^2(2N^\alpha M - \gamma(N^\alpha Y_1 + N f(Y_1) - N^{1+\alpha}e^a)f'(Y_1)}{\gamma\Phi^2} \lesseqgtr 0\end{aligned}$$

where $\Phi = N\Delta^2 + 2N\varepsilon^2$ under perfect risk correlation and $\Phi = N\Delta^2 + 2\varepsilon^2$ under no risk correlation.

The non-monotonicity result is rather intuitive. If the agricultural sector generates high levels of income, traditional education becomes a relatively more attractive alternative to formal education, which will shift π^* more towards zero and thus change the composition of the optimal household human capital portfolio away from schooling. This is particularly interesting in the

[12] See Bhalotra (2002), Bhalotra and Heady (2003), Edmonds (2005) and Rogers and Swinnerton (2004), as well as section 2.2 for a discussion of these references.

case where liquidity constraints are binding, because the positive effect of higher parental income is then counterbalanced by the agricultural sector becoming relatively more profitable compared to the urban sector and thus generates an inverse U replationship between π^* and Y_1, see section 3.3.

It should be noted that under quadratic preferences and no liquidity constraints, the direct effect of an income increase in Y_1 without considering the correlation with y_2^a has, counterintuitively, a negative effect on π. Since π^* is already at its optimum regardless of first period income, an income increase translates directly into a consumption increase and thus an increase in risk aversion. There is then an overall negative impact on investment in the risky compared to the risk free asset. This is, as mentioned above, a rather awkward feature of the quadratic utility function. Although quadratic preferences are more tractable analytically, they are less attractive because they lack the constant relative risk aversion characteristic over consumption. However, before turning to the more common class of CRRA utility functions, I will briefly analyse the effect of prudence on the optimal human capital portfolio of the household.

3.2.2 Cubic utility

The quadratic utility function was chosen to ensure that the existence of prudence is not in itself generating the results, and it will be shown below that the effects of prudence might be somewhat surprising. In order to be able to analyse the direct effects of prudence on the human capital investment decisions of the household, I will simply add a small cubic term to the quadratic utility function in equation (5). This introduces prudence, as the third derivative is now positive.

The cubic utility is given by

$$U(c_t) = Mc_t - \frac{1}{2}\gamma c_t^2 + \frac{1}{6}\eta c_t^3 \tag{8}$$

Where the prudence parameter is η, which is very small and postive. Now $U'(c) = M - \gamma c + \frac{1}{2}\eta c^2 > 0$, $U''(c) = -\gamma + \eta c < 0$ (by assumption on the size of η), and the third derivative is positive and given by the prudence parameter, $U'''(c) = \eta > 0$. Notice that there is no longer certainty equivalence in the marginal utility due to the postive prudence parameter $EU'(c_2) > U'(Ec_2)$.[13] This utility function is only well behaved for very small values of η, which is all that is needed for determining the effect of introducing prudence on the household proportion of children in school, π. This is simply given by the derivative of π with respect to η measured at $\eta = 0$, $\frac{\partial \pi}{\partial \eta}\Big|_{\eta=0}$. The optimal portfolio allocation π^* and savings level s^* under prudence are found by solving the two first order conditions. The maximisation problem is the same as above. Under perfect risk correlation in the labour market outcome among urban

[13] See appendix A2.

siblings, the first order conditions with respect to s and π, (3) and (4), are now

$$\begin{aligned} M - \gamma c_1 + \frac{1}{2}\eta c_1^2 &= M - \gamma E c_2 + \frac{1}{2}\eta (E c_2)^2 + \frac{1}{2}\eta (\pi N^{1-\alpha}\varepsilon)^2 \\ N(e^b - e^a)U'(c_1) &= N^{1-\alpha}(\mu - y_2^a)\left(U'(Ec_2) + \frac{1}{2}\eta(\pi N^{1-\alpha}\varepsilon)^2\right) - (\gamma - \eta(\Gamma + \mu))\pi N^{2-2\alpha}\varepsilon^2 \end{aligned}$$

respectively, where $EU'(c_2) = M - \gamma E(c_2) + \frac{1}{2}\eta E(c_2)^2 + \frac{1}{2}\eta(\pi N^{1-\alpha}\varepsilon)^2$.

And the corresponding first order conditions under no risk correlation are

$$\begin{aligned} M - \gamma c_1 + \frac{1}{2}\eta c_1^2 &= M - \gamma E(c_2) + \frac{1}{2}\eta E(c_2)^2 + \frac{1}{2}\eta\pi N^{1-2\alpha}\varepsilon^2 \\ N(e^b - e^a)U'(c_1) &= N^{1-\alpha}(\mu - y_2^a)\left(U'(Ec_2) + \frac{1}{2}\eta\pi N^{1-2\alpha}\varepsilon^2\right) - (\gamma - \eta(\Gamma + \mu))\,\pi^2 N^{1-2\alpha}\varepsilon^2 \end{aligned}$$

for s and π, respectively, and $EU'(c_2) = M - \gamma E(c_2) + \frac{1}{2}\eta E(c_2)^2 + \frac{1}{2}\eta\pi N^{1-2\alpha}\varepsilon^2$. See appendix A2 for derivations. Again, this gives two equations, which can be solved for the two unknowns, s^* and π^*.

It can then be shown, through implicit derivation of the analytical solutions for π^* with respect to η that introducing prudence will have a *positive* effect on the proportion of children sent to school, $\frac{\partial \pi^*}{\partial \eta}\Big|_{\eta=0} > 0$. This may seem puzzling, since schooling is the more risky investment. However, by setting up the cubic utility function, risk aversion and prudence are two separate parameters. Prudence increases the preferences for precautionary savings and, somewhat surprisingly, at the same time η has a negative impact on the relative risk aversion. This can be seen from the specification of the degree of relative risk aversion under cubic preferences: $-cU''(c)/U'(c) = c(\gamma - \eta c)/(M - \gamma c + \frac{1}{2}\eta c^2)$. Introducing prudence thus makes it optimal for the household to reduce consumption today and postpone it for the future, which here results in allocating a larger proportion of children to the more costly and more risky type of education, schooling.

3.2.3 CRRA utility

The constant relative risk aversion (CRRA) utility functions are among the most commonly used utility functions. They allow for the presence of both risk aversion and prudence at the same time, and as the name indicates, the relative degree of risk aversion does not change as consumption levels increase, contrary to the quadratic utility function. It is therefore likely to be a more realistic preference structure. Especially so, when looking at poor households in developing countries. Analytically, however, the standard CRRA utility function is less tractable than the quadratic utility function. The comparison of the two sets of preferences will therefore be based on the calibration results, rather than on the analytical results.

The CRRA utility function used in the calibrations below is given by

$$U(c_t) = \begin{cases} \frac{c_t^{1-\rho}}{1-\rho}, & \text{for } \rho \neq 1 \\ \ln(c_t), & \text{for } \rho = 1 \end{cases}$$

The constant relative risk aversion parameter is given by $\rho = -cU''(c)/U'(c)$, where $U'(c) = c^{-\rho}$ and $U''(c) = -\rho c^{-\rho-1}$. Prudence is positive as can be seen from $U'''(c) = \rho(\rho+1)c^{-\rho-2} > 0$. The degree of relative prudence is also constant in consumption and given by $\rho + 1 = -cU'''(c)/U''(c)$. Thus, here it is not possible to separate out the effect of risk aversion from the effect of prudence, since they are both captured by ρ.

3.3 Introducing liquidity constraints

The model described in section 3.1 with an unspecified preference structure differs fundamentally from most models on child labour and schooling by including both future uncertainty about returns to schooling, no liquidity constraints, no agency problems and N children. When comparing this to the, by now, benchmark model developed by Baland & Robinson (2000), this corresponds a situation, where uncertainty is added to their world of perfect capital markets and two-sided altruism. This differs from Pouliot (2005), who introduces uncertainty into the parallel world of one-child households with one-sided altruism, positive bequests and perfect capital markets, i.e. parents do not rely on their child for old-age support. As Pouliot, I find a clear negative effect of uncertainty on schooling. The effect is strengthened by the introduction of a liquidity constraint and even more so if agency problems are also introduced because this, in effect, simply just increases the amount of uncertainty.

Most papers on child labour and schooling operate in a world with strong liquidity constraints. Shutting down the perfect credit market is a simple way of introducing such liquidity constraints in the human capital porfolio model above. By doing so, the model predictions become more directly comparable with the standard theories of child labour reviewed in section 2. In a world with no credit markets the households are faced with the following maximisation problem

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

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

$$c_1 = Y_1 - (1-\pi)Ne^a - \pi Ne^b$$

$$c_2 = N^{-\alpha}((1-\pi)Ny_2^a + \pi Ny_2^b)$$

There is now one first order condition with one unknown, π, the analytical solution for which

is

$$\pi^*_{cor} = \frac{N^{1-\alpha}\Delta y(M - \gamma N^{1-\alpha} y_2^a) - N\Delta e(M - \gamma(Y_1 - Ne^a))}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2\right]}$$

under perfect risk correlation in the urban labour market outcome among siblings and

$$\pi^*_{uncor} = \frac{N^{1-\alpha}\Delta y(M - \gamma N^{1-\alpha} y_2^a) - N\Delta e(M - \gamma(Y_1 - Ne^a))}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2\right]}$$

under no risk correlation. For both, $\Delta y = \mu - y_2^a$ and $\Delta e = e^b - e^a$. From these analytical solutions it is clear that now the relative size of the marginal utility in period one compared to period two is important for determining the size of π. If marginal utility in period one is very high, the second term of the numerator is high, which in principle can run π below zero if it is strong enough. The effect of uncertainty on π^* (when $\pi^* > 0$) is now also stronger, especially if N is high and for uncorrelated risk.

$$\frac{\partial \pi^*_{cor}}{\partial \varepsilon^2} = -\frac{N^{3-3\alpha}\Delta y(M - \gamma N^{1-\alpha} y_2^a) - N^{3-2\alpha}\Delta e(M - \gamma Y_1 + \gamma N e^a)}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2\right]^2} < 0$$

$$\frac{\partial \pi^*_{uncor}}{\partial \varepsilon^2} = -\frac{N^{2-3\alpha}\Delta y(M - \gamma N^{1-\alpha} y_2^a) - N^{2-2\alpha}\Delta e(M - \gamma Y_1 + \gamma N e^a)}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2\right]^2} < 0$$

The effects of fertility on the proportion of children in school are also altered. They are still ambiguous, but more likely to be negative than the corresponding derivatives under no liquidity constraints, especially so if N is large or if α is close to 1 under no risk correlation among urban siblings. The two partial derivatives are now given by

$$\begin{aligned}\frac{\partial \pi^*_{cor}}{\partial N} &= \frac{\pi}{N} - \frac{\left(\gamma(1-\alpha)N^{1-2\alpha}(y_2^a + 2\pi\Delta y) + \alpha N^{-\alpha}(M - \gamma N^{1-\alpha} y_2^a)\right)\Delta y}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2\right]} \\ &\quad - \frac{\gamma N(e^a + 2\pi\Delta e)\Delta e + \gamma\pi N^{1-2\alpha}(2-2\alpha)\varepsilon^2}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2\right]} \lesseqgtr 0\end{aligned}$$

$$\begin{aligned}\frac{\partial \pi^*_{uncor}}{\partial N} &= \frac{\pi}{N} - \frac{\left(\gamma(1-\alpha)N^{1-2\alpha}(y_2^a + 2\pi\Delta y) + \alpha N^{-\alpha}(M - \gamma N^{1-\alpha} y_2^a)\right)\Delta y}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2\right]} \\ &\quad - \frac{\gamma N(e^a + 2\pi\Delta e)\Delta e + \gamma\pi N^{-2\alpha}(1-2\alpha)\varepsilon^2}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2\right]} \lesseqgtr 0\end{aligned}$$

Finally, the non-monotonicity result with respect to parental income carries over to the situation with liquidity constraints. For the liquidity constrained household there is a clear direct positive effect of an increase in first period parental income

$$\frac{\partial \pi^*_{cor}}{\partial Y_1} = \frac{N\Delta e}{N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2} > 0$$

$$\frac{\partial \pi^*_{uncor}}{\partial Y_1} = \frac{N\Delta e}{N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2} > 0$$

but the effect is counterbalanced by the negative effect of the corresponding increase in second period agricultural income when $y_2^a = f(Y_1), f' > 0$, such that the overall effect of an increase in parental income becomes ambiguous

$$\frac{\partial \pi^*_{cor}}{\partial Y_1} = \frac{\partial \pi^*}{\partial y_2^a}\frac{\partial y_2^a}{\partial Y_1} = \frac{-N^{1-\alpha}\left(N^{1-\alpha}\mu + M\right)f'(Y_1) + \gamma N\Delta e + 2\gamma\pi N^{2-2\alpha}\Delta y f'(Y_1)}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{2-2\alpha}\varepsilon^2\right]} \lessgtr 0$$

$$\frac{\partial \pi^*_{uncor}}{\partial Y_1} = \frac{\partial \pi^*}{\partial y_2^a}\frac{\partial y_2^a}{\partial Y_1} = \frac{-N^{1-\alpha}\left(N^{1-\alpha}\mu + M\right)f'(Y_1) + \gamma N\Delta e + 2\gamma\pi N^{2-2\alpha}\Delta y f'(Y_1)}{\gamma\left[N^{2-2\alpha}\Delta y^2 + N^2\Delta e^2 + N^{1-2\alpha}\varepsilon^2\right]} \lessgtr 0$$

both under perfect risk correlation and no risk correlation among siblings in the urban labour market.

In previous literature, the non-monotonicity in the relationship between schooling or child labour and income or even the lack of significance in the correlation is generally explained by either (i) a dramatic drop in the need for child labour as soon as the household is able to meet subsistence needs based purely on parental earnings, which generates strong non-linearities in the demand for child labour in the neighbourhood of the poverty line, Basu and Van (1998) and Edmonds (2005); (ii) missing or incomplete markets which can lead to the 'wealth paradox', when child labour has to compensate for incomplete labour markets as in Bhalotra and Heady (2003); (iii) or agency problems if parents cannot rely on getting the expected old-age support from their children because these consider the second period parental income too high to be in need of support, Rogers and Swinnerton (2004). All three explanations generate local non-monotonicities, while maintaining a global postively monotonic relationship between schooling and parental income.

In this paper, the non-monotonicity between income and schooling stems from the relative attractiveness of the agricultural sector compared to the urban sector, and from the assumption that there are no additional returns from formal compared to traditional education in the traditional agricultural sector. This generates global non-monotonicity with a positive effect of parental income on π^* for lower levels of Y_1 and a negative effect for higher levels of Y_1, since Y_1 and second period agricultural income y_2^a are highly positively correlated.

4 Calibrations

Although one can find analytical solutions for the optimal proportion of formally educated children, π^* and show analytically that there is a negative effect of income dispersion or uncertainty, $\frac{\partial \pi}{\partial \varepsilon} < 0$, this does not indicate whether existing levels of uncertainty in urban income can actually result in less than full enrolment within a household. Only by calibrating the model,

using actual levels of school expenditures and income, is it possible to determine whether existing urban income dispersion, $Var(y_2^b) = \varepsilon^2$ is enough for the model to predict that at least one child will be educated traditionally and thus result in $\pi^* < 1$ even when there are no liquidity constraints. That is, whether existing levels of urban income uncertainty could potentially keep some children out of school purely due to future income diversification. Here it should be noted that, for calibration purposes, I am essentially equating uncertainty with income dispersion, and that the number of children in the calibration analysis is discrete.

In the following, there is a brief description of the data used and the assumptions made, when determining the size of the exogenous variables in the calibrations. In section 4.2, I show the results when calibrating the model from section 3 under quadratic, cubic and CRRA preferences. The focus is on how schooling, π react to future income uncertainty, ε when there are no liquidity constraints and no child labour; and on how the model derivatives with respect to N and Y_1 compare to the calibration results. These are important for future empirical testing of the model implications. In section 4.3, I introduce liquididity constraints and child labour and compare these effects to the effects of uncertainty on schooling when there are no child labour or liquidity constraints. The introduction of liquidity constraints and child labour is meant as an illustrative example of how the model captures the main components of the child labour literature, while allowing for the separate effects of uncertainty on school enrolment. Section 4.4 concludes.

4.1 Data

The model is calibrated using simple summary statistics from a large-scale nationwide household survey from Tanzania undertaken in 1994, the Human Resource and Development Survey (HRDS)[14]. It is a nationally representative survey of 5,000 households out of which more than half of the households have school-aged children. The HRDS data contains detailed information on individual household members, their educational status and current economic activity. At household level, it includes location, main source of income, detailed assets and expenditure information and, not least, schooling expenditures information. For calibration purposes only rural households with children of school-age are included, which results in a sample of 1982 households.

[14]The Tanzanian Human Resource and Development Survey (HRDS) is a nationally representative survey from 1994 of 5,000 households. The survey was a joint effort undertaken by the Department of Economics of the University of Dar es Salaam, the Government of Tanzania, and the World Bank, and was funded by the World Bank, the Government of Japan, and the British Overseas Development Agency. For more information or access to the data see www.worldbank.org/lsms

Table 1. Summary statistics of HRDS variables and their model equivalents.

HRDS variable		HRDS data	normalised	Model
AE daily HH expenditure, urban sector	mean	1.84	2.42	y_2^b
	s.d.	2.02	1.99	ε
AE daily HH expenditure, agri sector	mean	0.76	1	$Y_1 = y_2^a$
	s.d.	0.51	0	
Annual school expenditure, cluster mean	mean	5.96	0.02	e^b
Total number of children in HH	mean	3.91		N
Proportion of children in/through school	mean	0.63		π
# observations		1982		

Data source: HRDS data. Note, y_2^b is the household expenditure among urban households, where the main source of income is urban. y_2^a is the household expenditure among rural households, where the main source of income is agricultural. All expenditure amounts are in USD. An exchange rate of 1 USD = 455 Tsh is used. AE is short for adult equivalent

The model is thus calibrated for the average rural household is school-aged children in 1994 Tanzania. Calibrating the model using data driven numerical values is helpful in determining the relative levels of exogenous variables.

Rural and urban income levels are proxied by the adult equivalent household expenditure levels for households in rural and urban areas, respectively. Expenditure measures in the data include values of home production. Agricultural income, Y_1 and y_2^a are assumed to be of the same size, and expected future urban income, $E(y_2^b) = \mu$ is simply set to current adult equivalent expenditure levels of urban households whose main income source is also urban.

The educational expenditure associated with schooling, e^b is directly given in the data as the cluster average of primary school expenditures. Since the model is set up for rural households, the mean for rural clusters is used. The educational expenditure associated with traditional agricultural education is not observable. If e^a is negative, it can be thought of as the opportunity costs of time children spend in school, and thus as a measure of income generated by child labour. If e^a is positive, it can be thought of as the opportunity costs of parents' time spent supervising the children in traditional education. When calibrating the model with no child labour and no liquidity constraints, I simply proxy e^a by half of the costs associated with formal schooling. Traditional education is then cheaper than formal education, but also less profitable.

Agricultural income levels in the two periods are normalised to unity, $Y_1 = y_2^a = 1$ with zero standard deviation. This results in $E(y_2^b) = \mu = 1.84/0.76 = 2.42$ and $\varepsilon = s.d.(y_2^b) = \sqrt{(2.02^2 - 0.51^2)/0.76} = 2.24$.[15] The actual cost of schooling in rural areas is very low and only

[15] The expenditure standard deviation among urban households is very high due to a long right hand side tail in the expenditure distribution. Alternatively, I therefore cap ε at the value of μ, such that the urban uncertainty is an uncertainty which either drives income in zero or doubles it, i.e. $\varepsilon^b = 2.42 - 0.51/0.76 = 1.75$

2% of household expenditures, thus $e^b = 0.02$ and $e^a = 0.01$. These schooling expenditures do not include indirect costs of schooling, such as distance, and should therefore be seen as a lower bound. They do, however, include uniform costs. It should be noted that all of these amounts are measured in USD and adult equivalent terms.

When calibrating the model, I primarily allow ε and N to vary. The urban income dispersion or uncertainty, ε runs in the $[0; 2.4]$ interval with steps of 0.1. Thus the degree of uncertainty can run roughly from 0 to 100 per cent of average income level. The number of children, N is allowed to be 1, 2, 4, or 6 children, i.e. the model is calibrated for discrete numbers of children only and π can therefore also only take a limited number of values. $N = 1$ is included to allow comparisons with the standard models of child labour and schooling in the literature. According to the summary statistics in table 1, rural households have an average almost 4 children. The schooling rate among the 7-17 year olds in rural areas was 63% in 1994 (as opposed to 66% at national level). Unless mentioned otherwise, $\alpha = 0.95$. I choose a high α in order to make first and second period income levels comparable and to avoid strong consumption smoothing mechanisms. The effect of changing α is shown below.

As in the analytical set-up, the model is calibrated with two choice variables, π and s, which are chosen to maximise the household utililty function (1) given the budget constraints (2). The calibration results for π^* will show how large the dispersion in urban income, ε^2, has to be for the model to produce realistic enrolment rates under the three different types of preferences.

4.2 Preference structures

4.2.1 Quadratic utility

In order to calibrate the model for the quadratic utility function, it is necessary to specify the preference parameters parameters, M and γ. In a world of no consumption smoothing, first period consumption would be below 1, whereas expected second period consumption would be around 2 if all children are sent to school and α is close to 1. For these levels, $M = 7$ and the risk aversion parameter, $\gamma = 2$ ensure that marginal utilities of the two periods are positive given the allowed variations in income.

The results for the optimal portfolio choice of the proportion of children in school, π^* are summarised in figure 0 for the case of no risk correlation and perfect risk correlation in siblings urban labour market outcome and for the specific case of $N = 4$. Figure 0 is meant as an introduction to the following figures and therefore includes data points. Uncertainty measured by ε is on the X-axis, the optimal proportion of children in school, π is on the Y-axis. The left panel shows the effect of uncertainty on the optimal proportion of children in school, when there is no correlation among migrant siblings' urban income risk. The right panel show the effect of uncertainty, when there is perfect correlation among siblings' urban income risk. When

uncertainty is perfectly uncorrelated (left panel), the model calibrations predict full enrolment ($\pi = 1$), given the parameter specifications, as long as $\varepsilon \leq 2.3$. Remember, everything is discrete. Thus, when epsilon jumps to $\varepsilon = 2.4$, $\pi = 0.75$ meaning that the household now chooses only to educate 3 out of 4 children formally, i.e. one child is educated traditionally. In the right panel, less uncertainty is needed before it is optimal for the household to only send 3 out of 4 children to school. Already for $\varepsilon = 1.7, \pi = 0.75$. As epsilon increases, the optimal proportion of children in school drops, but in a discrete manner. For $\varepsilon \geq 2.1$, only 2 out of 4 children are sent to school.

[Figure 0]

Thus, as it was shown analytically above, there is a clear negative effect of ε on π. The important information is, however, that the negative effect of uncertainty is present in the neighbourhood of the actual level of urban income spread, that is for $\varepsilon = 2.24$. As expected, the effect is stronger under perfect risk correlation compared to no risk correlation. Figure 0 is a representation of the average household without any liquidity constraints or immediate returns to child labour. The negative effects of uncertainty on the optimal proportion of children in school is purely driven by the need for risk diversification and thus future income source diversification. When there is perfect risk correlation among siblings in their urban labour market outcomes, the only source of risk diversification is between the agricultural and the urban sector. On the other hand, when uncertainty about the urban labour market lottery is perfectly uncorrelated across siblings, the risk diversification can happen both between the agricultural and the urban sector, and among the migrant children in the urban sector, the negative effect of uncertainty is therefore substantially reduced.

In figure 1, I allow for different household sizes by letting the total number of children N equal 1, 2, 4 or 6. It is clear that no matter how many children the household has, if parents face no uncertainty about the future income of their children ($\varepsilon = 0$), then they will always educate all of their children irrespective of N. This is an obvious implication of the fact that there are no liquidity constraints.

[Figure 1]

However, as uncertainty increases, there are clear portfolio effects in households with more than one child. For $N = 1$ there is no difference between being in the world of perfectly correlated or uncorrelated ε's. This is natural, since the correlation is between migrant siblings in urban areas. Comparing the two panels of figure 1 also gives an indication of the importance of allowing for sibling dependence in the portfolio model. Assuming that the human capital investment decision of each child in the household is made independently of all of his/her siblings (which corresponds to the $N = 1$ case) and then just adding over the total number of

children in the household will yield very different predictions from a model, where such sibling dependence is taken into account, say for $N = 4$, in particularly so for correlated ε's.

4.2.2 Cubic utility

Calibrating the cubic utility function as opposed to the quadratic is simply done by substituting the utility function in (5) with the one in (8) using the same parameter values as above, $M = 7, \gamma = 2$ and now allowing the prudence parameter to vary at low values, $\eta = [0.1; 0.4]$, to ensure that $U''(c)$ will always be negative. The results are as expected. Introducing prudence has a positive impact on the optimal proportion of children sent to school π^*, which is mostly evident from the case of perfect risk correlation in the urban labour market outcomes, see figure 2 for $N = 4$.

[Figure 2]

Figure 2 shows that for uncertainty levels of $\varepsilon = 2$ and a prudence parameter $\eta < 0.3$, households will educate 1 out of 4 children traditionally ($\pi = 0.75$) if there is perfect correlation among siblings in the urban labour market, whereas they will educate all children formally ($\pi = 1$) if the urban labour market draws are perfectly uncorrelated over migrant children. For $\eta \geq 0.3$ and $\varepsilon \leq 2$, all four children are sent to school. Compared to the quadratic preferences, slightly higher levels of uncertainty is now necessary for it to be optimal for the household to keep at least one child at home for traditional education. Formal education is simply a better savings strategy than traditional education.

4.2.3 CRRA utility

Deciding on the parameter values for the quadratic and cubic preferences is somewhat arbitrary in the sense that they are sensitive to the level of consumption and are chosen to ensure that marginal utilities in both period one and period two are non-negative. The remaing results are therefore all based on CRRA preferences. The value of the relative risk aversion parameter of ρ is allowed to vary and all calibrations are done for $\rho = 1$, 2 and 3, although the results reported in the text below are for $\rho = 2$. See appendix A3 for all CRRA calibration results. In general, the larger ρ is, the more sensitive π is to changes in the exogenous variables and increasing the relative risk aversion has the expected effect of shifting the graphs downwards and thus reducing the optimal proportion of children sent to school. Looking at the graphs, there are indications that the chosen preference parameters of the quadratic and cubic utility functions most closely resemble the case of log utility and $\rho = 1$.

[Figure 3]

Figure 3 corresponds to figure 1 above, now based on CRRA preferences with $\rho = 2$. First, as for the case of quadratic utility, households will always send all their children to school if there is no uncertainty. Second, as the level of uncertainty about future urban income increases, the need for risk diversification gets stronger and the optimal human capital portfolio shifts towards traditional education for one or more children. Under CRRA preferences, the model predicts that the average household with 4 children will educate at least one child traditionally if the dispersion in urban income $\varepsilon > 1.5$ under perfect risk correlation in the urban labour market. More uncertainty is needed when the urban labour market draws are perfectly uncorrelated across migrant siblings, only when $\varepsilon > 2.1$ will the household need to diversify income sources not only within the urban sector, but also between the urban and the agricultural sector. Again, the adjusted observed spread in urban income, $\varepsilon = 1.75$, lies well within the span of these two extremes. Third, the portfolio effects of having more than one child are now more pronounced compared to quadratic utility, higher N and thus higher consumption levels no longer results in higher risk risk aversion as it is the case under quadrati preferences. There are clear positive portfolio effects of belonging to households with more children compared to less when the urban labour markets draws are perfectly uncorrelated, more children makes it possible to increase the diversification of the urban income risk reducing the need for the agricultural sector in achieving the optimal risk diversification. The results are more ambiguous when there is perfect correlation in the urban labour markets draws.

The important thing to notice here is that existing levels of uncertainty can indeed result in parents only sending some, but not all children to school. This negative effect on the optimal human capital portfolio allocation is surprisingly large, taking the perfect credit markets into consideration. Even for moderate levels of uncertainty, which match the actual income spread among urban households, and without any liquidity constrainst or child labour, the model is able to predict an interval of optimal school enrolment rates within which the actual enrolment rate of $\pi = 0.63$ lies. For the average household, the pure effect of uncertainty is thus so strong that actual school enrolment rates could, in principle, be explained solely by the existence of uncertainty. Hence, the roots of child labour and lack of schooling need not lie solely with incomplete credit markets and poverty, but could also be caused by the fact that rural households are not only concerned with securing their current, but also their future old-age income.

The calibration of this simple human capital portfolio model thus shows that realistic levels of uncertainty about future income of children can indeeed have a negative impact on the optimal proportion of children in school within the household, even under no liquidity constraints and only future returns to children engaged in traditional education. This central implication of the model relies upon the assumptions of parents depending on their children for old age security, of no covariant risk between urban and agricultural income, as well as on

the sectoral divide in returns to formal and traditional education. Assumptions which might not be standard in the child labour and schooling literature, but which each have substantial support in other literatures, all reviewed above.

4.3 Introducing child labour and liquidity constraints

Literature on child labour and schooling focuses on explaining the existence of child labour and lack of schooling as consequences of ex-post risk coping mechanisms when households are faced with negative income shocks and of the inability of parents to borrow against the future returns of schooling of the children. That is, they assume liquidity constraints and immediate net returns to children working in the traditional agricultural sector as opposed to future returns. In the following, I allow for both. Child labour thus still carries an element of education in the sense that there are returns to learning-by-doing and $y_2^a > -e^a$. By introducing both liquidity constraints and child labour, I am able to compare the model predictions under uncertainty ($\varepsilon > 0$) and sibling dependence ($N > 1$) with those of standard child labour models under no uncertainty ($\varepsilon = 0$) and one-child households ($N = 1$), as well as with the two recent papers where uncertainty has been introduced into one-child households.

In figure 4, simple liquidity constraints have been introduced in the portfolio model above under CRRA preferences. Households can now save, but they can no longer borrow on the credit market, $s \geq 0$. Figure A3 in appendix A3 shows the corresponding figures under different degrees of relative risk aversion. Comparing figure 3 and 4 (as well as figures A1 and A3), it easily shows that - given the numerical values for the average household, where costs of schooling are relatively low and returns are 1.5 times larger than in the agricultural sector - the introduction of a liquidity constraint has virtually no effect[16]. Only once immediate returns to child labour are also introduced such that one child in the agricultural sector generates exactly enough income to cover the schooling expenses of a sibling $e^a = -e^b$, is there a clear negative effect.

[Figure 4 & 5]

The introduction of child labour as an immediate return to traditional education generates a possibility of transferring income from period two to period one via the human capital market, given the incompleteness of the financial capital market. This does not seem to be necessary for households with 4 children or less, but for households with 6 children it is now optimal to always educate one child traditionally, even when there is no uncertainty. Comparing the isolated effect of uncertainty in figure 3 with the isolated effect of liquidity constraints and

[16] In chapter 4 of this thesis, the same model is calibrated using numerical values from a different data set where costs of schooling is slightly higher and returns are lower, and there are more children in the average household. This results in more markedly effects of introducing liquidity constraints.

child labour for $\varepsilon = 0$ in figure 5, it is clear that uncertainty has a negative effect on the optimal choice of education of *all* children, whereas the constraint and child labour effects only really dominate in households with more children than the average $N = 4$. This emphasises the importance of allowing for N children, rather than just one child. Assuming that the optimal solution for one child carries through for all N children of the same household is clearly not correct, regardless of the degree of uncertainty. Under no uncertainty, even if the immediate returns to child labour were of the same size as current parental income or future returns to traditional education, i.e. $-e^a = Y_1 = y_2^a = 1$, the optimal solution for the one child would still be schooling, unless future returns are discounted enough to drop below current returns. As uncertainty about future urban income increases, the importance of allowing for some degree of sibling dependency is clear from the portfolio effects implied by differences in fertility. These portfolio effects seem even more pronounced in figure 5, compared to figure 4.

The main conclusion to take from these calibration results is that although the combination of child labour and liquidity constraints can have negative effects on the optimal proportion of children in school, these effects are strengthened partly by the introduction of $N > 1$ children, and partly by the existence of uncertainty $\varepsilon > 0$, which also in itself has strong negative effects on the optimal human capital portfolio. While the existing explanations in the literature for low enrolment rates into primary schools are focussed on the inability of parents to meet the direct and indirect costs of schooling and the role of children in ex-post risk coping mechanisms, the calibrations show that the ex-ante risk diversification strategies of a household may be at least equally important for the human capital investment decisions of the household. The introduction of uncertainty into a simple human capital portfolio model, which allows for a joint schooling decision of children in a household thus offers an alternative and complementary explanation to why it may be optimal for parents not to send *all* of their children to school, even if they can afford to do so.

In addition, the portfolio model offers a simple explanation for a non-monotonic relationship between child labour, schooling and income. The difference in returns between the agricultural sector and the urban sector generates global non-monotonicity, as discussed above. This is obvious from figure 6, which shows the effect on different income levels $Y_1 = [0.5; 3]$ on the optimal human capital portfolio π^* for the average household with $N = 4$ under liquidity constrainst and with immediate returns to child labour. For the very low levels of (agricultural) income there is a positive effect of income increases on π^* driven by the fact that the household is constrained and income increases allow households to allocate more children to the most profitable educational alternative, schooling. However, if the first period parental income is very high, so is the expected second period agricultural income and thus the relative returns to traditional education compared to formal education increase, making traditional education relatively more attractive. It is therefore optimal for the household to educate some children

traditionally. This shift toward traditional education happens earlier the higher the level of uncertainty in the urban sector relative to the agricultural sector, which here is normalised to be risk free. This provides an alternative explanation for the mixed empirical evidence with respect to income, schooling and child labour.

[Figure 6]

Finally, it should be noted that there is one parameter in the calibration, which has not yet been discussed, α. This determines the fraction of income that each child shares with his/her parents in the second period. When $\alpha = 0$, children share all of their income with parents, when $\alpha = 1$ children share $1/Nth$ of their income with parents. In all of the calibrations above $\alpha = 0.95$ and thus children share slightly more than $1/Nth$ of their income with parents, such that parents in the second period in total receives slightly more than one full income. This number is, of course, chosen arbitrarily. From the three panels of figure A7, it shows that the effect of changes in α are fairly small when there is no immediate return to child labour, but large and negative as α approaches zero and there are immediate returns to child labour. This effect is purely a result of consumption smoothing. For very low α, parental income in the second period can be more than N times the current first period income and the only possibility of transferring resources from the second period to the first period is to shift children from formal education to traditional education, which now generates not only future but also immediate returns. Thus for low levels of α, the negative effects of the combination of liquidity constraints and child labour are strengthened.

5 Conclusions and Policy Implications

In this paper I asked the question of whether future income uncertainty can result in households not educating *all* their children formally as an optimal risk diversification strategy to secure old-age subsistence of parents. To answer the question I develop a simple portfolio model of human capital investment of all children in a household. The model differs from most models of child labour and schooling by analysing the human capital investment decisions from the broader perspective of a rural household, allowing for future income uncertainty and considering both the old-age dependency of parents on children and the sibling dependency. When focusing on the human capital investment decisions of all children, it becomes obvious that several factors can influence such the joint decision. The basis for the model and its assumptions build on insights from different strands of literature with the aim of incorporating the variety of factors, which could be of importance. The emphasis is placed on ex-ante, rather than ex-post, risk diversification as a means of income smoothing, on the strong sectoral divide between the agricultural and urban sector and the dichotomy in the returns to specific versus general human

capital, on the role of children as old-age security assets of their parents, and on the dependency that this creates among siblings because educational choices are not made independently for each child, but rather as a joint decision over siblings giving natural rise to sibling differences, which is not in any way driven by heterogenity or adverse economic conditions.

It is straightforward to show analytically that uncertainty about future income transfers from children, which in essence is uncertainty about returns to the human capital investments, has a negative effect on investments in the most uncertain type of human capital, here schooling. This result hinges upon the assumption of a sectoral divide in returns to formal and traditional education for which there is ample evidence in the literature, e.g. Rosenzweig (1995), Foster and Rosenzweig (1996) and Fafchamps and Wahba (2006).

The analytical result is, however, a qualitative finding and it does not indicate whether actual levels of uncertainty have any effect on the optimal proportion of children in school. The actual level of uncertainty could in principle be too low for the household to consider it worth giving up income in return for less risk exposure. The model is therefore calibrated using data driven numerical values and a variety of difference preference specifications. I find that moderate levels of uncertainty, based on the spread of income observed in data, is enough uncertainty for the average household choose a suboptimal human capital portfolio allocation of their children compared to a situation of no uncertainty. The need for risk diversification can thus result in parents only sending some, but not all, children to school. The negative effect of uncertainty is surprisingly large. Comparing the isolated effect of uncertainty with the isolated effect of liquidity constraints and child labour, it is clear that uncertainty influence the optimal choice of education of all children, whereas the constraint and child labour effects only really dominate in households with more children than the average $N = 4$. Although fairly robust to the choice of preference parameters, these results are based on simple moments taken from the data. The logical next step is therefore to find empirical implications of the model, which can be estimated and tested on a full data set.

However, based on the findings of the model calibrations, it does seem safe to conclude that future income uncertainty can indeed result in less than full school enrolment among siblings of a household. The focus on ex-ante income smoothing adds a new perspective to the child labour debate, which has previously been centered around the need for ex-post consumption smoothing for the liquidity constrained household. It also has direct implications for educational policies aimed at ensuring full enrolment, since lack of enrolment might not only be a matter of costs of schooling, but also of content. If the dichotomy in the educational system force parents to diversify human capital investments of their young children between traditional agricultural education and modern formal schooling in order to achieve future income source diversification, then an obvious policy implication is to increase the returns of formal schooling in the agricultural sector. This can be done either by shifting part of the traditional educa-

tion, currently undertaken by parents, into the formal schooling system, thus teaching children specific agricultural skills along with more general skills, such as writing and alegra; or by modernising the agricultural sector to create 'learning opportunites' and thus increase returns to formal schooling in the agricultural sector, see Foster and Rosenzweig (1996). Households are likely still to diversify future income sources, but it need no longer be a diversification decision taken at an early stage of human capital investments.

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6 Figures

Figure 0. Quadratic preferences ($M = 7, \gamma = 2$), effect of uncertainty, ε on proportion of children in school, π^*

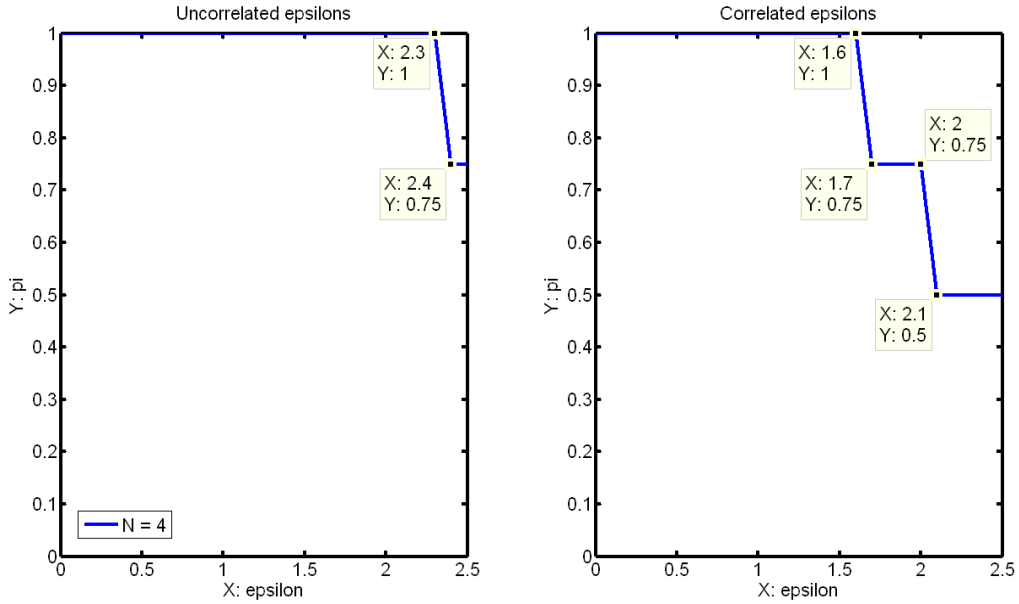


Figure 1. Quadratic preferences ($M = 7, \gamma = 2$), effect of uncertainty, ε on proportion of children in school, π^* over number of children in the household, N.

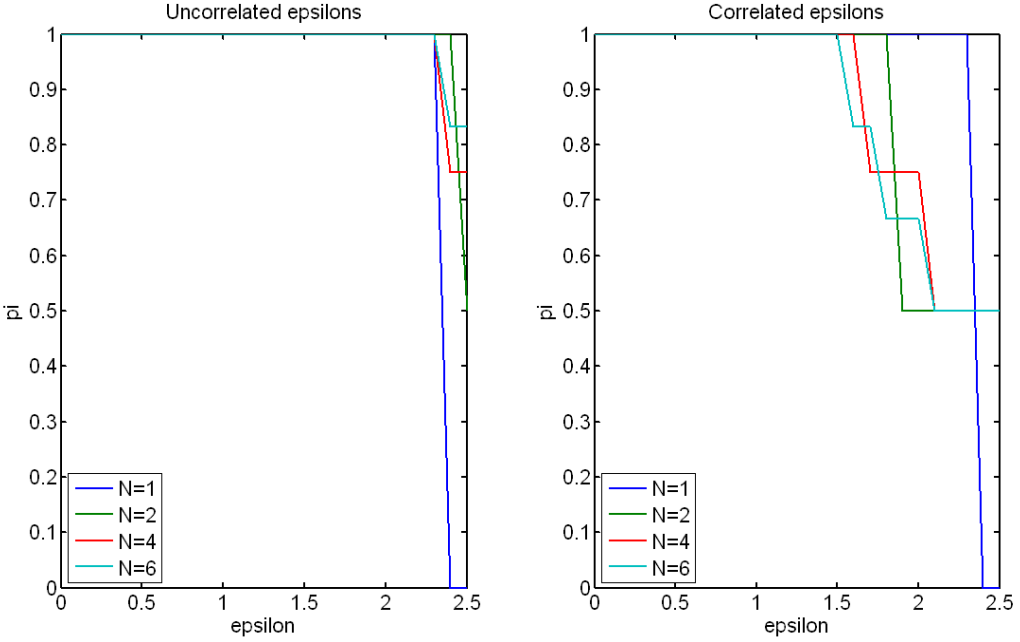


Figure 2. Cubic preferences ($M = 7, \gamma = 2$), effect of uncertainty, ε on proportion of children in school, π^* over different degrees of prudence, η and for fixed $N = 4$

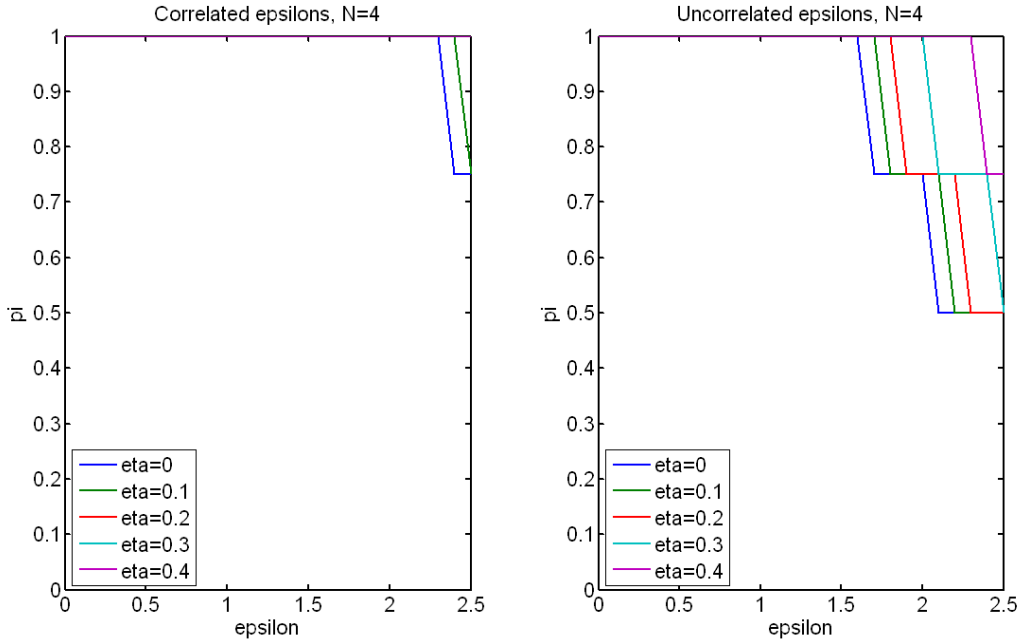


Figure 3. CRRA preferences ($\rho = 2$), effect of uncertainty, ε on proportion of children in school, π over number of children in the household, N

- under no liquidity constraints and no child labour

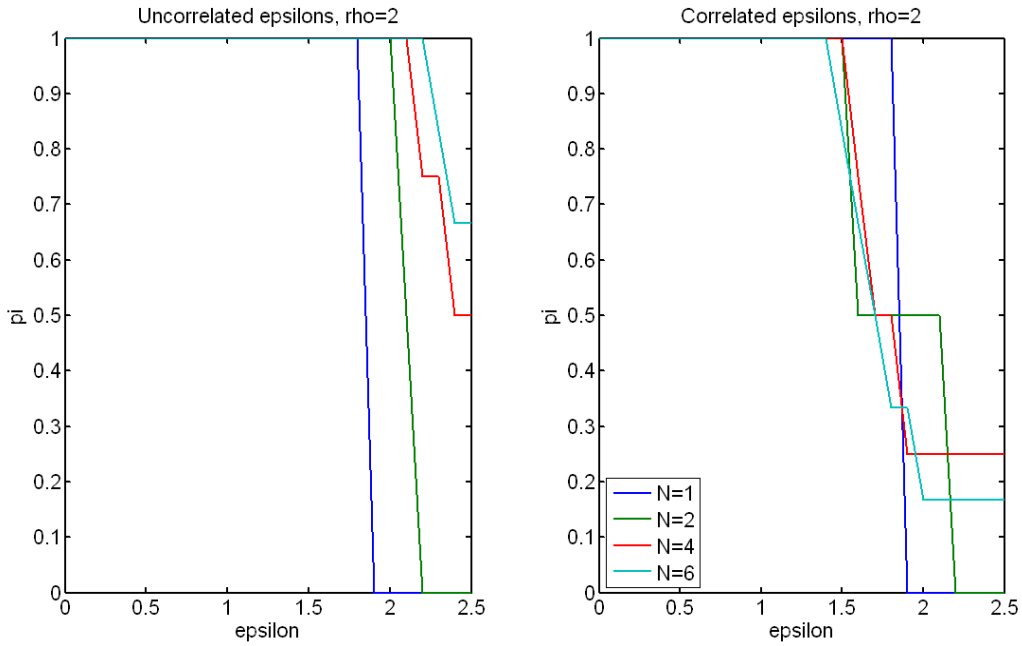


Figure 4. CRRA preferences ($\rho = 2$), effect of uncertainty, ε on proportion of children in school, π over number of children in the household, N

- under liquidity constraints and no child labour

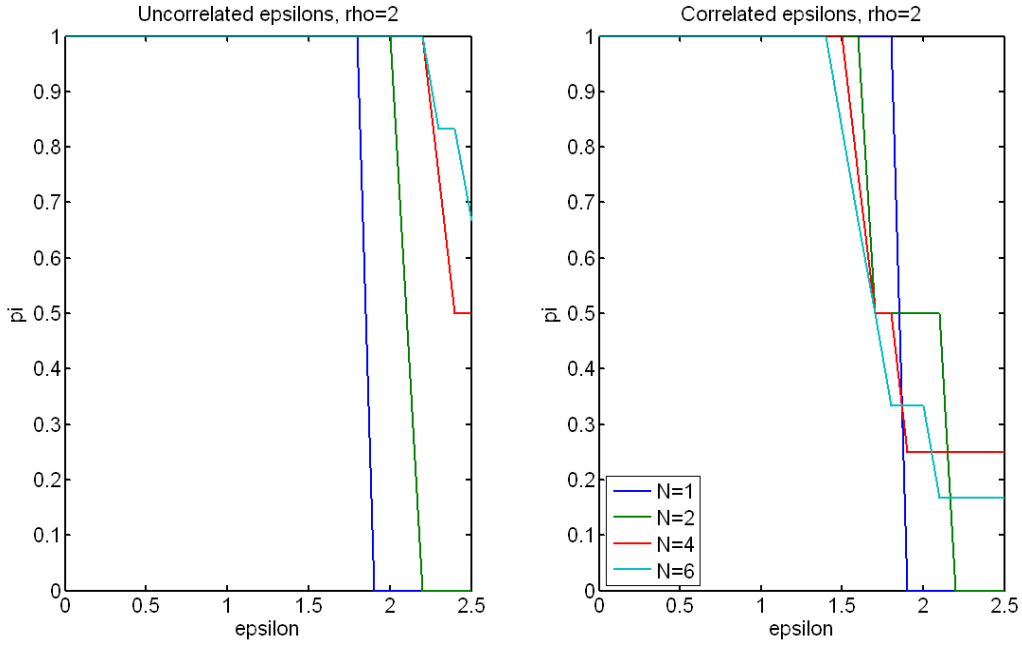


Figure 5. CRRA preferences ($\rho = 2$), effect of uncertainty, ε on proportion of children in school, π over number of children in the household, N

- under liquidity constraints and child labour

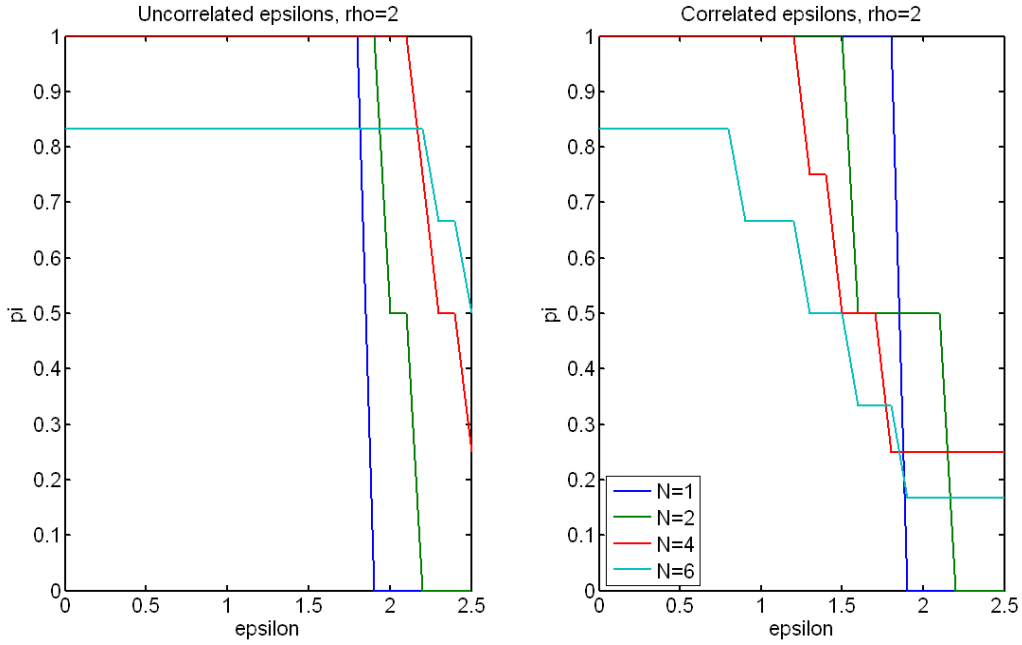
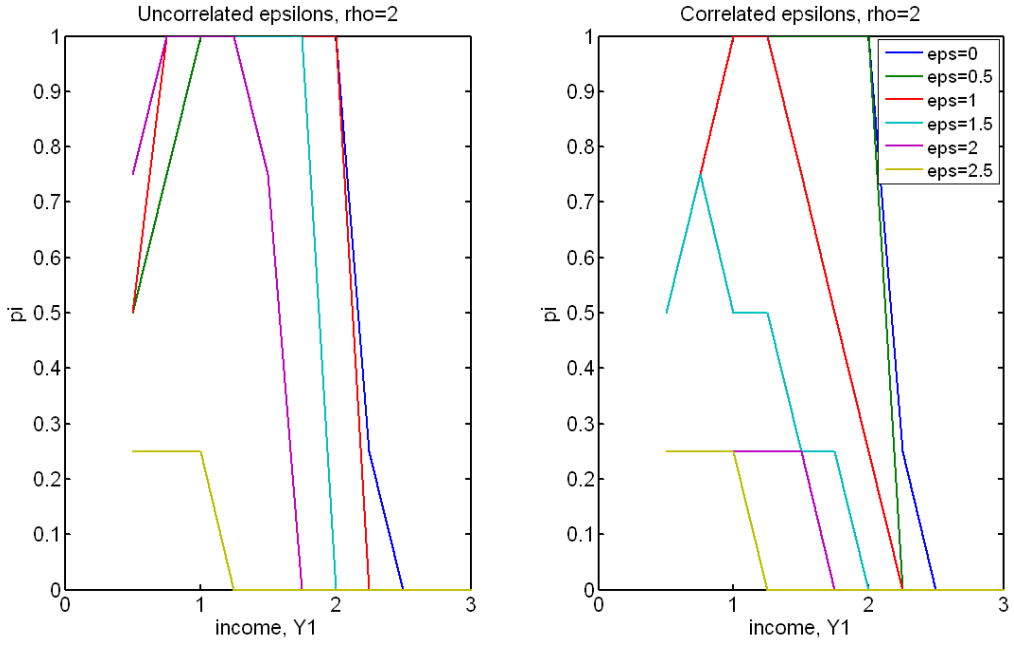


Figure 6. CRRA preferences ($\rho = 2$), effect of agricultural income Y_1 on proportion of children in school, π for $N = 4$

- under liquidity constraints and child labour



7 Appendix A1

The covariance term $cov(N^{1-\alpha}y_2^b, U'(c_2))$ differ depending on whether there is perfect risk correlation or no risk correlation between the second period urban labour market outcome of siblings. Under perfect risk correlation and quadratic preferences, the covariance term is given by

$$\begin{aligned}
cov(N^{1-\alpha}y_2^b, U'(c_2)) &= E[(N^{1-\alpha}y_2^b - N^{1-\alpha}\mu)(U'(c_2) - EU'(c_2))] \\
&= \frac{1}{2}[(N^{1-\alpha}(\mu+\varepsilon) - N^{1-\alpha}\mu)(\{M - \gamma(N^{-\alpha}(1-\pi)Ny_2^a + \pi N(\mu+\varepsilon) + s)\} \\
&\quad -\{M - \gamma(N^{-\alpha}(1-\pi)Ny_2^a + \pi N\mu + s)\})] \\
&\quad +\frac{1}{2}[(N^{1-\alpha}(\mu-\varepsilon) - N^{1-\alpha}\mu)(\{M - \gamma(N^{-\alpha}(1-\pi)Ny_2^a + \pi N(\mu-\varepsilon) + s)\} \\
&\quad -\{M - \gamma(N^{-\alpha}(1-\pi)Ny_2^a + \pi N\mu + s)\})] \\
&= \frac{1}{2}[-\gamma\pi N^{2(1-\alpha)}\varepsilon^2] + \frac{1}{2}[-\gamma\pi N^{2(1-\alpha)}(-\varepsilon)^2] \\
&= -\gamma\pi N^{2-2\alpha}\varepsilon^2
\end{aligned}$$

Under no risk correlation, it is given by

$$\begin{aligned}
cov(N^{1-\alpha}y_2^b, U'(c_2)) &= E[(N^{1-\alpha}y_2^b - N^{1-\alpha}\mu)(U'(c_2) - EU'(c_2))] \\
&= E[N^{1-\alpha}(y_2^b - \mu)(-\gamma\pi N^{1-\alpha}(y_2^b - \mu))] \\
&= -\gamma N^{-2\alpha}E[\{N(y_2^b - \mu)\}\{\pi N(y_2^b - \mu)\}] \\
&= -\gamma N^{-2\alpha}\sum_{i=0}^{\pi N}\binom{\pi N}{i}\frac{1}{2^{\pi N}}\{[(1-\pi)N + i]\varepsilon - [N-i]\varepsilon\}\{i\varepsilon - [\pi N - i]\varepsilon\} \\
&= -\gamma\pi N^{1-2\alpha}\varepsilon^2
\end{aligned}$$

8 Appendix A2

Deriving first order conditions under the cubic utility function. The first order condition for savings, s under perfect risk correlation among siblings in urban labour market is

$$\begin{aligned}
U'(c_1) &= EU'(c_2) \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma Ec_2+\frac{1}{2}\eta E(c_2^2) \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma Ec_2+\frac{1}{2}\eta E([(1-\pi)N^{1-\alpha}y_2^a+\pi N^{1-\alpha}y_2^b+s]^2) \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma Ec_2+\frac{1}{2}\eta (Ec_2)^2+\frac{1}{2}\eta(\pi N^{1-\alpha}\varepsilon)^2
\end{aligned}$$

and under no risk correlation is

$$\begin{aligned}
U'(c_1) &= EU'(c_2) \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma Ec_2+\frac{1}{2}\eta E(c_2^2) \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma Ec_2+\frac{1}{2}\eta \sum_{i=0}^{\pi N}\binom{\pi N}{i}\frac{1}{2^{\pi N}}[Ec_2+N^{-\alpha}((\pi N-i)\varepsilon-i\varepsilon)]^2 \\
M-\gamma c_1+\frac{1}{2}\eta c_1^2 &= M-\gamma E(c_2)+\frac{1}{2}\eta E(c_2)^2+\frac{1}{2}\eta\pi N^{1-2\alpha}\varepsilon^2
\end{aligned}$$

The covariance term in the first order condition for the proportion of children in formal education, π under perfect risk correlation among siblings in urban labour market is then

$$\begin{aligned}
cov(N^{1-\alpha}y_2^b, U'(c_2)) &= E[(N^{1-\alpha}y_2^b-N^{1-\alpha}\mu)(U'(c_2)-EU'(c_2))] \\
&= E[N^{1-\alpha}(y_2^b-\mu)(-\gamma(c_2-Ec_2)+\frac{1}{2}\eta(c_2^2-E(c_2)^2-(\pi N^{1-\alpha}\varepsilon)^2))] \\
&= E[N^{1-\alpha}(y_2^b-\mu)(-\gamma\pi N^{1-\alpha}(y_2^b-\mu) \\
&\quad +\frac{1}{2}\eta((\pi N^{1-\alpha}y_2^b)^2+(\pi N^{1-\alpha}\mu)^2+2\Gamma\pi N^{1-\alpha}(y_2^b-\mu)^2-(\pi N^{1-\alpha}\varepsilon)^2))] \\
&= (-\gamma+\eta(\Gamma+\mu))\pi N^{2-2\alpha}\varepsilon^2
\end{aligned}$$

where $\Gamma=(1-\pi)N^{1-\alpha}y_2^a+s$. The first order condition for π under perfect risk correlation is then given by

$$\begin{aligned}
N(e^b-e^a)U'(c_1) &= N^{1-\alpha}(\mu-y_2^a)EU'(c_2)+cov[N^{1-\alpha}y_2^b, U'(c_2)] \\
N(e^b-e^a)U'(c_1) &= N^{1-\alpha}(\mu-y_2^a)\left(U'(Ec_2)+\frac{1}{2}\eta(\pi N^{1-\alpha}\varepsilon)^2\right)-(\gamma-\eta(\Gamma+\mu))\pi N^{2-2\alpha}\varepsilon^2
\end{aligned}$$

while under no risk correlation the covariance is

$$\begin{aligned}
cov(N^{1-\alpha}y_2^b, U'(c_2)) &= E[(N^{1-\alpha}y_2^b - N^{1-\alpha}\mu)(U'(c_2) - EU'(c_2))] \\
&= E[N^{1-\alpha}(y_2^b - \mu)(-\gamma(c_2 - Ec_2) + \frac{1}{2}\eta(c_2^2 - E(c_2)^2 - \pi N^{1-2\alpha}\varepsilon^2))] \\
&= E[N^{1-\alpha}(y_2^b - \mu)(-\gamma\pi N^{1-\alpha}(y_2^b - \mu) \\
&\quad + \frac{1}{2}\eta((\pi N^{1-\alpha}y_2^b)^2 - (\pi N^{1-\alpha}\mu)^2 + 2\Gamma\pi N^{1-\alpha}(y_2^b - \mu) - \pi N^{1-2\alpha}\varepsilon^2))] \\
&= \sum_{i=0}^{\pi N}\binom{\pi N}{i}\frac{1}{2^{\pi N}}[\pi N^{-2\alpha}(-\gamma + \eta(\Gamma + \mu)\left((N-i)\varepsilon - ((1-\pi)N + i)\varepsilon\right)^2) \\
&\quad + \frac{1}{2}\eta\pi N^{-3\alpha}(\left(\pi(N-i)\varepsilon - ((1-\pi)N + i)\varepsilon\right)^3 - \left((N-i)^2\varepsilon^3 + ((1-\pi)N + i)^2(-\varepsilon^3\right)))] \\
&= (-\gamma + \eta(\Gamma + \mu))\,\pi^2 N^{1-2\alpha}\varepsilon^2
\end{aligned}$$

where $\Gamma = (1-\pi)N^{1-\alpha}y_2^a + s$. The first order condition for π under no risk correlation is then given by

$$\begin{aligned}
N(e^b - e^a)U'(c_1) &= N^{1-\alpha}(\mu - y_2^a)EU'(c_2) + cov[N^{1-\alpha}y_2^b, U'(c_2)] \\
N(e^b - e^a)U'(c_1) &= N^{1-\alpha}(\mu - y_2^a)\left(U'(Ec_2) + \frac{1}{2}\eta\pi N^{1-2\alpha}\varepsilon^2\right) - (\gamma - \eta(\Gamma + \mu))\,\pi^2 N^{1-2\alpha}\varepsilon^2
\end{aligned}$$

9 Appendix A3: CRRA figures

Figure A1. Effect of uncertainty ε on π^* under no liquidity constraints and no child labour.

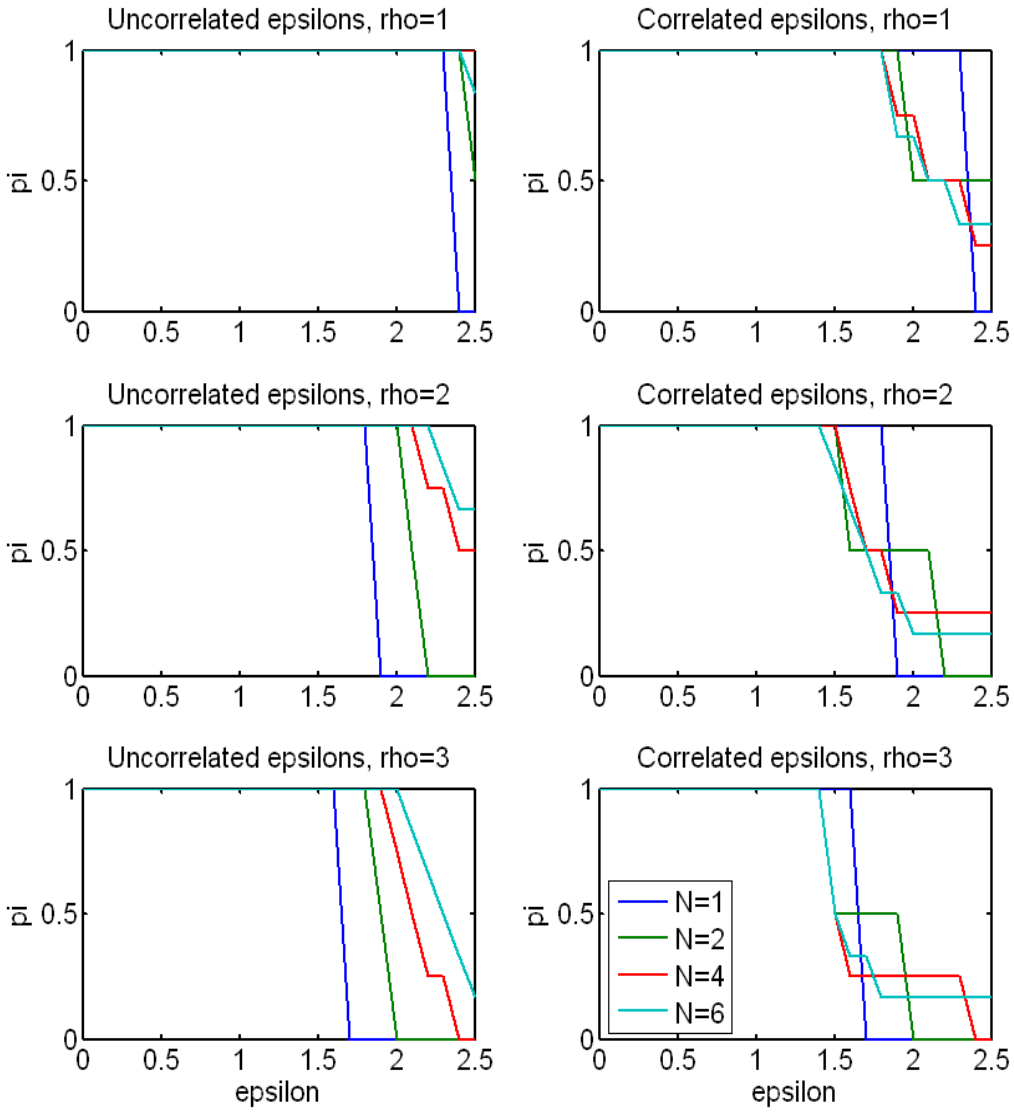


Figure A2. Effect of agricultural income Y_1 on π^* under no liquidity constraints and no child labour.

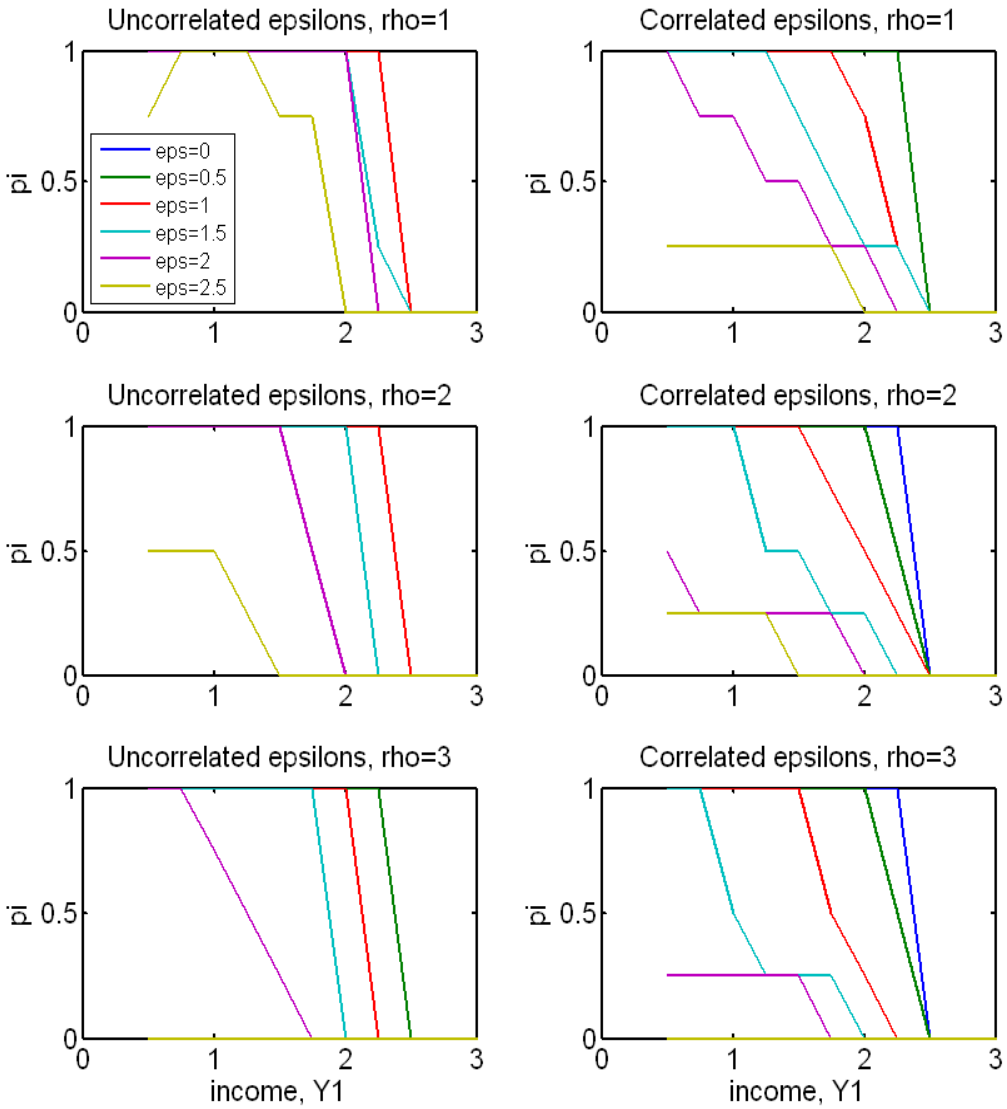


Figure A3. Effect of uncertainty ε on π^* under liquidity constraints and no child labour.

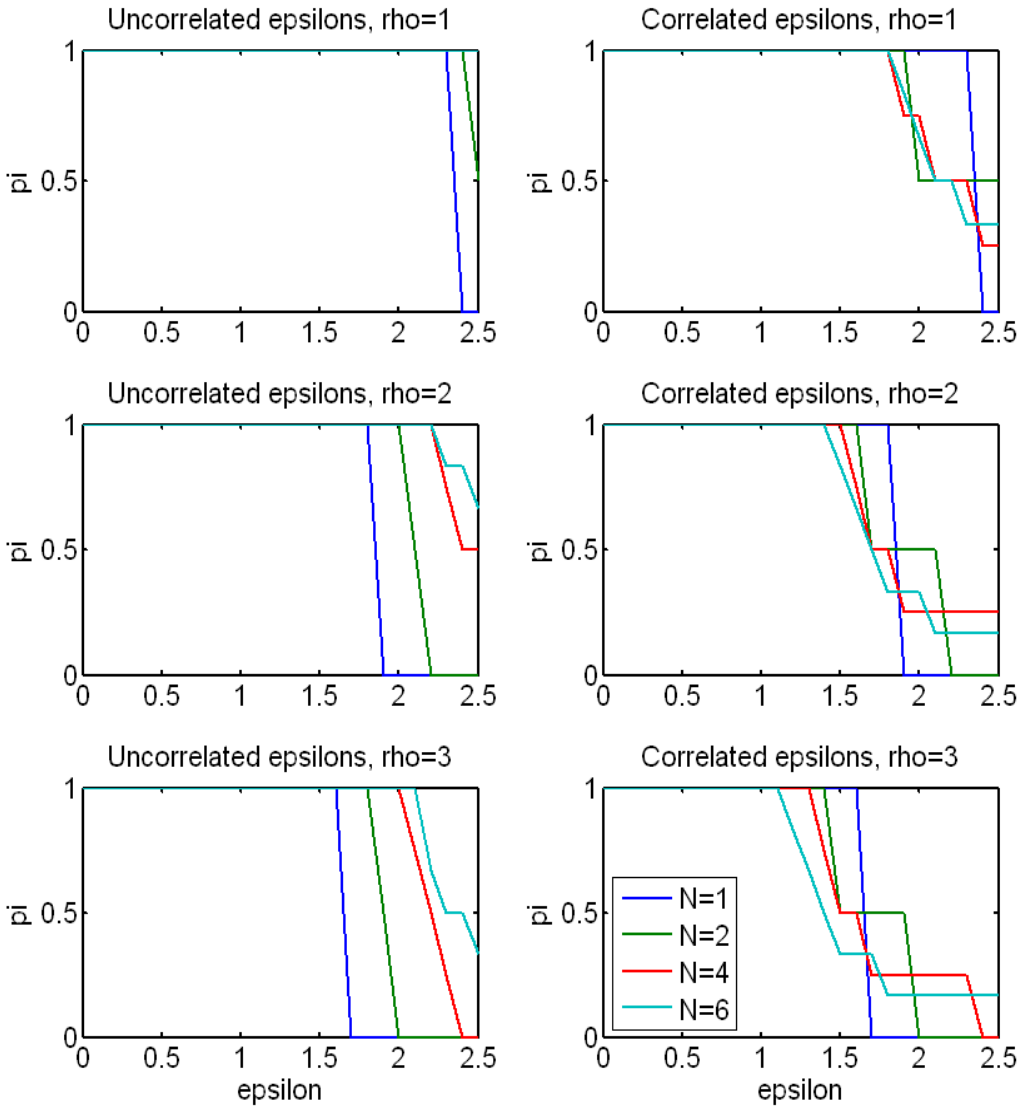


Figure A4. Effect of agricultural income Y_1 on π^* under liquidity constraints and no child labour.

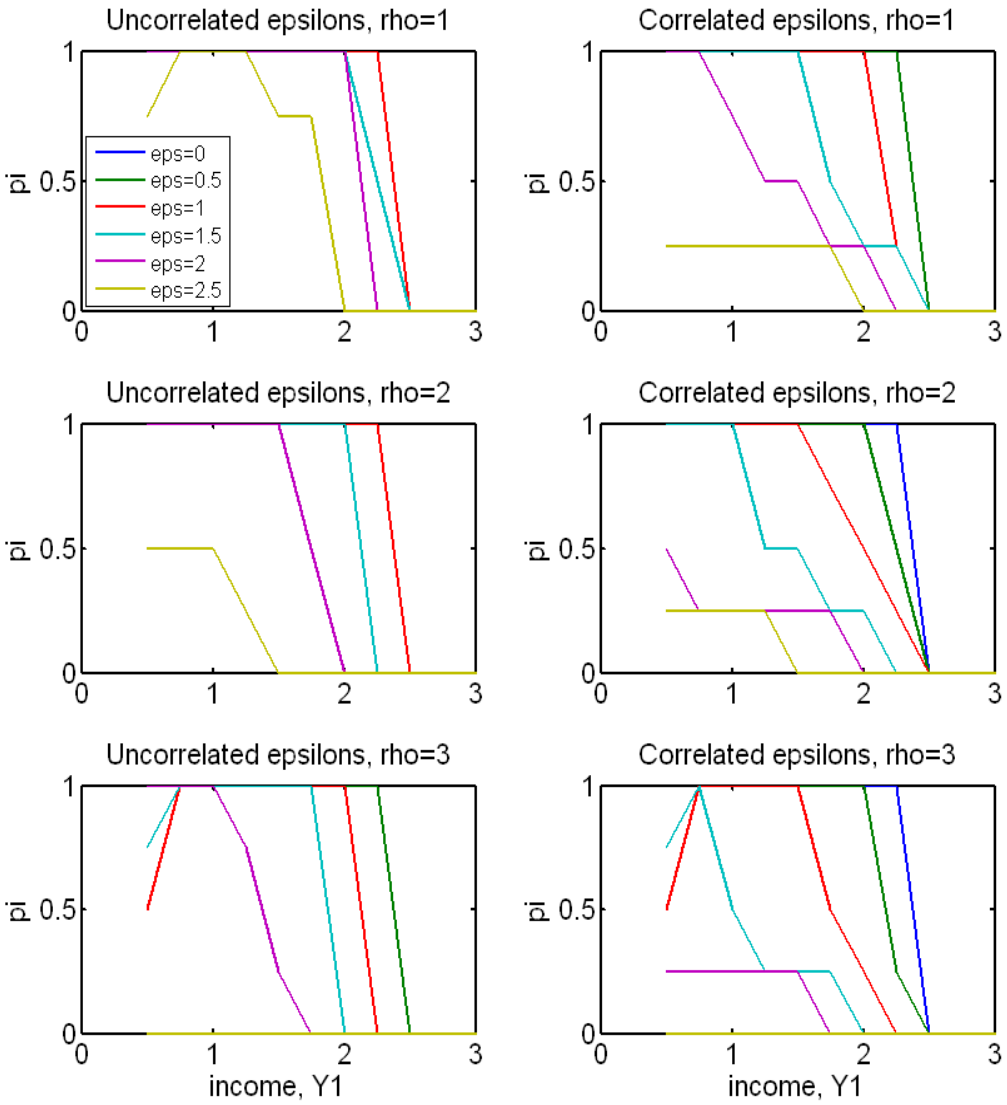


Figure A5. Effect of uncertainty ε on π^* under liquidity constraints and child labour.

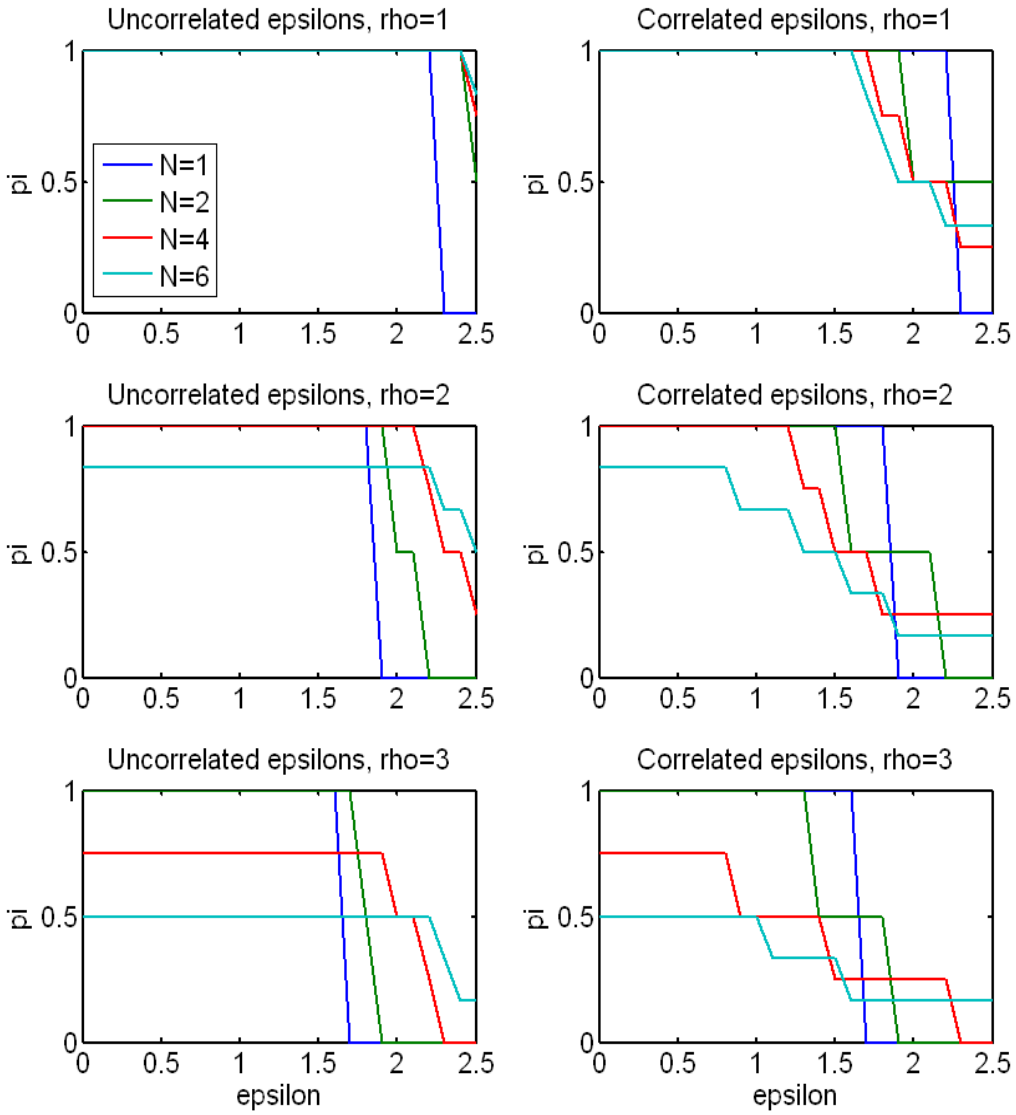


Figure A6. Effect of agricultural income Y_1 on π^* under liquidity constraints and child labour.

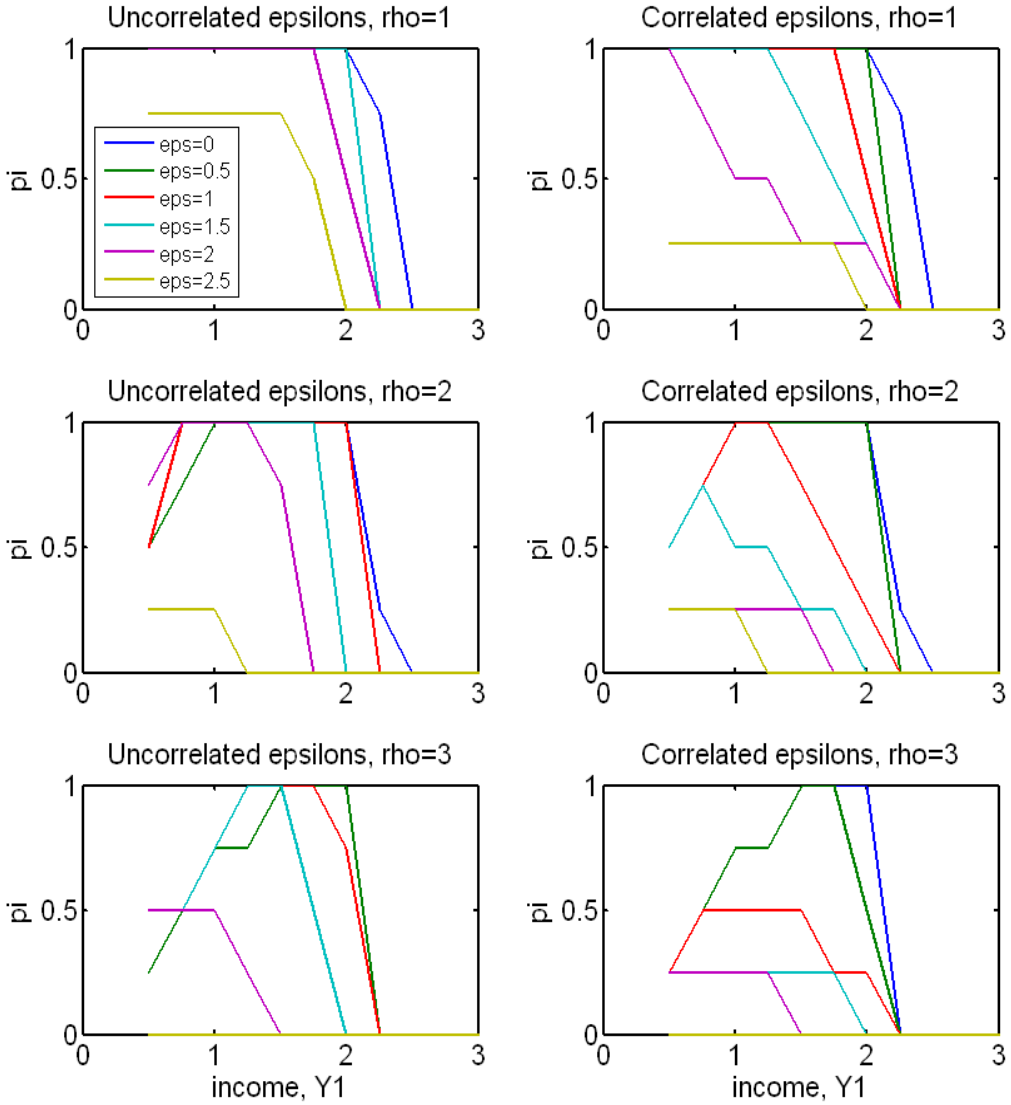
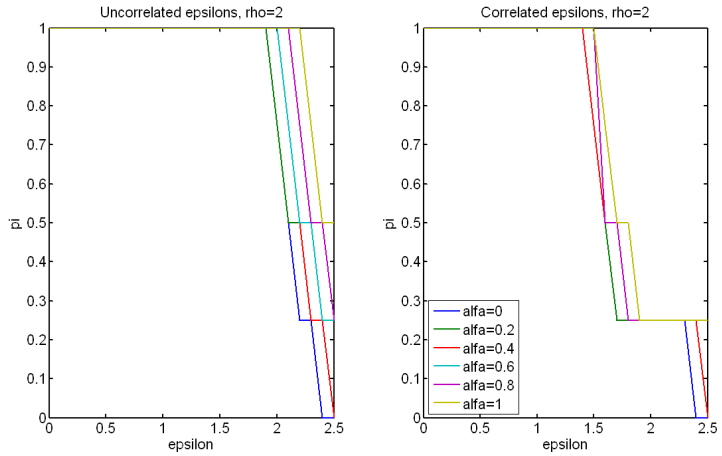
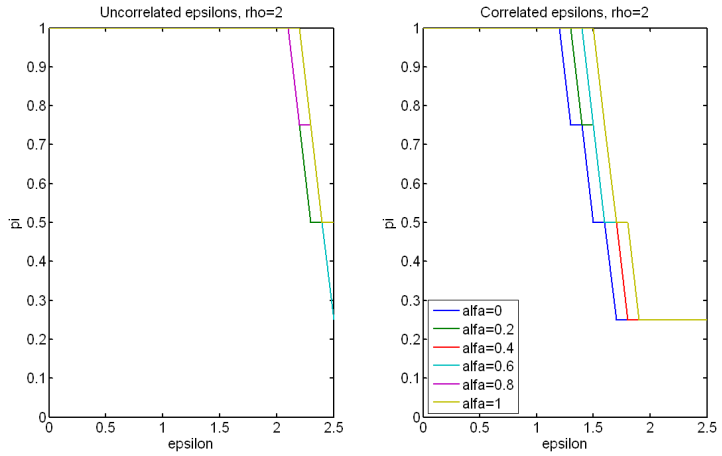


Figure A7 Effect of changes in α on π^*

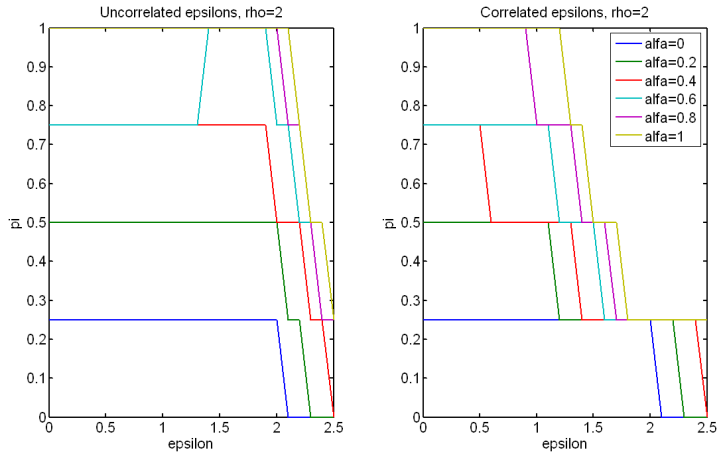
- under no liquidity constraints and no child labour



- under liquidity constraints and no child labour



- under liquidity constraints and child labour



Sibling Dependence, Uncertainty and Education. Findings from Tanzania

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July 18, 2008

Abstract

Primary school enrolment rates are continuously low in many developing countries. The main explanation in the economic literature on schooling is focused on credit constraints and child labour, implying that the indirect cost of schooling in terms of foregone earnings is too high. This paper investigates the effects of future income uncertainty on sibling dependence in the schooling decisions of rural households in developing countries. Schooling tends to direct skills towards future urban employment, whereas traditional rural education or on-farm learning-by-doing tends to direct skills towards future agricultural employment. Given this dichtomy, the question is then: Does future income uncertainty influence the joint educational choice made by parents on behalf of their children and is it possible to test this on simple cross-sectional data? I extend a simple human capital portfolio model to a three period setting. This allows me to explore the natural sequentiality in the schooling decision of older and younger siblings. The model can generate testable empirical implications, which can be taken to any standard cross-sectional data set. I find empirical evidence of negative sibling dependence in the educational decision, which is consistent with a human capital portfolio theory of risk diversification and which cannot be explained by sibling rivalry over scarce resources for credit constrained households. The paper thus provides a complementary explanation to why enrolment rates in developing countries are often continuously low.

Keywords: Schooling, human capital investment, specific human capital, old-age security, uncertainty, risk and income source diversification, liquidity constraints, Tanzania, Africa

Chapter 3 of PhD thesis

1 Introduction

Primary school enrolment rates are continuously low in many developing countries. The main explanation in the economic literature on schooling is focused on credit constraints and child labour, implying that the indirect cost of schooling in terms of foregone earnings is too high, see Edmonds (2007) for a detailed literature review as well as chapter 2 of this thesis. Government policies focusing on lowering the direct costs of schooling in terms of tuition fees, availability of books and uniforms might ameliorate the problem, but if high indirect costs are the main reason for low enrolment rates, such policies will not be enough to overcome the household budget constraint. In Sub-Saharan Africa, especially in rural areas where household-based production systems dominate the agricultural sector, the concept of foregone earnings of sending children to school becomes more vague and, more importantly, on-farm child work may itself be an essential component of traditional education, a possible alternative to formal schooling, as suggested by Rodgers and Standing (1981), Bekombo (1981), Grootaert and Kanbur (1995), and more recently and in more detail by Bock (2002). Furthermore, rural areas suffer from missing capital and pension markets, generating a need for informal insurance and savings mechanisms to shield consumption against income failure and secure old-age subsistence. Liquidity constraints and high foregone earnings of child labour may therefore not be the only explanations for low enrolment rates in primary schools.

In this paper, I argue that the rural-urban divide and uncertainty about future income of children, upon which parents rely for old-age security, combined with the fact that most children have siblings and parents are therefore likely to make a joint human capital investment decision regarding *all* their children, can make it optimal for parents to send some, but not all, of their children to school. Lack of schooling might therefore not only be due to cost side constraints in the human capital investment decision, but could also be due to uncertainties about the return side. However, the vast majority of papers on child labour and schooling focus on the cost side of the human capital investment decision (Edmonds (2007)), and on the role of child labour when households are exposed to transitory income shocks, e.g. Jacoby and Skoufias (1997), Jensen (2000) and Beegle, Dehejia, and Gatti (2006). This paper contributes to the existing literature by focusing on the uncertainty associated with the future returns of the human capital investment decision. The purpose being to complement the exisiting, and by all means valid, cost side explanations for child labour with an additional explanation that, given the empirical findings, sheds new light on the human capital investment decisions faced by parents in rural areas.

Most developing countries have a large agricultural sector and a somewhat smaller urban sector. There will always be uncertainty about future income in both of these sectors, but the uncertainties across sectors may largely be uncorrelated. As long as schooling tends to direct children towards future urban sector employment, and on-farm child work or learning-by-doing

is thought of as a traditional way of educating a child for future employment in the agricultural sector, then it can be shown that enough uncertainty about future income can prevent full school enrolment among siblings, even in a world with perfect credit markets. Missing capital markets can thus influence parental choice of schooling in two additional ways, apart from the standard credit constraint argument. First, income source diversification becomes an important means of income smoothing, as Morduch (1995) puts it, for households to minimise the risk of complete income failure both at present and in the future. Second, children play an important role of being old-age pension providers for their parents, since both private and public pension schemes are very limited. Future earnings and future income source diversification of children therefore become important for parents to secure their old-age subsistence.

Using a simple two-period human capital portfolio model for the joint educational decision of siblings, I show that future income uncertainty can indeed have a negative effect on the proportion of siblings in school. Model calibrations show that the negative effect can be surprisingly large even for moderate levels of uncertainty. Although model calibrations are based on simple data moments, the findings give some indications of the importance of uncertainty in the human capital investment decision. A logical extension would be to estimate the effect of future uncertainty on the actual proportion of children in school. However, it is, by definition, very difficult to get a good measure of future uncertainty, and thus virtually impossible to identify the actual effect of uncertainty on the optimal human capital portfolio of children in a household. An alternative is therefore to find other implications of the influence of future income uncertainty on the joint schooling decision which can be estimated in data and which cannot be caused by any other observationally equivalent explanations. One possibility is to take advantage of the natural sequentiality in schooling between younger and older siblings. The two-period model is therefore extended to a three-period model, which yields direct implications for the nature of sibling dependency caused by risk diversification and different from sibling dependency caused by sibling rivalry over scarce resources, as suggested by Morduch (2000). The three period model allows for younger and older cohorts of siblings and analyses the effect of schooling of the older cohort on the younger one. Lack of schooling due to child labour or credit constraints result in a positive relationship between the schooling of the older and younger siblings, because the older cohort generate income when the school fees of the younger cohort have to be paid. However, lack of schooling due to risk diversification result in a negative relationship between the older and younger cohorts within a household, even when credit markets are perfect. Calibrating, and partly simulating, the three period model yields testable empirical implications, which can be taken to standard cross-sectional data set without any requirements about only observing households with completed fertility and completed schooling among their children.

Based on a nation-wide large scale cross-sectional household survey undertaken in Tanzania

in 1994, I find evidence of sibling dependency consistent with risk diversification having a strong influence on the joint human capital investment decision of sons, but not of daughters. Results are considerably stronger among rural households compared to urban households. These results are consistent with the fact that most societies in Tanzania are patrilineal and therefore only sons are of importance for old-age security, and with the fact that only rural households have a credible option of educating their children traditionally through on-farm learning by doing. Sibling dependence in the schooling decision might therefore not only be caused by sibling rivalry for scarce resources, but can also be due to a need for risk management by diversifying future income sources. This has direct implications for educational policies, since lack of enrolment might not only be a matter of costs of schooling, but also of content in terms of a relevant curricula for future employment in the agricultural sector. In fact, when questioned about which subjects should be taught in primary schools, parents invariably allocate top rank to a course in 'technical skills for agriculture and business', indicating a demand for skills diversification in formal education.

In section 2 the theoretical framework is outlined describing both the two-period model and the three-period extension as well as the results of the model calibrations. Data is described in section 3, whereas section 4 has a description of the empirical specification used for estimation, and the empirical results are analysed and discussed. Section 5 concludes.

2 Theoretical Framework

The model developed in this section differs from most of the models in the existing literature in two ways. First, the model is not a one parent-one child model of human capital investment, but rather a one parent-N children model thus allowing for dependency among siblings in the joint human capital investment decisions of the parents. Second, the model introduces future income uncertainty, which means uncertainty about the returns to education. A matter which, despite the importance for the investment decision, has largely been ignored in the literature[1]. The two period model is a direct replication of the two period model in chapter 2 of this thesis. The contribution of this chapter is the extension to a three period model, which generates testable empirical predictions that can be taken directly to any standard cross sectional data set.

In the following section, the basic two-period model set-up gives a general understanding of how uncertainty can affect the human capital investment allocation. The model is calibrated using information from a nationwide large-scale household survey in Tanzania in section 2.2. The three period model is laid out in section 2.3 and calibration results are described in section 2.4.

[1] Two exceptions are recent papers by Pouliot (2005) and by Estevan and Baland (2007)

2.1 The basic two-period model

The model is a two period unitary household model, where parents function as a unified sole decision maker. There is no discounting of the future and no interest rate on savings or credit. 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 thus 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. Second period income of children in the agricultural sector will be a function of the first period parental income under the assumption that children will be working in similar agricultural production systems as their parents, and parents transfer specific human capital skills to their children as part of their traditional education. Thus $y_2^a = f(Y_1), f'(Y_1) > 0$.

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

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

[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 investment 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.

where π is the proportion of children, which parents have chosen 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 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 considered both non-negative.[5]

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 question is: can this alone result in less than full school enrolment among siblings, i.e. a model prediction of $\pi < 1$ solely due to uncertainty.

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 of all children, which is given by the income of children in the agricultural sector $(1-\pi)Ny_2^a$, and the income of children in the urban sector πNy_2^b. Children are thus 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 $\alpha > 0$. In principle, $\alpha \in [0;1]$, but in the following I will assume that $\alpha \in]0;1[$ to ensure that there is a positive, but diminishing marginal effect of having more children on second period income. When $\alpha = 0$, children share all their income with their parents. When $\alpha = 1$ children share only a fraction $1/N$ of their income with their parents, resulting in parents receiving the equivalent of one full income from their children in total. If there is only one child in the household that child will be the sole breadwinner of the family in the second period and is forced to share his/her full income with the parents, irrespective of the size of α.

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 first order condition with respect to s is

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

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

[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.

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

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

where

$$E[N^{1-\alpha}(y_2^b - y_2^a)U'(c_2)] = E(N^{1-\alpha}(y_2^b - y_2^a))EU'(c_2) + cov(N^{1-\alpha}y_2^b, U'(c_2)) - cov(N^{1-\alpha}y_2^a, U'(c_2))$$

Uncertainty about second period income results in two covariance terms, both negative, between the second period income variables, y_2^a and y_2^b, and marginal utility, $U'(c_2)$. These terms will, when they are strong enough, pull the optimal portfolio allocation, π^* away from each of the two corner solutions. Uncertainty in the agricultural sector will have a positive effect on π^* because it will increase the right hand side of the first order consition for π and pull towards the $\pi^* = 1$ corner solution. Uncertainty in the urban sector, on the other hand, will have a negative effect on π^* because it will decrease the right hand side of the the first order condition for π and thus pull towards the $\pi^* = 0$ corner solution.

In the following, I assume that there is no covariant uncertainty between second period income from children in the urban sector and children in the agricultural sector. This allows me to simplify the problem by normalising uncertainty about income from the agricultural sector to zero, and thus solely focus on the effect of uncertainty of urban income on the optimal proportion of children in formal schooling. Going back to the first order condition for π, equation (4), this means concentrating on the covariance term, which can reduce the right-hand side of the first order condition and thus reduce the optimal π^*. That is, focusing on the somewhat more relevant question of what can result in an optimal π^* below 1, rather than what can result in an optimal π^* above 0.

This is not to say that there is no uncertainty in the agricultural sector, but rather that uncertainty associated with income transfers from distant migrant children in the urban sector is higher. These migrant children may face higher income levels, but also relatively more variation, since the urban labour market entails a 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 income transfers 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[6].

[6] The uncertainty could thus also, in effect, be an intergenerational agency problem between parents and

The uncertainty, that parents face about income transfers from migrant children in the urban sector is modelled as a simple mean-preserving spread. Each migrant child can either get a good (typically formal sector) job or not, where the probability of a good draw in the urban labour market is given by $p = 0.5$. Migrant children in good jobs have an urban income of $y_2^b = \mu + \varepsilon$, whereas migrant children without good jobs have an urban income of $y_2^b = \mu - \varepsilon$.[7] This means that 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 $Var(y_2^b) = \varepsilon^2$. Given this specification of uncertainty, the first order condition for π rewrites (4) as

$$N(e^b - e^a)U'(c_1) = N^{1-\alpha}(\mu - y_2^a)EU'(c_2) + cov[N^{1-\alpha}y_2^b, U'(c_2)] - 0$$

where the specification of the covariance term will depend on the degree of risk correlation in the urban labour market outcome. The expected total income transfers from all the πN children, which have gone to the urban sector, is simply $E(\pi N^{1-\alpha}y_2^b) = \pi N^{1-\alpha}\mu$, independent of the degree of risk correlation among migrant siblings. But the variance of their expected total income, $Var(\pi N^{1-\alpha}y_2^b)$ and the covariance above, $cov(N^{1-\alpha}y_2^b, U'(c_2))$ will both depend on the degree of risk correlation in urban income.

I consider the two extremes where income transfers from siblings in urban employment are either perfectly correlated or uncorrelated. Reality is likely to lie somewhere in between. When there is perfect risk correlation among siblings in urban employment, all siblings will either have a good draw and then their income transfers will amount to $\pi N^{1-\alpha}(\mu + \varepsilon)$, or they will all have a bad draw 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 there is no risk correlation among siblings, they all face the same urban labour market lottery irrespective of the labour market outcomes of their siblings. 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, $Var(\pi N^{1-\alpha}y_2^b) = N^{-\alpha}\sum_{i=0}^{\pi N}\binom{\pi N}{i}\frac{1}{2^{\pi N}}(i\varepsilon - (\pi N - i)\varepsilon)^2 = \pi N^{1-\alpha}\varepsilon^2$.

migrant children. Their degree of success is harder to monitor and lack of family control increases 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. In chapter 1, Lassen and I analyse the effect of such sanctions on the demand for formal schooling.

[7] I do not explicitly consider a mortality risk of young adults as in Estevan and Baland (2007). However, the model could easily be extended to include such risk, but if mortality risk is exogenous to choice of education, it would simply just add a higher level of uncertainty in both the agricultural and urban sector. The qualitative findings of the model would not change.

As long as uncertainty in the agricultural sector and the urban sector do not covary, households will have an incentive to diversify their human capital investments to reduce future risk exposure. For a given set of preferences, it can be shown that, once the optimal choice of π^* and s^* have been found by solving the two first order conditions, the derivative of π^* with respect to ε is negative. If the need for diversification is strong enough, that is if ε is large enough, it will have a negative impact on the proportion of children sent to school in the optimal human capital portfolio of the household.

2.2 Calibrations

Although it is possible to show analytically, that the partial derivative of π^* with respect to ε is negative. This does not indicate whether existing levels of uncertainty in urban income alone can result in less than full enrolment. Only by calibrating the model, using actual levels of school expenditures and income in both the agricultural and urban sector, is it possible to determine whether the actual dispersion in urban income, $Var(y_2^b) = \varepsilon^2$, could potentially keep some children out of school purely due to future income or risk diversification, even under perfect credit markets.

The model is calibrated for the average household using simple data moments based on the table of summary statistics (table 1 in section 3), and constant relative risk aversion preferences with a risk aversion parameter of $\rho = 2$.[8] Rural and urban income are proxied by rural and urban household expenditure measures of 0.707 and 1.247 USD, respectively. First period parental income and second period agricultural income are normalised to unity $Y_1 = y_2^a = 1$, the spread of second period agricultural income is normalised to zero, and second period urban income and spread are adjusted accordingly, resulting in $y_2^b = 1.26/0.708 = 1.780$ and $\varepsilon = (1.218 - 0.501)/0.708 = 1.013$. Schooling expenditures (e^b), including annual uniform expenses, amount to 2.5 per cent of parental income, expenses associated with educating the children traditionally are simply set at half, i.e. $e^a = 0.0125$.[9]

Figure 1 shows the pure effect of future urban income uncertainty ε on the optimal proportion of siblings educated formally π^* for $N = 1, 3, 5$, and 7 children, respectively[10]. The discrete jumps in the graph stem from the discrete number of children. For instance, when $\varepsilon \in [1.1; 1.6]$ a household with three children (green line) will only be sending one out of the three to school under perfect correlation in ε's. On average, the sample of households have 5-6 children in rural areas.

[8] For additional calibration results on the two-period model, please refer to chapter 2.

[9] The parameter values differ from those of chapter 2 because a different and smaller sample is used. I only include households which have both children of school age and children beyond school age in order to resemble the three period model as closely as possible. However, this does not change the qualitative findings of the calibrations.

[10] For a simpler version of figure 1, refer to figure 0 in chapter 2 of this thesis.

(Figure 1)

It is clear from figure 1 that future uncertainty, the level of which is proxied by actual levels of income spread, can indeed result in households diversifying their human capital investments. For the average household with five children, an $\varepsilon = 1$ (which corresponds to the standard deviation of the average income level in data) results in a predicted interval of π^* of [0.6;1] and likewise the actual enrolment rate of $\pi^* = 0.7$ corresponds to an optimal human capital portfolio when future urban income uncertainty is in the interval of $\varepsilon = [0.9; 1.7]$. Both intervals include the observed values in the data. These are the predictions based on a model of perfect credit markets, the less than full school enrolment is thus purely a result of risk diversification and not in any way driven by sibling rivalry over resources. Adding credit constraints ($s \geq 0$) and child labour ($e^a = -0.025$) to the calibrations shift the graphs inwards towards the origin, resulting in even lower optimal levels of π^*, see figure 2. Now the actual enrolment rate of $\pi^* = 0.7$ corresponds to an interval of uncertainty of $\varepsilon = [0.3; 1.2]$. Without uncertainty ($\varepsilon = 0$), the model predicts that the optimal schooling rate for households with five children is 0.8, which is slightly above the actual enrolment rates. This enrolment rate is a pure effect of sibling rivalry in the constrained household, but any further reduction due to uncertainty ($\varepsilon > 0$) is an effect of sibling portfolio dependence in the need for risk diversification.

(Figure 2)

From these two figures it is difficult to determine whether sibling dependence is primarily caused by sibling rivalry over scarce resources or by the need to diversify future income sources and their associated risk. Both explanations can generate model predictions consistent with simple data moments and the two effects are likely to co-exist. The point of this exercise is not to question the importance of liquidity constraints and scarcity of resources in the human capital investment decisions of the household, but to emphasise that liquidity constraints and child labour might not be the full explanation for lack of schooling.

2.3 A Three Period Model

The two-period model is appealing for its simplicity, the negative effect of future income uncertainty on the human capital portfolio decision of the parents is immediate. Unfortunately, the model does not lend itself very easily to cross sectional data or even standard panel data, because the time span would be too short to cover the two periods in question. However, one of the key aspects of the model is the prediction that households will tend to diversify future income sources if there is enough uncertainty about future income. This need for diversification can spill over into the schooling choice today and create potential for a negative sibling dependence in schooling; a negative dependence, which is not generated by constraint effects

due to sibling rivalry for currently scarce resources, but purely driven by the need for risk diversification in the human capital portfolio of siblings. The challenge then becomes to test for negative sibling depence in schooling without implicitly testing for a liquidity constraint.

This can be done by exploring the natural sequentiality in the schooling decision of siblings and looking at two different cohorts of siblings within a household. The older cohort, who have completed schooling will be generating income and is therefore able to contribute resources to the household rather than demand them. That is, all else equal, households with older economically active siblings will have less of a binding liquidity constraint than households without. This in itself should have a positive effect on schooling if households are liquidity constrained. On the other hand, if the proportion of formally educated older siblings is higher than the optimal overall proportion of formally educated children in the household π^*, then this is likely to have a negative effect on the proportion of formally educated younger siblings for the desired future income source diversification to be achieved.

By extending the model to a three period model, it becomes possible to analyse how exactly the portfolio allocation of the older siblings should affect the portfolio allocation of the younger ones. This will have direct empirical implications, which can be tested in the cross sectional data as long as there are enough households with children both of and beyond school age. The three period model is set up such that older siblings are educated in the first period and work in the second and third period. Younger siblings are educated in the second period and only work in the third period. Parents generate income in the first and the second period, but not in the third period, where they have reached old age and rely fully on the income of their children. The human capital investment decision now becomes sequential. There will still be an optimal overall π^* for the parents, which depends on the degree of uncertainty about future income, here isolated in the urban sector. The sequentiality will generate predictions of how the proportion of formally educated siblings from the first cohort, π_1^* will affect the proportion of formally educated siblings from the second cohort, π_2^* such that the overall optimal π^* is achieved. The total number of children N as well as the allocation of children between the two cohorts, N_1 and N_2 are all exogenous.

In period 1, parents face uncertainty about period 2 and 3 and maximise the following expected utility function

$$\max_{\pi_1,\pi_2,s_1,s_2} EW(c_1, c_2, c_3) = U(C_1) + EU(c_2) + EU(c_3)$$

subject to the budget constraints for the three periods

$$\begin{aligned} c_1 &= Y_1 - (1-\pi_1)N_1 e^a - \pi_1 N_1 e^b - s_1 \\ c_2 &= Y_2 + N_1^{-\alpha_2}[(1-\pi_1)N_1 y_{12}^a + \pi_1 N_1 y_{12}^b] - (1-\pi_2)N_2 e^a - \pi_2 N_2 e^b + s_1 - s_2 \\ c_3 &= N^{-\alpha_3}[((1-\pi_1)N_1 + (1-\pi_2)N_2)y_3^a + \pi_1 N_1 y_{13}^b + \pi_2 N_2 E y_{23}^b] + s_2 \end{aligned}$$

N_1 is the size of the first and older cohort of siblings, π_1 is the proportion of these that are educated formally. Their second period urban income is y_{12}^b, which has a mean preserving spread of ε_{12}, and their third period urban income is y_{13}^b with a mean preserving spread of ε_{13}. N_2 is the size of the second and younger cohort of siblings. π_2 is the proportion of these that are educated formally, and their third period urban income is y_{23}^b with a mean preserving spread of ε_{23}. The total number of children is $N = N_1 + N_2$. The assumptions from the two period model are maintained. I do, however, allow for different degrees of income transfers in period 2 and period 3, such that $\alpha_2 < \alpha_3$. This is to mimic the fact that only in old-age are parents dependend on their children for subsistence, as well as the fact that older siblings in period 2 will primarily be of an age where they are about to establish their own households and therefore may not contribute as much to the parental household as in the future.

The key point of interest, in terms of empirical implications, is the relationship between π_2 on π_1. This relation is immediate if the system is solved backwards in time, that is solving the maximisation problem in period 2, taking the outcome of period 1 as given. The maximisation problem therefore simplifies to the following

$$\max_{\pi_2, s_2} EW(c_2, c_3) = U(c_2) + EU(c_3)$$

subject to

$$\begin{aligned} c_2 &= Y_2 + N_1^{-\alpha_2}[(1-\pi_1)N_1 y_2^a + \pi_1 N_1 y_{12}^b] - (1-\pi_2)N_2 e^a - \pi_2 N_2 e^b + s_1 - s_2 \\ c_3 &= N^{-\alpha_3}[((1-\pi_1)N_1 + (1-\pi_2)N_2)y_3^a + \pi_1 N_1 y_{13}^b + \pi_2 N_2 y_{23}^b] + s_2 \end{aligned}$$

which, under the assumption of no liquidity constraints, yields two first order conditions for π_2 and s_2, respectively.

$$\begin{aligned} N_2(e^b - e^a)U'(c_2) &= E\left[N^{-\alpha_3} N_2 (y_{23}^b - y_3^a)U'(c_3)\right] \\ U'(c_2) &= EU'(c_3) \end{aligned}$$

It is possible to find the derivative of π_2 with respect to π_1 without specifying the preference or uncertainty structure by differentiating the system above and using Cramer's rule. Although

not perfectly unambiguous analytically, it turns out that under no liquidity constraints and no child labour and with enough uncertainty, the derivate $d\pi_2/d\pi_1$ is negative. Whereas if liquidity constraints are imposed, child labour is introduced and uncertainty is virtually nil, then the derivative $d\pi_2/d\pi_1$ is positive. See appendix A1 for the exact specification.

2.4 Calibrations and Simulations

Before turning to the empirical analysis, the qualitative results in terms of the $d\pi_2/d\pi_1$ derivative are verified numerically. The second period maximisation problem of the three period model is therefore calibrated under a set of different uncertainty structures in the three urban income measures y^b_{12}, y^b_{13} and y^b_{23}. Uncertainty is still modelled as a mean preserving spread for the urban sector and normalised to zero in the agricultural sector. However, now the uncertainty measures, (ε_{12}, ε_{13} and ε_{23}) can be perfectly correlated or uncorrelated within cohort, between cohorts and over time. This gives rise to a variety of different combinations of uncertainty structures. In the following graphs, I have assumed that uncertainty is uncorrelated over time ($\varepsilon_{12} \neq \varepsilon_{13}$), but perfectly correlated within and between sibling cohorts ($\varepsilon_{23} = \varepsilon_{13}$). This is entirely for illustrative purposes. Calibrations are done for all the possible combinations of uncertainty structures and the overall qualitative results are the same.

Due to the perfect correlation within cohorts, period 2 can either be in a high income state ($y_{12} = \mu + \varepsilon_{12}$) or in a low income state ($y_{12} = \mu - \varepsilon_{12}$), depending on the urban labour market outcomes for the $\pi_1 N_1$ children in the urban sector. The model is calibrated for $N_1 = 3, N_2 = 3, \alpha_2 = 1.5, \alpha_3 = 0.95$ and $y_2 = 0.5$, the remaining values are identical to the calibration of the two period model above. Parental second period income has been reduced to ensure that the sum of parental income and the income transfers from the oldest cohort are in the neighbourhood of 1, the normalised agricultural income. E.g. if all N_1 are traditionally educated and earn $y^a_2 = 1$, the total income of the household in the second period is $0.5 + 3/3^{1.5} = 1.0774$. Argueably, this is a bit arbitrary, but the qualitive results are robust to different specifications. What is important is to have some degree of binding liquidity constraints under no credit markets.

In figure 3 the negative relationship between schooling of the older and younger cohort is very clear. The left panel shows the relationship when the second period urban outcome for cohort one is high, the right panel when the second period urban outcome is low. It is clear, that there is only a negative relationshipbetween π_1 and π_2 if there is enough uncertainty. For uncertainty levels below the normalised agricultural income ($\varepsilon < 1$) households will always be educating all children in the younger cohort irrespective of the older cohort. The need for risk diversification is not strong enough to generate any sibling dependence. Each line represents a different degree of uncertainty (ε) and thus different optimal overall π^* from the two period problem. Heterogeneity across households, in terms of the uncertainty level they are facing, will

generate a variety of different optimal π^*'s and thus different optimal (π_1, π_2) combinations.

(Figure 3)

Take the purple line ($\varepsilon = 1$) in the right panel above as an example. Here the optimal overall $\pi^* = \frac{1}{2}$, or 3 out of 6 children are being sent to school. When $\pi_1 = 1$ all three older siblings are sent to school and therefore none of the younger ones are in school, and vice versa. If uncertainty increases ($\varepsilon \in [1.25; 1.75]$), this depresses the overall optimal π^* to $1/6th$ and only one out of the total of six children are sent to school such that either $\pi_1 = 1/3$ or $\pi_2 = 1/3$ (blue dotted line). The negative relationship between π_1 and π_2 is thus purely mechanical in the sense that it is fully determined by the overall optimal π^* and it only exists for $\pi^* > 0$ and $\pi^* < 1$. When $\pi^* = 0, \pi_1 = \pi_2 = 0$ and when $\pi^* = 1, \pi_1 = \pi_2 = 1$.

The possible heterogeneity in π^* results in a cross sectional relationship between π_1 and π_2 which is not strictly negative. This can be shown by simulating a distribution for π^* and π_1 and from these generate π_2. Overall it must hold that $\pi^* = (\pi_1 N_1 + \pi_2 N_2)/N$ such that $\pi_2 = (\pi^* N - \pi_1 N_1)/N_2$. From this, the mechanical negative relationship between π_1 and π_2 is obvious. The simulations are very simple and do not incorporate the model as such. The main point is simply to show the negative relationship between π_1 and π_2 as a consequence of $\pi^* < 1$ due to a need for risk diversification. To ensure a discrete nature in the overall optimal π^*, it is generated as n^b/N, where n^b is the optimal number of children with schooling out of the total number of N children. N is drawn from a Poisson distribution with $E(N) = 5.6$ as in the data. n^b is drawn from a binomial distribution given N and with probability $E(\pi) = 0.715$ as in the data, see table 1 in section 3. From the simulation results in figure 4, it can be seen that if the distribution of π^* covers the full range between 0 and 1, then a least squares estimation of the cross sectional relationship between π_1 and π_2 results in an inverse U relationship.

(Figure 4)

The correpsonding graph based on the actual data for π_1 and π_2 without any restrictions on π^* is given below in figure 5. Eyeballing the two figures, they seem very close. A joint test of equality of regression coefficients for the two π_1 terms in the least squares regression cannot be rejected.

(Figure 5)

Comparing figure 4 and figure 5, it shows that the simulated conditional mean function from a very simple version of the model (where the only role of uncertainty is to make $\pi^* < 1$) gives exactly the relationship seen in the data.

The obvious question is then, what else (other than uncertainty and the need for risk diversification) could result in an optimal overall $\pi^* < 1$, which would generate the same relationship

between π_1 and π_2. Liquidity constraints and child labour cannot, I will return to this shortly. Another possibilty is that heterogenity in π^* is driven by heterogeneity in ability (in terms of schooling) across or within households. If there is heterogenity in ability *across* households but not within households, such that each household sample from an ability distribution and all children within households are identical, then the overall π^* for each household will always be at a corner. There will thus be a bang–bang solution in the sense that for the low ability household $\pi^* = 0$ (for these returns to traditional eduaction will be higher than the returns to formal education), and for high ability households $\pi^* = 1$ (for these schooling is the most profitable educational choice). This is a consequence of no uncertainty and no liquidity constraints.

On the other hand, if the optimal overall $\pi^* < 1$ due to heterogeneity *within* households, such that schooling is only a profitable investment for some children, then this will yield the same predictions in figure 4 as uncertainty. Thus, I cannot distinguish the effect on π^* of within household ability differences from uncertainty and the need for risk diversification. However, it must be said that for within household ability differences to be generating the same results, the dispersion in ability within households must be large enough to locate some siblings below the cut off point where schooling is no longer the most profitable educational choice, and other siblings above.

Although liquidity constraints can result in less than full enrolment among siblings within a household, they can never actually general an optimal $\pi^* < 1$. For liquidity constained households, the optimal π^* always equals unity as long as schooling is the most profitable educational choice, but the household is forced into a second best solution because it is not able to optimize intertemporarily. For such households, the choice of π_1 will affect the choice of π_2. Even if the household was not able to achieve $\pi_1 = 1$ due to liquidity constraints, higher π_1 will result in higher second period income and, all else equal, this will ameliorate the liquidity constraint when it comes to educating the younger cohort. That is, there will be a positive relationship between π_1 and π_2. The simulations in figure 4 are based on an underlying relationship between π_1 and π_2 as illustrated in figure 3, however when introducing liquidity constraints and child labour the relationship between π_1 and π_2 is completely different, see figure 6.

(Figure 6)

In figure 6 it is clear that when there is no uncertainty ($\varepsilon = 0$), but child labour and liquidity constraints ($e^a = -0.025, s = 0$), the relationship between π_1 and π_2 is positive under high second period outcome for $\pi_1 N_1$ urban migrants and zero under low second period outcome. The positive effect under high second period outcome shows exactly the proposed effect of the second period income of the older cohort ameliorating the liquidity constraint in the human capital investment decision for the younger cohort.

Any negative relationship between π_1 and π_2 in the data will thus be due human capital diversification, either as a consequence of uncertainty and the need for risk diversification or simply due to within household ability differences. It can not be generated by liquidity constraints and child labour. There are two other, equally important, implications of the human capital portfolio model. If $\pi^* < 1$ due to risk diversification of future income sources, then the negative sibling dependence should in principle only hold for rural households, because urban households do not have the agricultural income diversification possibility. Second, the portfolio effect should also only hold for sons and not for daughters, because Tanzania is largely a patrilineal society where the obligations of daughters vis-a-vis their family shift to their husband's family upon marriage. Daughters can therefore not be relied upon for old-age security and, thus, there is no need for ensuring risk diversification of their future income sources. Within household ability differences can not generate such predictions. There are no reasons to believe that within household ability heterogenity is gender specific, nor that only rural households should face within household ability differences, but urban households should not. Testing for differences across gender and across sector is therefore an implicit test of the uncertainty explanation versus the within household ability explanation.

3 Data

In order to test the empirical implications of the portfolio model above, I use a large-scale nationwide cross-sectional household survey from Tanzania undertaken in 1994, the Human Resource and Development Survey (HRDS).[11] It is a nationally representative survey of 5,000 households out of which more than half of the households have school-aged children. The HRDS data contains detailed information on individual household members, including their educational status. At household level, there is information about sources of income, detailed assets and expenditure information and, not least, schooling expenditures, school distance as well as the head's assesment of the quality of the local primary school. Out of the 5000 households, only households where the household head has children (or step-children) of school age as well as children beyond school age are included. Combined with a need for non-missing observations of the included variables, this reduces the sample to 1328 households, out of which slightly more than half are urban. Although the portfolio model is only applicable to rural households with access to both formal and traditional education, urban households are included for that exact comparison. Table 1 lists summary statistics for all relevant variables from the data set.

[11] The survey was a joint effort undertaken by the Department of Economics of the University of Dar es Salaam, the Government of Tanzania, and the World Bank, and was funded by the World Bank, the Government of Japan, and the British Overseas Development Agency. For more information or access to the data see www.worldbank.org/lsms

[Table 1]

There are three groups of variables, which are included in the emprirical analysis. First of all, the sibling composition and allocation between formal education and traditional education. N_1 children are all children beyond school age, N_2 children are of school age that is between 7-17 years old. π_1 and π_2 refer to the proportion of children which are through or in formal schooling, respectively. The variables are also split by gender, allowing to test the hypothesised sibling dependence separately for sons and daughters. There is an average of 5-6 children in total, the number is slightly higher in rural than in urban areas. There is an overall schooling rate of children of slightly more than 70% for this sample of households.

The second group of variables characterise the household. These variable include proxies for model variables. Parental income is proxied by household expenditure. There are no income measures in the data set, and commonly expenditure measures are thought to be better proxies for life time income and less prone to measurement error than income measures, especially when looking at rural households with a family-based agricultural production system, Deaton (1998). More than 90 per cent of rural households have agriculture as their main source of income, whereas this number is almost 35 per cent for urban households, indicating that the rural urban divide in terms of agriculture and non-agriculture is not perfect, but still useful. Schooling is almost three times more expensive in urban areas, compared to rural areas, where the annual school costs amount to roughly 6 USD and rural school children have an average of 1.5 km to cover to go to school. 40 per cent of rural households have at least 2 heads of livestock or 5 pigs or sheep. Each rural household has an average of almost 15 hectars of land, but there is a lot of dispersion in this number. The median rural household has 10 hectars and only the top quartile of the distribution have land holdings above 18 hectars. There is a fairly even distribution of muslims, catholic and protestants in rural areas, whereas muslims are a dominating group in urban areas. There are more than 100 different tribes in Tanzania, in the empirical analysis below I control for tribal affiliation of the largest ten tribes at village level. Although income sources are clearly predominantly agricultural in rural areas, there are still roughly 20 per cent of households with wage or self-employment business income. This number is naturally considerably higher in urban area.

The last group of variables are indicator variables for whether the household head considers the local primary school to have an adequate or good quality of the variable in question. In general, school quality does not seem to be rated too poorly, except for school supplies.

4 Empirical Specification and Results

The proportion of children enrolled in school is the choice variable in the second period of the three period model above and thus also the dependent variable in the empirical analysis

below. It can be expressed either as the number of children attending school, n_2^b, out of the total number of school-aged children, N_2, or as the proportion, $\pi_2 = n_2^b/N_2$. This gives rise to two alternative empirical model specifications, either a double censored Tobit model or a binomial count model. The doubled-censored Tobit model can estimate the proportion of N_2 children in school, π_2 taking into account that π_2 is censored at 0 and at 1. However, π_2 will be of a discrete character since there is a natural upper bound to the total number of young offspring in a household. The underlying assumption of continuity in the dependent variable of the Tobit model might therefore be inappropriate.

The alternative is to model the choice of n_2^b directly as a count variable. It is then important to use a count model, which takes the upper censoring into account, such that predicted values of n_2^b never exceeds N_2. This is the key feature of the standard binomial count model, Winkelman (1997). This model estimates the number of children attending primary school n_2^b, conditional on the total number of school-aged children in the household N_2.[12] When conditioning on N_2, it is clearly treated as exogenous to the schooling decision and all results should be interpreted given the number of school aged children. Although the main empirical analysis is based on the binomial count model, results are also reported for the Tobit model as well as the linear probability model in section 4.2 to check whether results are robust to model specification.

4.1 Econometric Model

The number of children in school n_2^b is assumed to be binomially distributed and can therefore be thought of as a sum of independent and homogenous Bernoulli-trials up until N_2. That is, the current household demand for schooling is modelled as a sum of N_2 binary individual choices concerning school attendance, which are assumed to be independent and with the same school attendance probabilities (π_2)[13].

$$\Pr(school_i = 1) = \pi_2, \qquad \text{where } i = 1, 2, ..., N_2 \text{ and } \pi_2 \in [0; 1]$$

and n_b is binomially distributed

$$\sum_{i=1}^{N_2} school_i = n_2^b \sim Bin(N_2, \pi_2)$$

The expected value of n_2^b is $E(n_2^b) = N_2\pi_2$ and the variance is $Var(n_2^b) = N_2\pi_2(1 - \pi_2)$. The effect of different explanatory variables contained in $\mathbf{x}$ will enter through the link function

[12] This model is not commonly used in the economics litearture, but a related example is by Thomas, Strauss, and Henriques (1990). They use the binomial model to study child mortality within families, conditional on the total number of children ever born.

[13] The assumptions of homogeneity and independence among children within the household will be relaxed shortly.

$G(\mathbf{x}'\boldsymbol{\beta})$ of the (conditional) probability of school attendance, $\pi_2(\mathbf{x}'\boldsymbol{\beta}) = G(\mathbf{x}'\boldsymbol{\beta}) = \frac{\exp(\mathbf{x}'\boldsymbol{\beta})}{1+\exp(\mathbf{x}'\boldsymbol{\beta})} = \Lambda(\mathbf{x}'\boldsymbol{\beta})$, which here is the logistic distribution. Assume that the conditional mean is correctly specified as $E(n_2^b|\mathbf{x}, N_2) = N_2\pi_2(\mathbf{x}'\boldsymbol{\beta})$ and the conditional probability of the number of children attending primary school being equal to n_2^b is $\Pr(y = n_2^b|\mathbf{x}) = \binom{n_2^b}{N_2}\pi_2(\mathbf{x}'\boldsymbol{\beta})^{n_2^b}(1-\pi_2(\mathbf{x}'\boldsymbol{\beta}))^{N_2-n_2^b}$. The log-likelihood function for each household is then given by

$$\ln L(\beta) = \ln \binom{n_2^b}{N_2} + n_2^b \ln \Lambda(\mathbf{x}'\boldsymbol{\beta}) + (N_2 - n_2^b)\ln(1 - \Lambda(\mathbf{x}'\boldsymbol{\beta}))$$

and the first order conditions with respect to $\boldsymbol{\beta}$ is given by

$$\frac{\partial \ln L}{\partial \boldsymbol{\beta}} = n_2^b\mathbf{x} - N_2\left(\frac{\exp(\mathbf{x}'\boldsymbol{\beta})}{1+\exp(\mathbf{x}'\boldsymbol{\beta})}\right)\mathbf{x} = \Big(n_2^b - E(n_2^b|\mathbf{x}, N_2\Big))\mathbf{x} = 0$$

the solution to which is the maximum likelihood estimator $\hat{\boldsymbol{\beta}}_{ML}$.

However, maximum likelihood estimation requires the underlying binomial distribution to be correctly specified, that is assuming homogeneity and independence concerning school attendance among the children of a household. If these assumptions do not hold, the model generates over- or under-dispersion relative to the specified distribution variance of n_2^b. By using the quasi-maximum likelihood estimator, that is finding the $\boldsymbol{\beta}$ that satisfies the first order condition rather than the $\boldsymbol{\beta}$ that maximises the likelihood function above, it is possible to relax the distributional assumptions concerning the conditional variance and instead allow for the robust sandwich estimator initially introduced by Huber (1967). The conditional variance of n_2^b, which is part of the robust sandwich estimator of $var(\boldsymbol{\beta})$, is then simply estimated by $\widehat{Var(n_2^b|\mathbf{x}, N_2)} = (n_2^b - \widehat{E(n_2^b|\mathbf{x}, N_2)})^2$, where $\widehat{E(n_2^b|\mathbf{x}, N_2)} = N_2\pi_2(\mathbf{x}'\hat{\boldsymbol{\beta}})$. The sandwich estimator is robust to over- and under-dispersion, heteroskedasticity, distributional misspecification and clustering, as long as the conditional mean is correctly specified, (Cameron and Trivedi (1998), Newson (1999) and Wooldridge (2002)). Thus, this variance estimator is robust to violation of the assumptions of homogeneity and independence among the school-aged children in the household.

4.2 Empirical Results

There are three testable empirical implications of the three period portfolio model. First of all, an implication of the need for future risk diversification is that, given enough uncertainty about future income transfers, there will be negative sibling dependence among the younger and older cohorts of siblings. Second, this should primarily hold for siblings in rural households, because urban households do not have the same diversification possibilities between formal and traditional education. Third, it should also only hold for sons and not for daughters due to the patrilineal structure of the Tanzanian society. The model is therefore in principle only

applicable to rural sons.

(Table 2)

Column 1 in table 2 is a binomial regression of the number of primary school attending sons from cohort 2 out of the total number of sons in cohort 2, N_2. It is regressed on π_1, N_1 of older brothers and N_2 as well as on proxies for the remaining model variables. Household income is proxied by the expenditure measure and a control for whether agriculture is the main source of income as well as an interaction term taking the parental agricultural earning abilities into account. Costs of schooling e^b are proxied by the average school cost in the village as well as the average distance to the local primary school in the village. Finally, an indicator variable for whether the household has a herd or not is included, this is thought as a proxy for e^a. The key variable of interest is the effect of π_1 on π_2 (which in effect is the dependent variable) among rural sons.

When π_1 enter as a linear term in the π_2 regression, it has no significant effect on π_2. However, if the effect of π_1 is allowed to be non-linear and a quadratic term is included, it is soon clear that the insignificance of the linear term is due to the underlying non-linearity. There is both a strong positive effect of π_1 on π_2 for lower levels of π_1 and a strong negative effect for higher levels of π_1. The turning point is constant across the three specifictions for rural sons in column 2-4, which allow for different sets of control vairables. In column 2 only the model proxies are included, column 3 also includes school quality controls and column 4 in addtion includes a number of household characteristics as well as tribal controls and religious affiliation. Somewhat surprisingly, apart from the quadratic π_1 terms, only the latter group is (jointly) significant. A series of other control variables have all been tested insignificant and without any influence of the π_1 estimated coefficients.

The turning point of the inverse U equals 0.57 for all three specifications in column 2-4. Below this point, the positive relationship between π_1 and π_2 is either due to the ameliorating effect of N_2 children on the liquidity constraints or simply a consequence of cross-sectional heterogenity in π^*, as illustrated in figure 4 and 5. It is impossible to separate which of these two positive effects are dominating. However, this is not true when it comes to the negative effect of π_1 on π_2 for higher levels of π_1. The model predicts that when there is no uncertainty about future income transfers, there will always be a positive effect of π_1 on π_2 due to the positive income effect. Only a considerable degree of uncertainty and thus a strong enough need to diversify risk by diversifying income sources can generate a negative effect of high levels of π_1 on π_2. That such a negative effect exists for rural sons cannot be rejected. It even exists for a substantial part of the N_1 distribution, only 30.46% of the rural households with sons have $\pi_1 \leq 0.57$ among sons. Thus, for a majority of younger sons, the parental need for future risk diversification seems to be a main determinant for their schooling decision.

The picture is different for rural daughters. The schooling rate of younger daughters (π_2) is estimated in column 5. There is no significant effect of schooling of their older sisters, irrespective of the functional form. Column 4 reports the quadratic effect, but a pure linear effect is also insignificant, although in some specifications a positive effect of the linear term is significant at 10%. The π_1 terms for rural daughters cannot be tested jointly significantly different from zero, they can also not be tested jointly significantly different from the two π_1 coefficients of the rural sons. There is too much imprecision to say anything conclusive about whether there is positive or negative sibling dependence among sisters. The schooling decision of girls do, however, seem to respond to income effects. There is a positive significant (at 10%) effect of log of household expenditure on schooling of the younger cohort of sisters with a high marginal effect of 32% for the average rural household with daughters. The distance to the local primary school also matters significantly. Calculating the marginal effect, an extra kilometer in terms of distance can reduce the proportion of younger sisters in school by 8 percentage points. Overall, it seems safe to conclude that for daughters it is unlikely to be portfolio effects among sisters, which dominate the schooling decisions made by parents, but there could be some degree of sister rivalry. This gender difference between sons and daughters is consistent with the risk diversifcation hypothesis, but not with the possible alternative of $\pi^* < 1$ due to within household ability differences.

There is a lot of imprecision in the estimates for both sons and daughters when the sample is split by gender. This is not surprising. First of all, only households, which have children of the same gender in both the younger and older cohort, are included. Second, there is less variation in the dependent variable because there are fewer N_2 sons or N_2 daughters, this will generate more corner solutions. Furthermore, there might be size effects from splitting the sample. More corner solutions can in itself generate stronger negative effects of π_1. However, if results were purely driven by size effects, they should be stronger for daughters than for sons because the sample for daughters is smaller than that for sons. This is not the case.

Households are aggregated to include all siblings of rural households in column 6 and, for comparison, of urban households in column 7. Finally, the model is also estimated on the full sample in column 8, which naturally increases the level of precision in the coefficient estimates. Now household expenditure has a strong significantly positive effect, and there is a negative effect of high levels of agricultural income, consistent with traditional education being a relatively more attractive educational alternative. But what is more important, is that the non-linear quadratic effects of π_1 on π_2 are also strongly significant on the full sample. In fact, they seem stronger for the full sample than for the rural sample, indicating that the size effects are likely to be negligible. The turning point of the inverse U of π_2 is now higher and very close to the actual rate of schooling in the data, $\pi^* = 0.7$. When looking at colum 6 and 7, however, it is clear that the quadratic effect stems from the rural households. Among urban

households there is a positive linear effect of π_1 on π_2, but the quadratic terms is insignificant. A joint test for whether the two π_1 terms for urban households in column 7 equals those of the rural households in column 6 is rejected at a 5% level, indicating that there is very limited scope for human capital diversification among siblings in urban households. Thus, the model implications of risk and income source diversification generating negative sibling dependence among older and younger siblings in rural households and, within these, primarily among sons, cannot be rejected by the data.

(Table 3)

The results are robust over a range of empirical specifications with the inclusion or exclusion of a number of different control variables, such as whether households have electricity, bank accounts, access to transport, and ownership of own house. From table 3 it also shows that, in addition, results are robust to choice of econometric model. The qualitative findings are the same both for the full sample of households, as well as when the sample is split by rural or urban households. The turning point for the inverse U of π_1 is also reasonable stable over the different specifications. It is 0.75 and 0.77 for the full sample in the Tobit model and the linear probability model, respectively, and 0.63 and 0.65 for the rural households in the same two models. This has to be compared with 0.7 and 0.63 for the full sample and the rural households, respectively, in the binomial model.

5 Conclusion and Policy Implications

The main contribution of this paper is to extend a simple two-period human capital portfolio model, which allows for two types of education with different returns and different risk, such that it can generate empirical predictions directly testable in standard household data from developing countries. By extending the model to a three-period model and allowing for sequentiality in the human capital investment decision of siblings, it is possible to derive testable model predictions of sibling dependence due to risk diversification, which differ from predictions based on sibling rivalry over scarce resources.

The key implication of the two-period model is that uncertainty about future income transfers from children generates a need for future risk and thus income source diversification, which spills over into a need for current human capital diversification in the educational choice of children. This human capital diversification is only possible in rural areas, where there exists a clear dichotomy between formal and traditional education and the associated future urban and agricultural employment. Traditional education in terms of on-farm learning by doing endows children with specific skills or human capital directing them towards future agricultural work or farming. Formal education, on the other hand, endows children with general human capital

suitable for future modern or urban employment. As long as returns and risks of the agricultural and the urban sector are uncorrelated, an obvious ex-ante risk management strategy of income smoothing is simply to ensure an optimal balancing of risk and returns from these two sectors by diversifying the human capital portfolio of children already when they are of school age.

Model implications makes it possible to disentangle sibling dependency due to risk diversification from the standard argument of sibling rivalry over scarce resources in the child labour literature. The testable empirical prediction is that there should be a negative relationship between schooling of the younger and older sibling cohorts. The empirical analysis shows that such a negative sibling dependence does indeed exist when the proportion of formally educated older siblings is high, consistent with a need ofr risk diversification due to uncertainty about future returns to education. The result holds for the full sample of households, and when looking into the specific subsamples, it holds for rural households and not for urban, and it is only strong and significant for the specific subsample of rural sons, exactly as expected considering the human capital portfolio model.

The question is then whether such a negative effect for the specific subsample of rural sons could be caused by something else. First, it cannot be explained by liquidity constraints, because these older siblings beyond school age typically contribute to household income. Second, birth order effets, which are often used as a prime indicator for whether or not a child is attending school in empirical analyses based on individual children, would also predict the opposite effect. It is generally thought that the older siblings work to help pay for schooling of the younger ones, the effect should therefore be positive. Third, the negative effect of a high proportion of schooling of older siblings on the proportion of schooling of the younger ones is also not likely to be caused by transitory income shocks. Transitory income shocks in rural areas are generally caused by failing agricultural income (e.g. due to adverse weather conditions), households with older formally educated siblings and thus access to urban income sources should be able to shield the schooling of the younger siblings better than households without, which would generate a positive rather than a negative relationship. Finally, within household ability differences could be generating the same overall results. Within household ability differences would also result in an over $\pi^* < 1$ with a mechanical negative relationship between π_1 and π_2 as found in the simulations. However, within household ability differences cannot explain the empirical findings in terms of gender differences and rural-urban differences.

The final conclusion is therefore that future income uncertainty and the need for risk diversification does affect the joint schooling decision to such an extent that there is negative sibling dependence between cohorts. The return side of the human capital investment decision can thus be a dominating factor in the human capital investment decision made by parents on behalf of their children. I do not wish to question the importance of liquidity constraints on the

schooling decision of children, in fact I also find some evidence of income effects, however what I do question is whether the liquidity constraint explanation, which only relates to the cost side of the human capital investment decision is indeed the full explanation. Taking the return side into consideration when analysing the human capital investment decisions of parents has important implications for educational policies. If the objective of policy makers is to ensure full enrolment into primary schools, lowering the costs of schooling will have a positive, but insufficient effect for the objective to be reached in rural areas where traditional agricultural production systems require specific skills, passed on by generations. Only in modern more complex agricultural production systems, where there are 'learning opportunities' from general human capital skills, as Rosenzweig (1995) puts it, will formal schooling generate a return. When the production technology is simple, there are generally very limited or no returns to formal schooling, e.g. Foster and Rosenzweig (1996), Fafchamps and Quisumbing (1999) and Jolliffe (2004). Parents, I am sure, perceive this.

So, is it possible to generate returns to formal schooling in simple agriculture? What if primary schooling did not only endow children with general human capital in terms of mathematics and reading and writing Kiswahili and English (as it is the case in Tanzania, where a third, tribal, language is the mother tongue of most children), but also endowed children in rural areas with some of the specific skills needed for a future life in farming? That is, adapting the curricula of primary education to the future needs and necessary life skills of the children supposed to attend school. As a matter of fact, the parents of the HRDS data give the answer themselves. In the survey, they have been asked a number of questions about education and school curricula, including a question on what they think are the important subjects that *should be* taught in primary schools[14]. They were asked to rank five subjects according to importance: (i) 'teaching good written and spoken Kiswahili', (ii) 'teaching good written and spoken English', (iii) 'religious or moral education that teaches children to be polite, respectful and good citizens', (iv) 'teaching technical skills for agriulture and business' (which is the only course out of the five that is not actually being taught), and (v) 'teaching mathematics and science'. There is no doubt about their answer, teaching technical skills for agriculture and business rank highest. Parents want, not only general, but also specific skills for their children. They want skills diversification.

[14] Section 2, part B, question 80-85 in the HRDS questionnaire.

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6 Figures

Figure 1. Effect of uncertainty ε on optimal overall proportion of siblings in school π^* - under no liquidity constraints and no child labour ($e^a = 0.0125$)

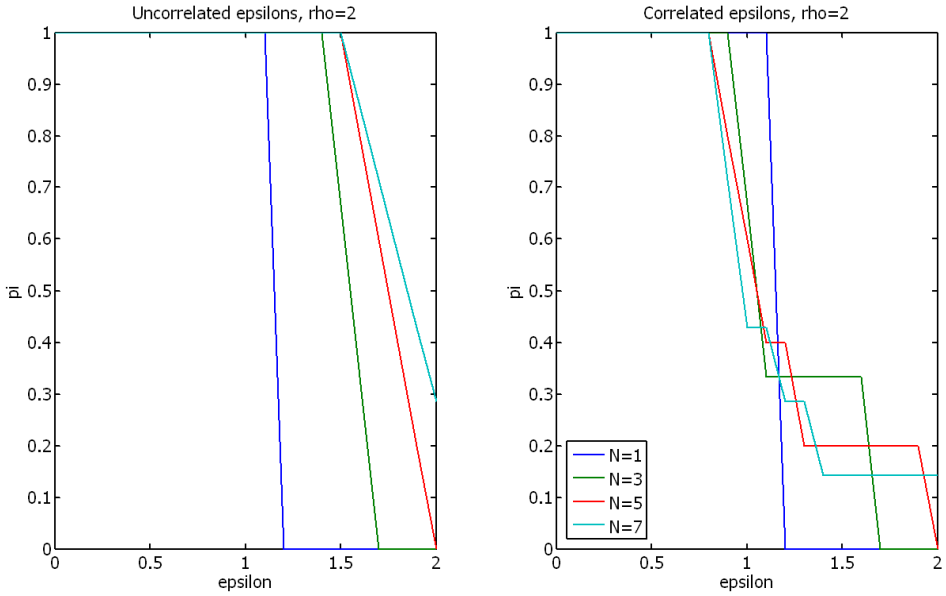


Figure 2. Effect of uncertainty ε on optimal overall proportion of siblings in school π^* - under liquidity constraints and child labour ($e^a = -0.025$)

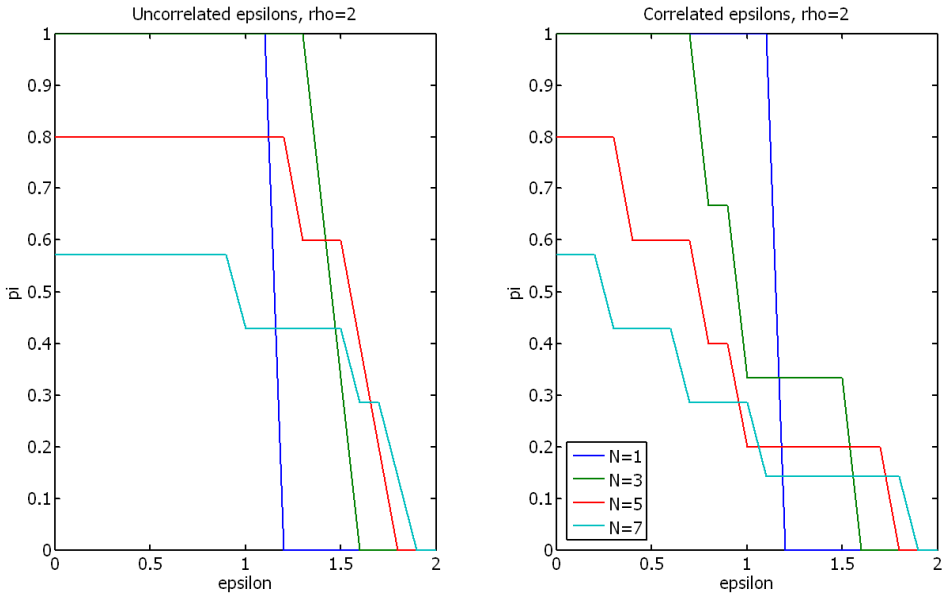


Figure 3. Effect of older cohort's π_1 on younger cohort's π_2

- under no liquidity constraints and no child labour ($s \lesseqgtr 0, e^a = 0.0125$)
- under no correlation over time and perfect correlation within cohorts and between cohorts

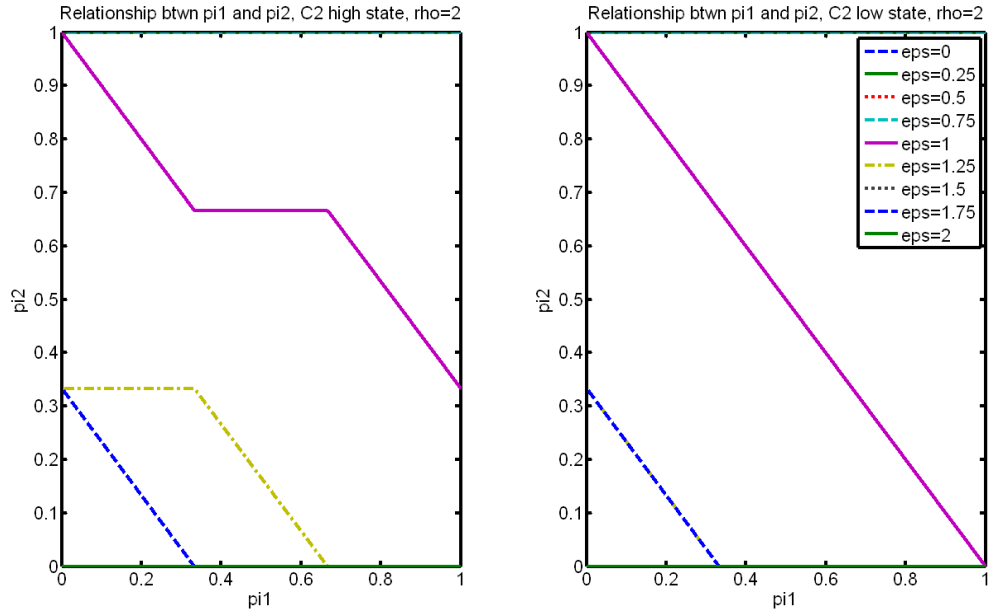


Figure 4. Estimation of π_1 and π_2 relationship on simulated data for full distribution of π^*

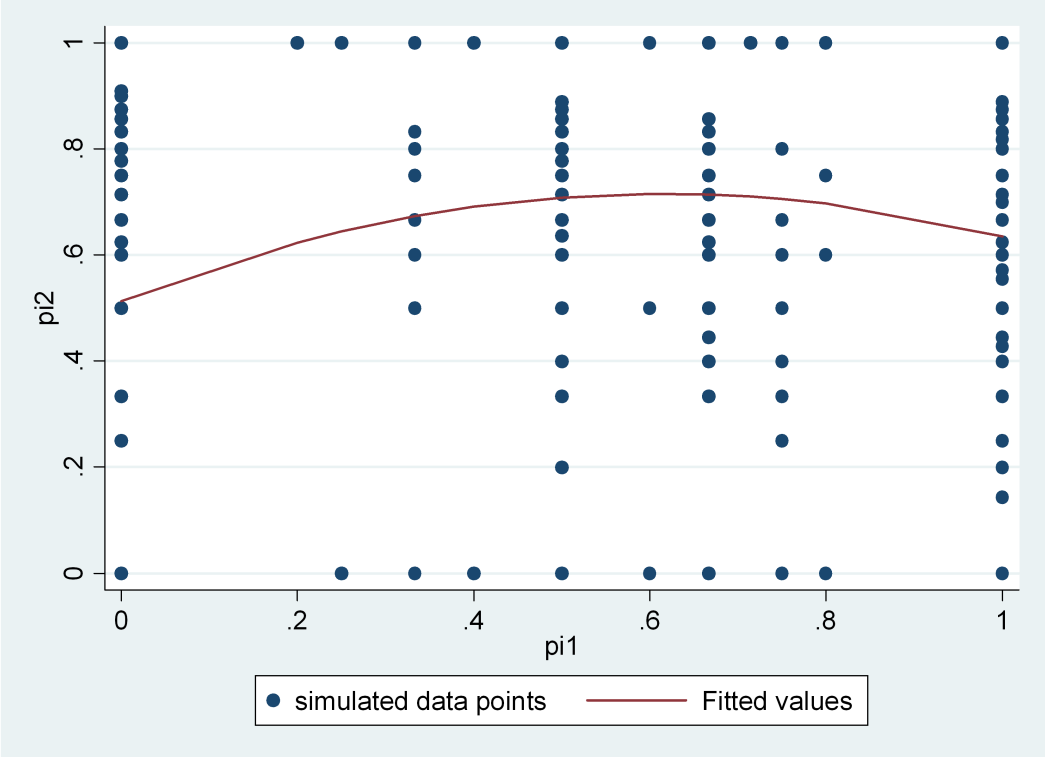


Figure 5. Estimation of π_1 and π_2 relationship on actual data for full distribution of π^*

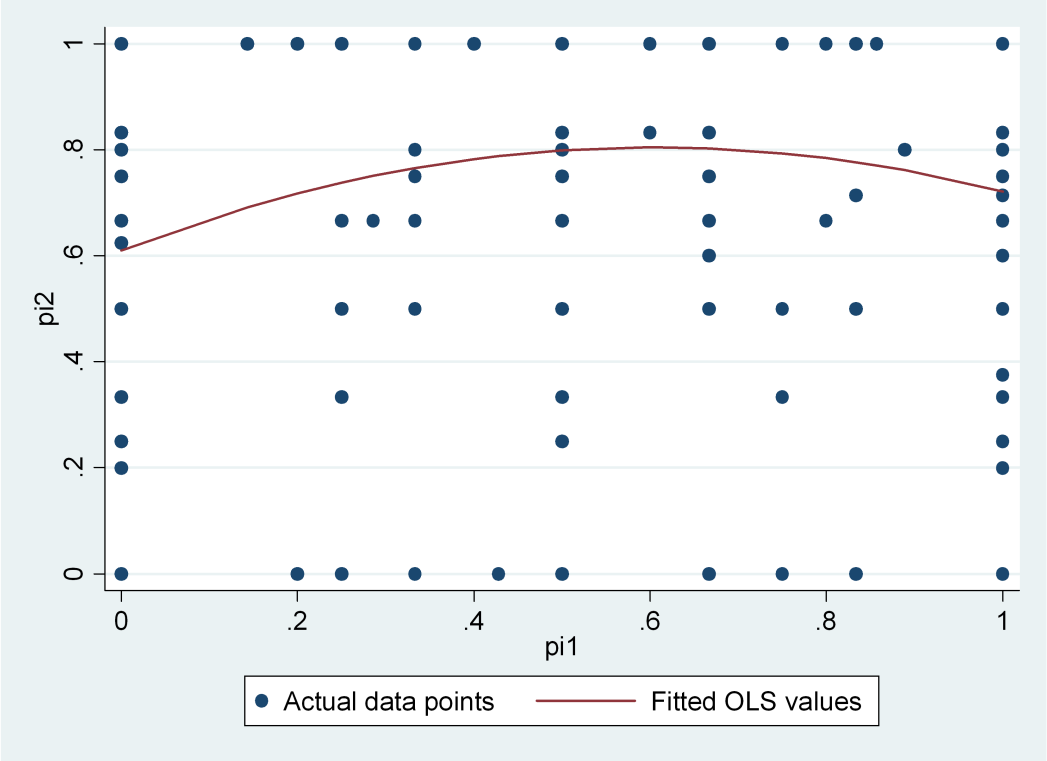
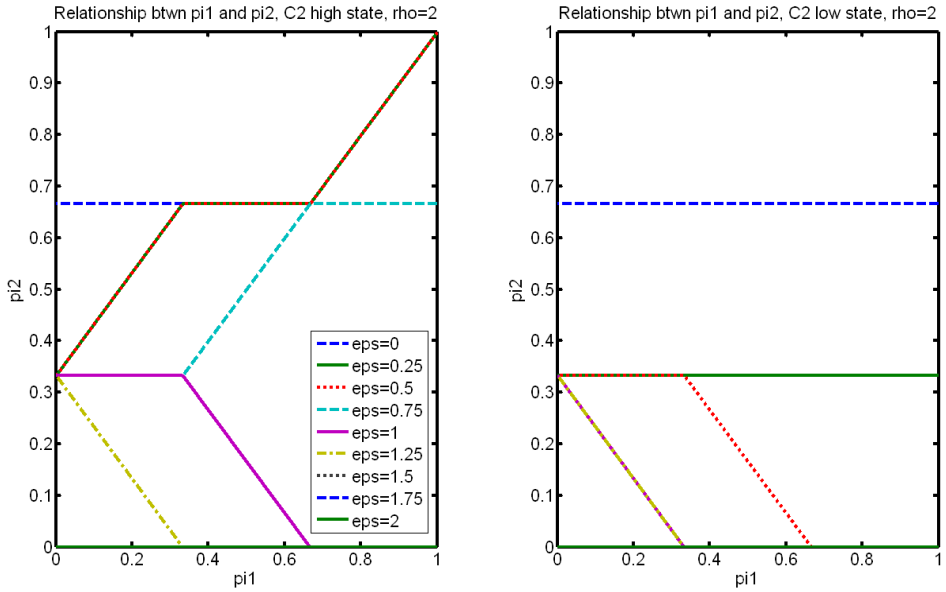


Figure 6. Effect of older cohort's π_1 on younger cohort's π_2

- under liquidity constraints and child labour ($s \geq 0, e^a = -0.025$)
- under no correlation over time and perfect correlation within and between cohorts



7 Tables

Table 1. Summary statistics

	Rural HHs				Urban HHs			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Sibling composition								
pi	0.715	0.260	0.000	1.000	0.787	0.274	0.000	1.000
pi1	0.721	0.329	0.000	1.000	0.780	0.347	0.000	1.000
pi1 (sons)	0.710	0.393	0.000	1.000	0.755	0.397	0.000	1.000
pi1 (daughters)	0.721	0.393	0.000	1.000	0.812	0.358	0.000	1.000
pi2	0.741	0.386	0.000	1.000	0.799	0.354	0.000	1.000
pi2 (sons)	0.739	0.398	0.000	1.000	0.808	0.368	0.000	1.000
pi2 (daughters)	0.746	0.411	0.000	1.000	0.808	0.370	0.000	1.000
N2 children in school	1.633	1.067	0.000	6.000	1.635	1.067	0.000	6.000
N2 sons in school	0.833	0.801	0.000	4.000	0.820	0.822	0.000	4.000
N2 daughters in school	0.800	0.856	0.000	4.000	0.815	0.821	0.000	4.000
N1	2.306	1.248	1.000	10.000	2.108	1.059	1.000	6.000
N1 sons	1.187	0.942	0.000	5.000	1.092	0.881	0.000	4.000
N1 daughters	1.119	1.000	0.000	6.000	1.016	0.893	0.000	4.000
N2	2.063	1.297	1.000	9.000	2.288	1.386	1.000	9.000
N2 sons	1.179	1.060	0.000	8.000	1.181	1.029	0.000	6.000
N2 daughters	0.884	0.919	0.000	5.000	1.107	1.033	0.000	6.000
Proportion of daughters	0.461	0.236	0.000	1.000	0.484	0.232	0.000	1.000
N	5.606	2.342	2.000	19.000	5.289	1.921	2.000	15.000
Household characteristics								
HH expenditure per AE per day	0.708	0.501	0.125	5.213	1.260	1.218	0.130	14.008
Agriculture is main income	0.904	0.295	0.000	1.000	0.344	0.475	0.000	1.000
Av. school costs in village	6.369	3.567	1.718	19.281	19.129	13.190	1.622	82.135
Av school distance (km)	1.542	1.033	0.185	5.417	1.317	0.627	0.111	3.625
HH has livestock	0.413	0.493	0.000	1.000	0.082	0.274	0.000	1.000
Land(ha)	14.682	14.696	0.000	125.000	6.058	14.759	0.000	250.000
HH size	8.508	3.219	3.000	32.000	8.093	2.780	3.000	25.000
HH head female	0.099	0.299	0.000	1.000	0.145	0.353	0.000	1.000
Muslim HH	0.277	0.448	0.000	1.000	0.567	0.496	0.000	1.000
Catholic HH	0.346	0.476	0.000	1.000	0.218	0.413	0.000	1.000
Protestant HH	0.265	0.441	0.000	1.000	0.148	0.356	0.000	1.000
Village prop. of HHs w wage income	0.164	0.118	0.000	0.565	0.571	0.218	0.053	1.222
Village prop. of HHs w business income	0.046	0.056	0.000	0.273	0.122	0.081	0.000	0.500
School quality assesment								
Teachers good/adequate	0.746	0.436	0.000	1.000	0.881	0.324	0.000	1.000
Headmaster good/adequate	0.823	0.382	0.000	1.000	0.917	0.276	0.000	1.000
School supplies good/adequate	0.411	0.492	0.000	1.000	0.454	0.498	0.000	1.000
Environment good/adequate	0.552	0.498	0.000	1.000	0.656	0.475	0.000	1.000
Self-reliance good/adequate	0.798	0.402	0.000	1.000	0.828	0.378	0.000	1.000
Swahili lessons good/adequate	0.869	0.338	0.000	1.000	0.932	0.252	0.000	1.000
English lessons good/adequate	0.593	0.492	0.000	1.000	0.731	0.444	0.000	1.000
Math lessons good/adequate	0.777	0.417	0.000	1.000	0.855	0.353	0.000	1.000
Moral lessons good/adequate	0.728	0.445	0.000	1.000	0.818	0.387	0.000	1.000
Max number of observations		**654**				**674**		

Table 2. Robust binomial regressions of n_2^b given N_2

	1	2	3	4	5	6	7	8
Dependent variable: nb2 out of N2	**Rural Sons**	**Rural Sons**	**Rural Sons**	**Rural Sons**	**Rural Daughters**	**Rural HHs**	**Urban HHs**	**All HHs**
pi1	0.251	3.706***	3.630***	3.760***	3.284	1.867**	2.211**	2.134***
	(0.248)	(1.378)	(1.373)	(1.405)	(2.622)	(0.816)	(1.017)	(0.613)
pi1 squared		-3.282**	-3.185**	-3.330**	-2.729	-1.476*	-1.314	-1.514***
		(1.275)	(1.275)	(1.300)	(2.580)	(0.772)	(0.916)	(0.566)
N2	-0.100	-0.128	-0.118	-0.189	-0.133	-0.034	-0.041	-0.032
	(0.097)	(0.092)	(0.090)	(0.126)	(0.162)	(0.062)	(0.085)	(0.050)
N1	0.112	0.021	0.054	0.028	0.393	0.195***	-0.064	0.080*
	(0.109)	(0.096)	(0.093)	(0.119)	(0.283)	(0.065)	(0.069)	(0.047)
Proportion of daughters	0.408	0.426	0.480	0.287	0.140	0.066	0.154	0.077
	(0.497)	(0.467)	(0.462)	(0.645)	(0.799)	(0.268)	(0.316)	(0.202)
ln(HH expenditure per AE per day, USD)	-0.694	-0.649	-0.607	-0.671	1.038*	0.423**	0.498***	0.475***
	(0.809)	(0.752)	(0.713)	(0.712)	(0.572)	(0.199)	(0.193)	(0.152)
ln(HH exp)*Agri. main income	0.896	0.863	0.867	0.863	-0.688	-0.231	-0.429*	-0.305*
	(0.835)	(0.778)	(0.742)	(0.725)	(0.607)	(0.227)	(0.248)	(0.174)
Agriculture is main income	0.286	0.366	0.435	0.514	-0.717	-0.236	0.003	-0.021
	(0.577)	(0.556)	(0.530)	(0.536)	(0.589)	(0.215)	(0.173)	(0.128)
Av. annual school costs in village, USD	0.025	0.021	0.009	-0.012	0.031	0.017	0.006	0.003
	(0.028)	(0.028)	(0.031)	(0.037)	(0.046)	(0.026)	(0.010)	(0.007)
Av school distance (km)	-0.082	-0.066	-0.077	-0.087	-0.264**	-0.083	-0.379***	-0.141***
	(0.081)	(0.087)	(0.093)	(0.095)	(0.127)	(0.059)	(0.121)	(0.054)
HH has livestock	-0.241	-0.301	-0.302	-0.311	0.097	-0.214	-0.235	-0.158
	(0.187)	(0.183)	(0.198)	(0.211)	(0.288)	(0.135)	(0.305)	(0.126)
Land (ha)				-0.002	0.013	0.002	0.017	0.005
				(0.006)	(0.009)	(0.004)	(0.011)	(0.004)
HH size				0.020	-0.029	-0.028	0.023	-0.013
				(0.037)	(0.048)	(0.024)	(0.047)	(0.021)
HH head female				-0.356	0.261	-0.222	0.318	0.048
				(0.400)	(0.438)	(0.187)	(0.297)	(0.167)
Village prop. of HHs w wage income				0.440	-1.184	-0.077	1.665***	0.535**
				(0.854)	(1.092)	(0.516)	(0.456)	(0.267)
Village prop. of HHs w business income				-0.189	10.228***	3.158**	2.786**	2.322***
				(2.194)	(2.254)	(1.406)	(1.263)	(0.805)
Constant	0.534	0.462	0.304	0.553	0.596	0.638	-1.003	0.145
	(0.656)	(0.619)	(0.692)	(0.754)	(1.029)	(0.440)	(0.661)	(0.337)
School quality controls	No	No	Yes	Yes	Yes	Yes**	Yes	Yes***
Tribal and religious controls	No	No	No	Yes***	Yes***	Yes***	Yes***	Yes***
Observations	363	363	363	363	281	654	674	1328

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

Table 3. Robustness check of econometric model

	Tobit model			Linear probability model		
Dependent variable: pi2	**All HHs**	**Rural HHs**	**Urban HHs**	**All HHs**	**Rural HHs**	**Urban HHs**
pi1	1.178***	1.092***	1.024	0.402***	0.406***	0.320
	(0.396)	(0.392)	(0.805)	(0.133)	(0.154)	(0.214)
pi1 squared	-0.788**	-0.873**	-0.314	-0.261**	-0.314**	-0.114
	(0.359)	(0.364)	(0.705)	(0.117)	(0.139)	(0.182)
N2	-0.119***	-0.083***	-0.196***	-0.011	-0.012	-0.011
	(0.029)	(0.032)	(0.058)	(0.010)	(0.014)	(0.014)
N1	0.052*	0.121***	-0.062	0.017**	0.045***	-0.010
	(0.028)	(0.035)	(0.050)	(0.009)	(0.012)	(0.011)
Proportion of daughters	-0.071	-0.079	0.003	-0.018	-0.029	0.009
	(0.126)	(0.137)	(0.247)	(0.041)	(0.057)	(0.058)
ln(HH expenditure per AE per day, USD)	0.271***	0.350***	0.238*	0.079***	0.130***	0.058**
	(0.088)	(0.121)	(0.131)	(0.025)	(0.045)	(0.029)
ln(HH exp)*Agri. main income	-0.145	-0.237*	-0.129	-0.036	-0.080	-0.034
	(0.099)	(0.134)	(0.186)	(0.029)	(0.049)	(0.042)
Agriculture is main income	-0.015	-0.149	0.001	-0.001	-0.050	0.003
	(0.082)	(0.144)	(0.133)	(0.024)	(0.054)	(0.030)
Av. annual school costs in village, USD	0.001	0.007	0.006	-0.000	0.004	0.000
	(0.004)	(0.012)	(0.006)	(0.001)	(0.005)	(0.001)
Av school distance (km)	-0.121***	-0.073**	-0.329***	-0.039***	-0.032**	-0.083***
	(0.030)	(0.031)	(0.088)	(0.011)	(0.015)	(0.023)
HH has livestock	-0.112	-0.125*	-0.194	-0.047*	-0.062**	-0.040
	(0.073)	(0.067)	(0.202)	(0.026)	(0.030)	(0.047)
Land (ha)	0.003	0.001	0.010*	0.000	0.000	0.001
	(0.002)	(0.002)	(0.006)	(0.001)	(0.001)	(0.001)
HH size	-0.000	-0.016	0.037	-0.000	-0.006	0.007
	(0.013)	(0.013)	(0.032)	(0.004)	(0.006)	(0.007)
HH head female	0.006	-0.104	0.133	-0.005	-0.042	0.024
	(0.098)	(0.104)	(0.202)	(0.030)	(0.042)	(0.046)
Village prop. of HHs w wage income	0.201	-0.026	0.879***	0.050	0.004	0.189***
	(0.158)	(0.270)	(0.308)	(0.048)	(0.114)	(0.072)
Village prop. of HHs w business income	1.211***	1.761***	1.721**	0.330**	0.629***	0.399*
	(0.456)	(0.598)	(0.859)	(0.135)	(0.238)	(0.206)
Constant	0.882***	1.060***	0.171	0.602***	0.692***	0.393***
	(0.201)	(0.254)	(0.460)	(0.069)	(0.102)	(0.126)
Observations	1328	654	674	1328	654	674
R-squared	.	.	.	0.117	0.128	0.159

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

8 Appendix A1

Under no liquidity constraints and no child labour, the derivative of π_2 with respect to $\pi_1$is found by using Cramer's rule on the system of first order conditions. It is given by

$$\frac{d\pi_2}{d\pi_1} = \frac{ED - BF}{AD - BC}$$

where

$$\begin{aligned}
A &= D = \left[-(e^b - e^a)N_2 U''(c_2) - E\left(N_2 N^{-\alpha_3}(y_{23}^b - y_3^a)U''(c_3)\right)\right] > 0 \\
B &= \left[-U''(c_2) - EU''(c_3)\right] > 0 \\
C &= \left[-\left((e^b - e^a)N_2\right)^2 U''(c_2) - E\left(\left(N_2 N^{-\alpha_3}(y_{23}^b - y_3^a)\right)^2 U''(c_3)\right)\right] > 0 \\
E &= \left[E\left(N_1 N^{-\alpha_3}(y_{13}^b - y_3^a)U''(c_3)\right) - N_1^{1-\alpha_2}(y_{12}^b - y_2^a)U''(c_2)\right] < 0 \\
F &= \left[E\left(N^{-2\alpha_3} N_2(y_{23}^b - y_3^a)N_1(y_{13}^b - y_3^a)U''(c_3)\right) - (e^b - e^a)N_1^{1-\alpha_2} N_2(y_{12}^b - y_2^a)U''(c_2)\right] < 0
\end{aligned}$$

Although not immediate from above, it turns out that the derivative is generally negative and in particularly so the larger the uncertainty.

Under liquidity constraints ($s = 0$) and child labour ($e^a < 0$), the derivative is simply given by

$$\frac{d\pi_2}{d\pi_1} = \frac{F}{C}$$

which is by all means easier to interpret. The sign depends on F, which now is ambiguous because consumption smoothing over time is difficult. If there is virtually no uncertainty (as it is typically the case in the standard child labour literature), there are high indirect costs of schooling such that $(e^b - e^a)$ is large, and the household is severely liquidity constrained such that $|U''(c_2)| >> |U''(c_3)|$ because second period consumption is smaller than third period consumption, then the second term in F will dominate and the derivative becomes positive. This positive effect is strengthened the larger the immediate gains from child labour in period 2 that is the higher the indirect costs of schooling $(e^b - e^a)$.

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

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July 18, 2008

Abstract

Lack of primary schooling among rural children in developing countries is often attributed to credit constraints and demand for child labour. However, it can be shown that the choice of not educating all children formally through schooling, but rather educating some children traditionally through on-farm learning-by-doing can be an optimal strategy for improved risk diversification within the household. In this paper, I test an intra-household human capital portfolio model on extraordinary panel data from a rural region in Northwestern Tanzania with a 13 year time horizon. The portfolio model allows for diversification of human capital investments as an ex-ante risk management mechanism. The need for risk management is driven by uncertainty about future income. Model assumptions and implications are strongly supported by the empirical findings. The results indicate that the need for future income source diversification can indeed affect current school decisions. This paper thus presents an alternative explanation for low rural school enrolment rates in developing countries. An alternative which is not in any way driven by resource constraints. This can potentially have far reaching policy implications.

Keywords: Schooling, child labour, human capital investment, future income uncertainty, risk diversification, liquidity constraints, Kagera, Tanzania, Africa

Chapter 4 of Ph.D. thesis.

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. 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. 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

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

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 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

[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 in the calibrations.

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 is[6]

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

[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 section 2.5 in chapter 2 for more detail.

[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.

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.

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

[7] For a detailed literature review on this subject, please refer to chapter 2.

[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. In chapter 1, Lassen and I analyse the effect of such sanctions on the demand for formal schooling.

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

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

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 $y_2^a = Y_1$.

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

[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 $s \geq 0$.

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 (see the detailed literature review in chapter 2 of this thesis), 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] In chapter 1, Lassen and I 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 chapter 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 chapter 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 section 2.6 of chapter 2 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

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

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 chapter 1, 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

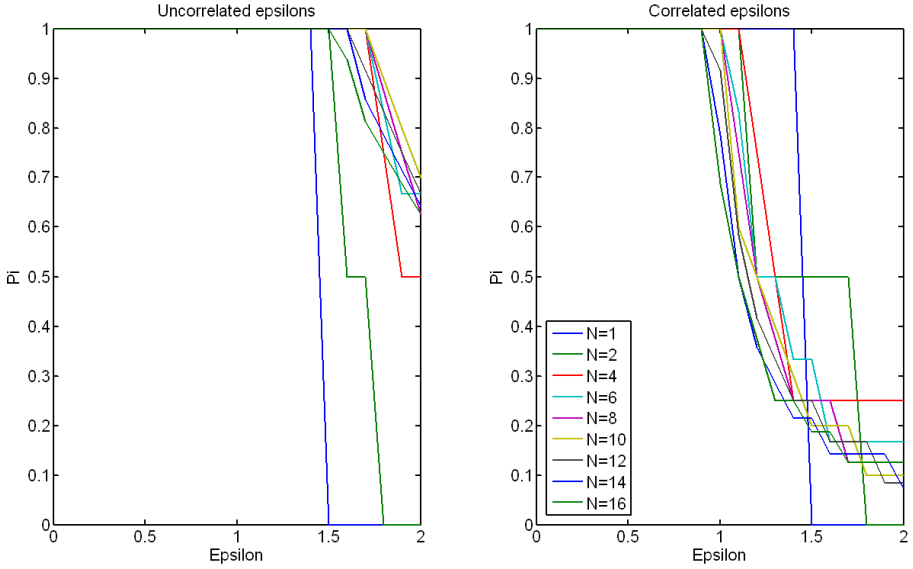


Figure 3.2. Effect of fertility on the optimal human capital portfolio, for different levels of risk ε

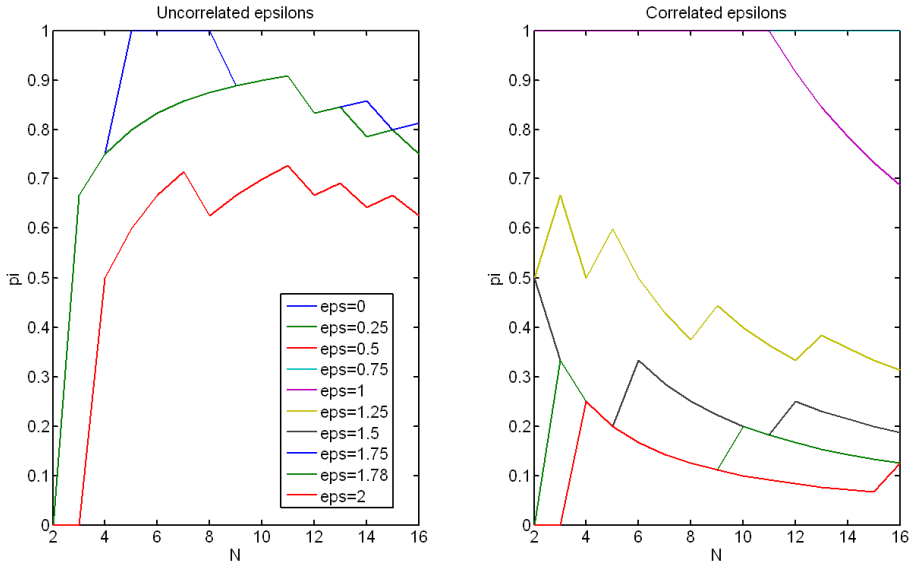


Figure 3.3. Effect of future urban income uncertainty on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

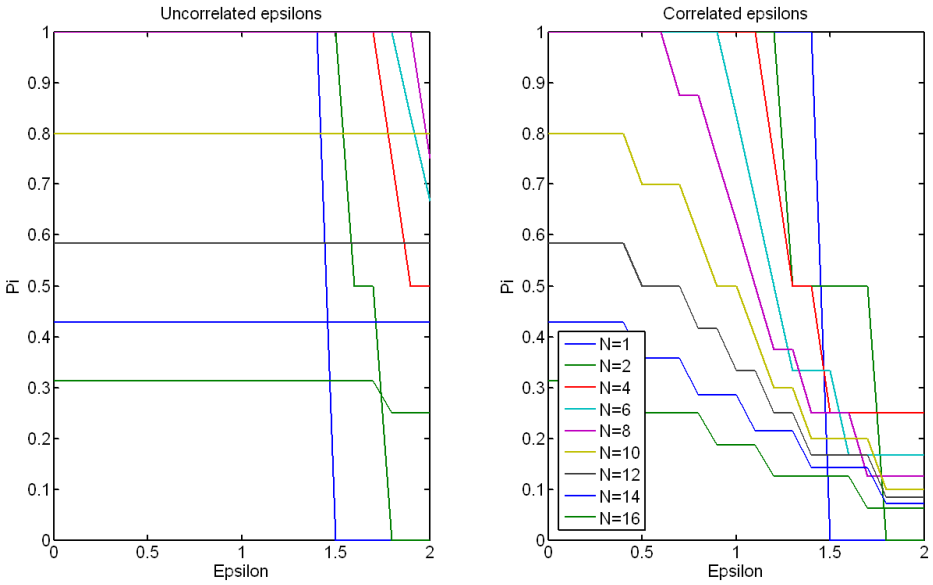


Figure 3.4. Effect of future urban income uncertainty on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

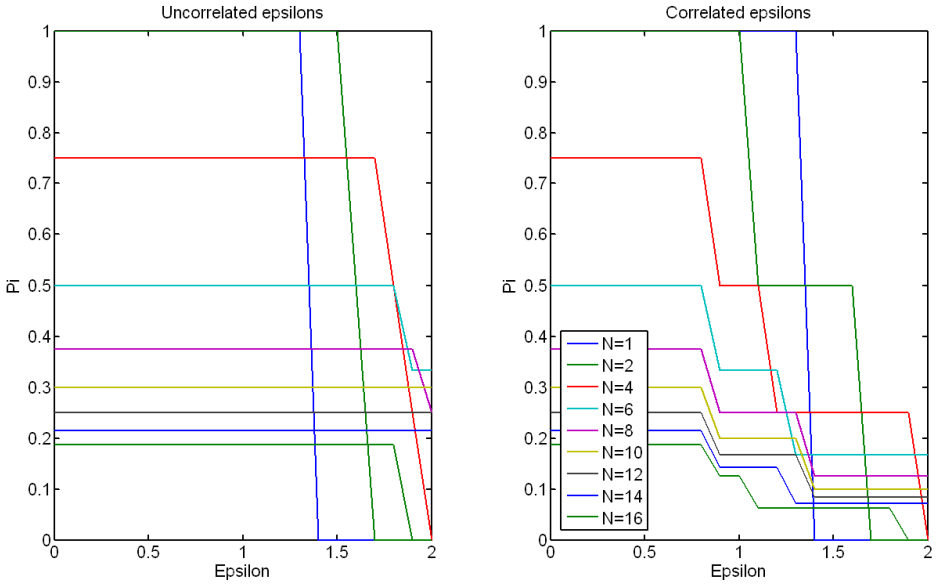


Figure 3.5. Effect of fertility on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

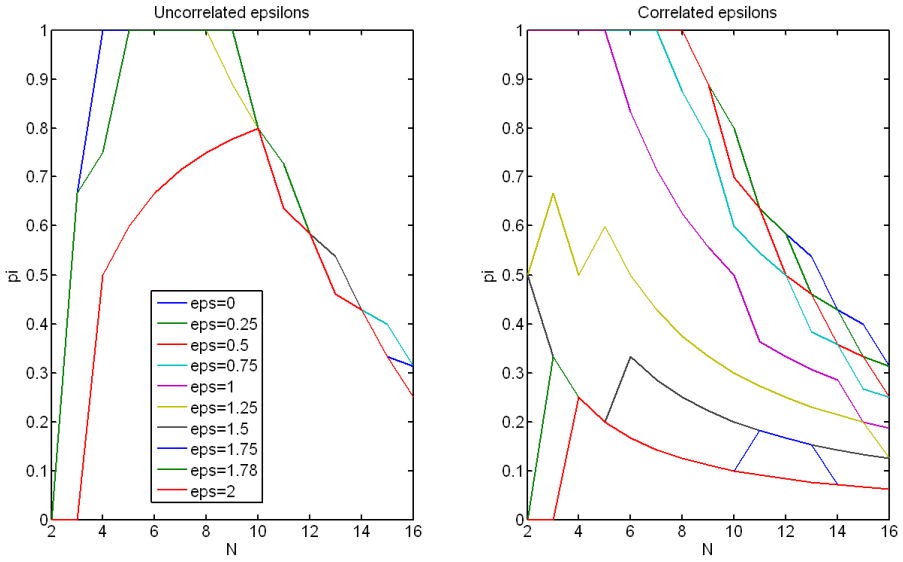


Figure 3.6. Effect of fertility on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

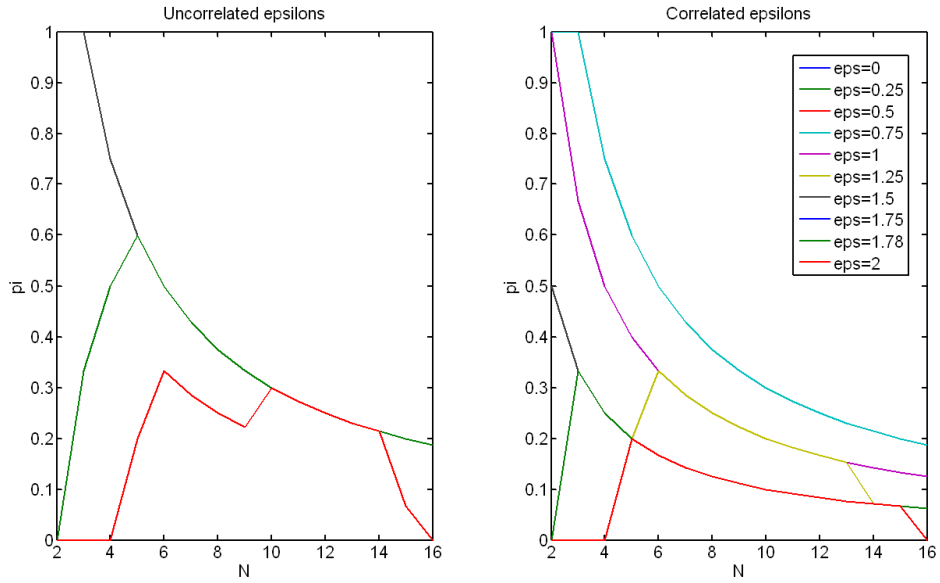


Figure 3.7. Effect of agricultural income on the optimal human capital portfolio under liquidity constraints, $s \geq 0$

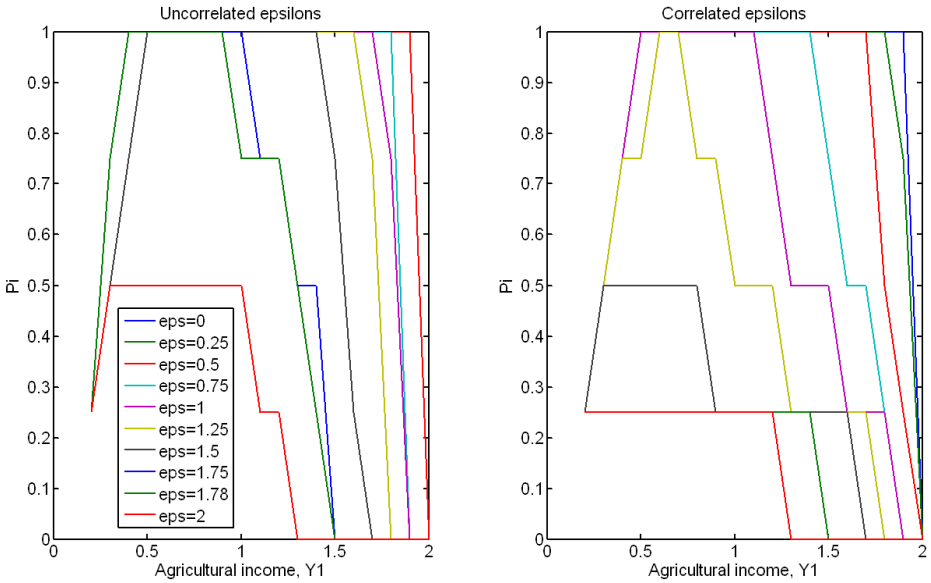


Figure 3.8. Effect of agricultural income on the optimal human capital portfolio under liquidity constraints and child labour, $s \geq 0$ & $e^a = -0.03$

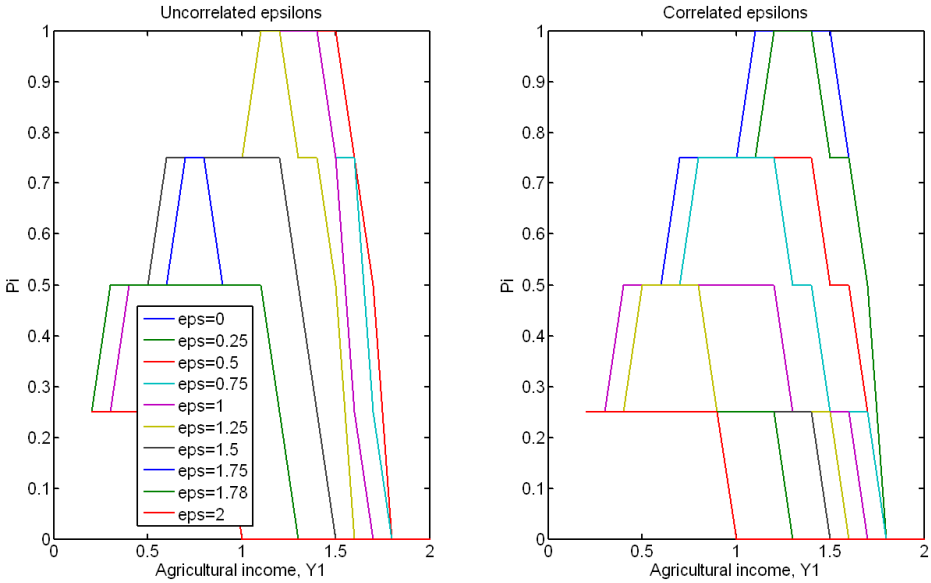


Figure 5.1. Income levels over average years of formal education among adult males in HH

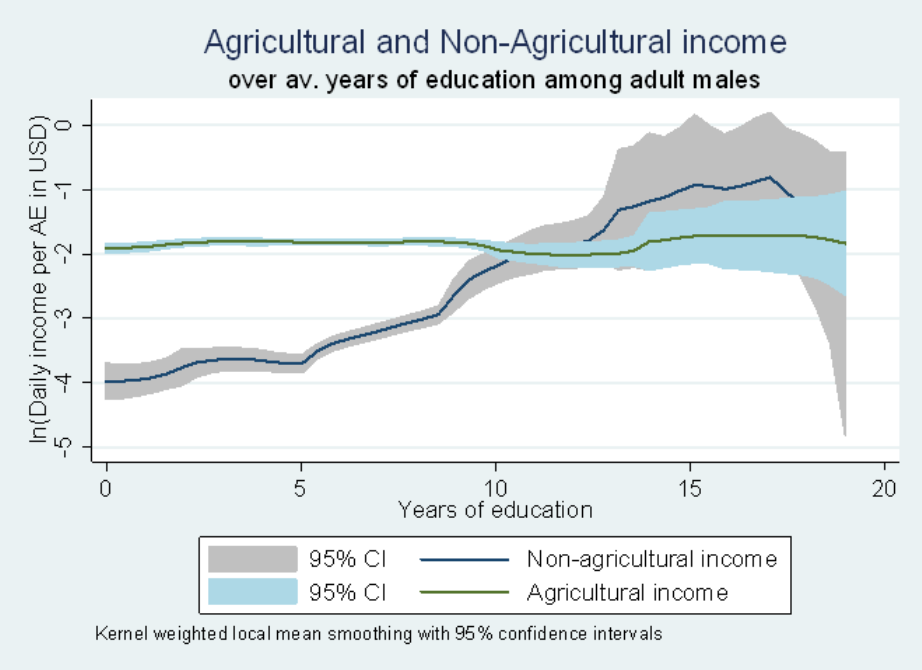


Figure 5.2. Proportion of formally educated sons over total number of sons in HH

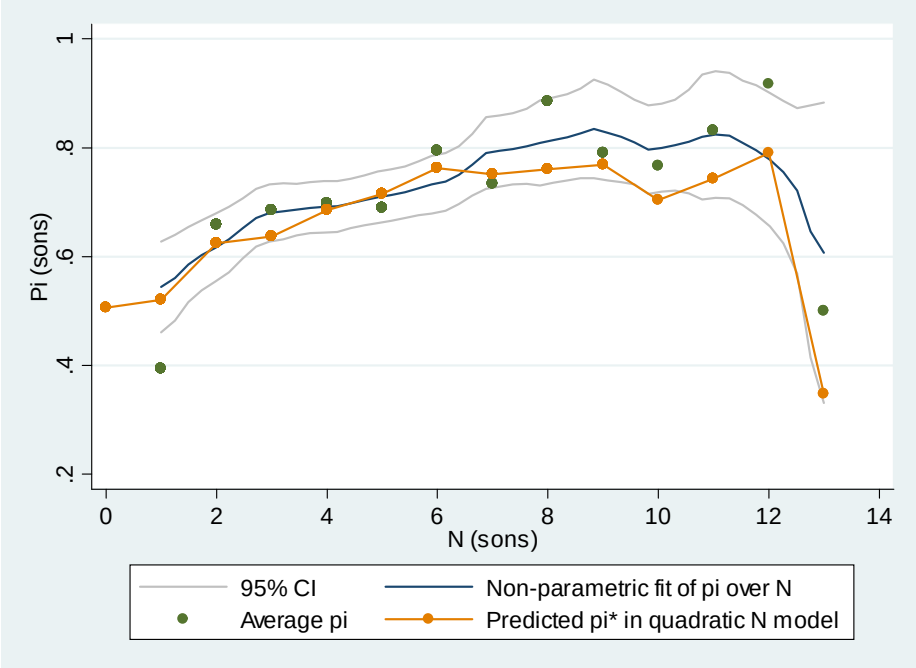


Figure 5.3. Proportion of formally educated sons over total number of sons in HH, split by HiEXP

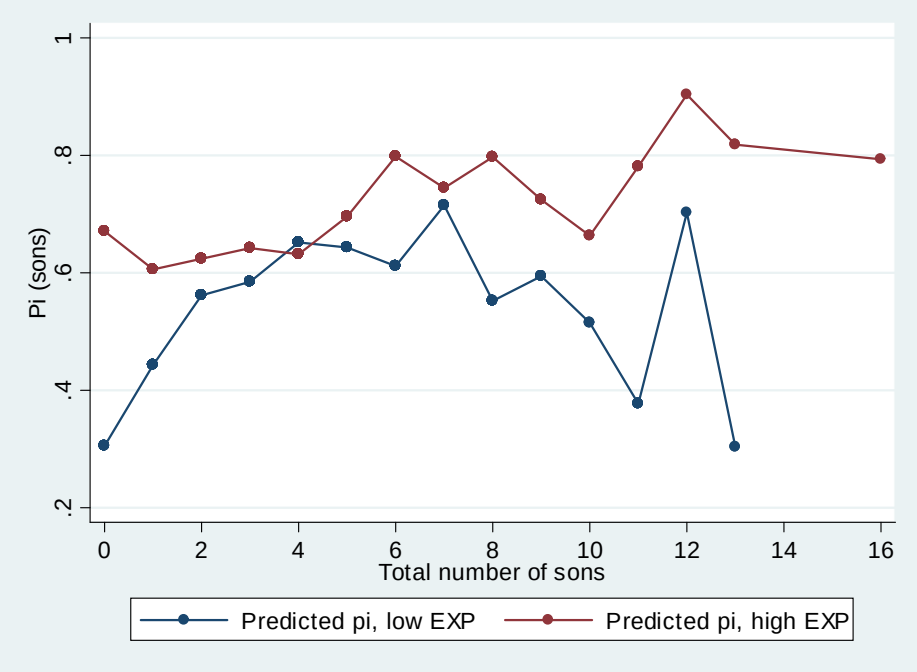


Figure 5.4. Actual π and predicted probabilitis of model (5)

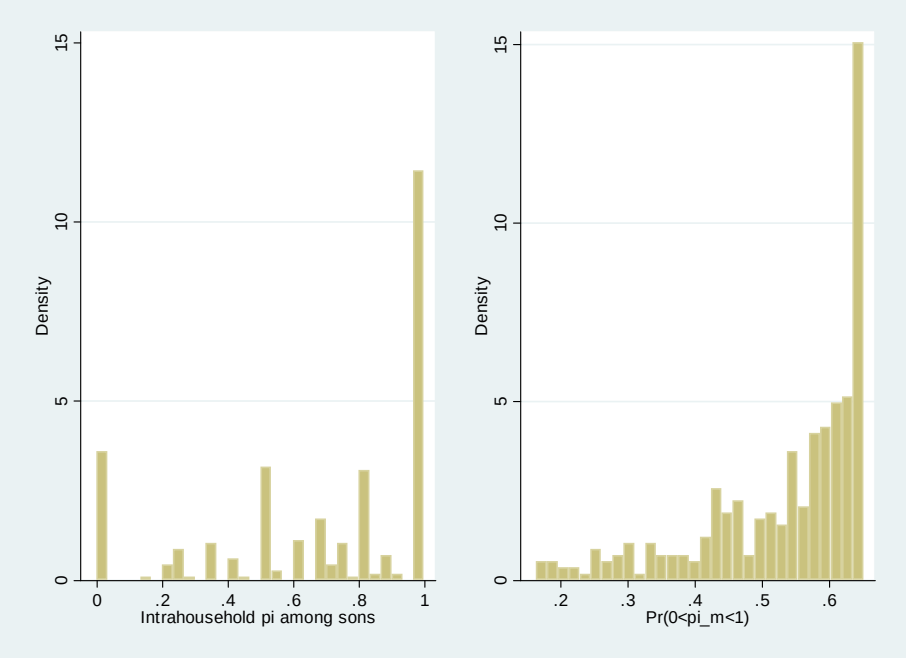
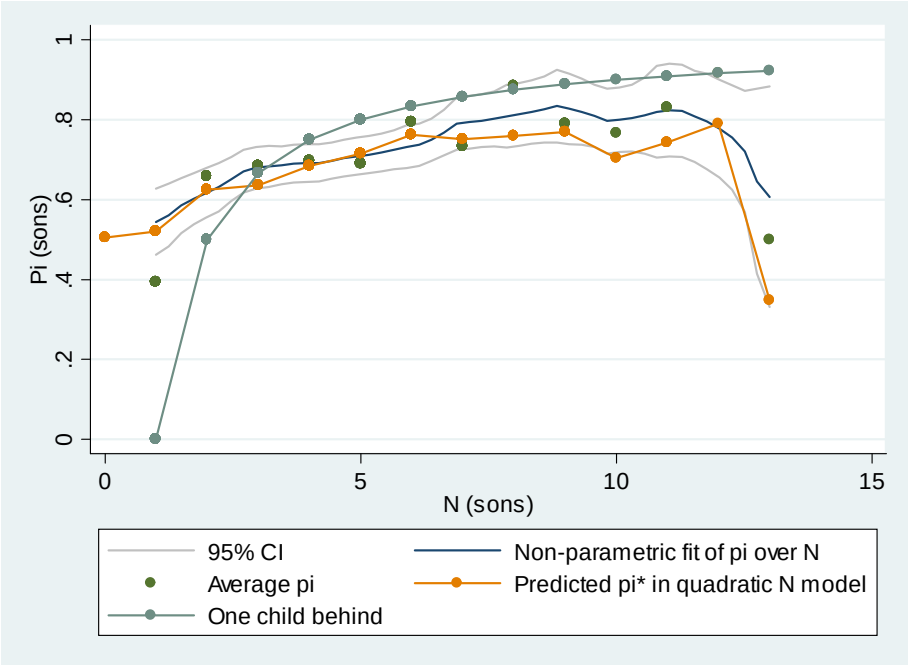


Figure 5.5. One-son-behind prediction compared to quadratic N model



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

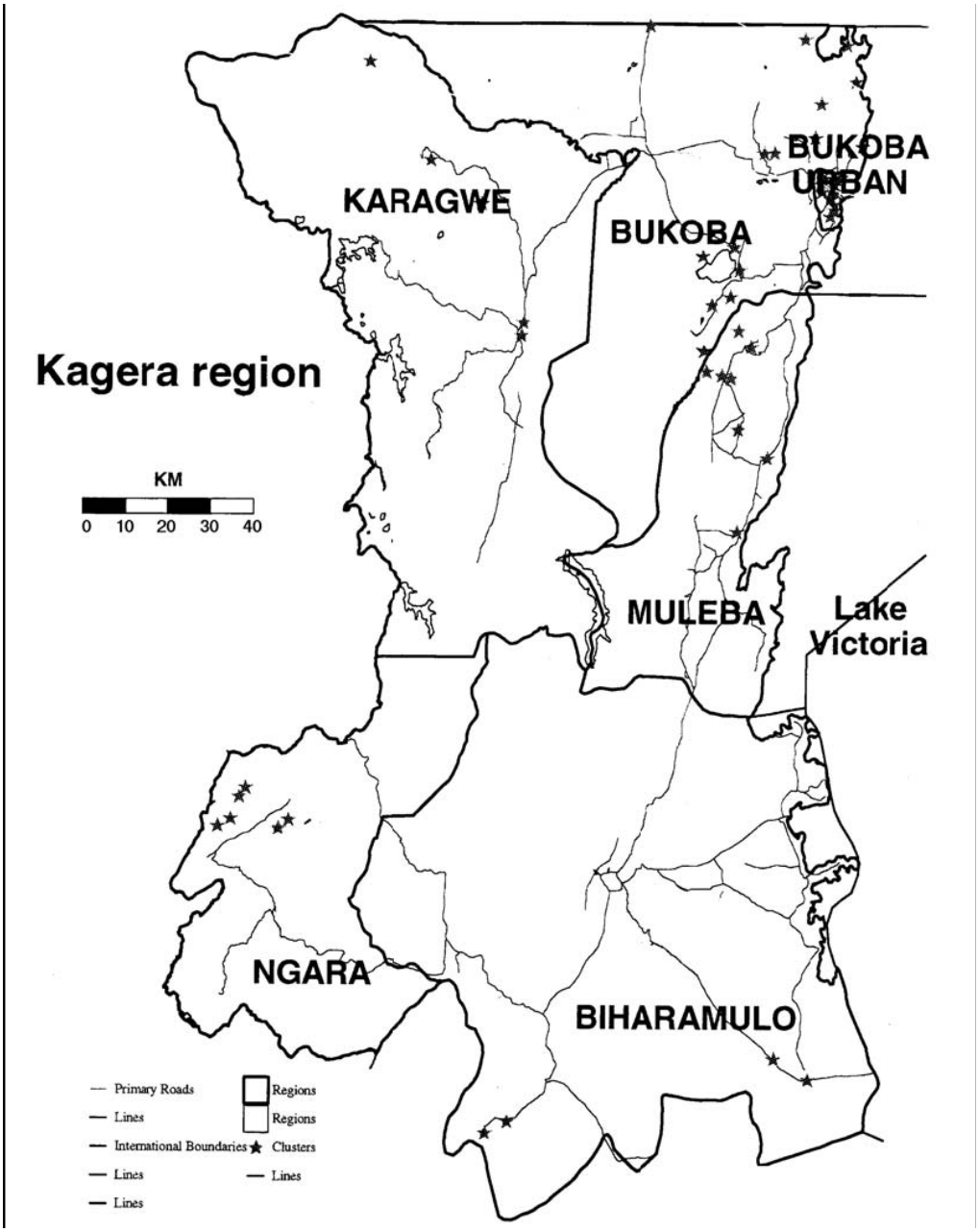
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5.5. Alternative econometric models for reduced form of π

	Model (5) Tobit	**Model (10a)** Tobit (het)	**Model (10b)** Tobit (het)	**Model (11)** CLAD	**Model (12)** Binomial	**Model (13)** 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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