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Household Shocks and Education Investment in Madagascar

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Abstract

This paper measures the extent to which households in Madagascar adjust children's school attendance in order to cope with exogenous shocks. We model the household's decisions to enroll children in school, and remove them from school, and measure the impact on these decisions of shocks to household income, assets and labor supply. In order to explore these questions more fully, we use a unique dataset with ten years of recall data on school attendance and household shocks. We estimate hazard models of school entry and exit, and measure the effect of shocks on these decisions. The probability of dropping out of school is significantly increased when a child's household experiences an illness, death or asset shock. The presence of a health and nutrition program in the local school is associated with earlier school entry and reduced probability of dropout among enrolled students.

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1. Introduction

While school attendance rates in Madagascar have risen in the last decade, retention rates are not high. The gross enrolment rate increased from 92 percent in 1995 to 132 percent in 2005, but primary school dropout rates remain above 50 percent (World Bank, 2008). Likewise, delayed enrollment remains a problem, with nearly one-third of children enrolling after their sixth birthday and over eight percent from age nine onward. From a policy perspective, it is important to understand the factors preventing children in Madagascar from progressing further in their education. The goal of this paper is to shed light on the types of unanticipated health and economic shocks that prompt children to drop out of school or delay their enrolment, in order to guide the design of policies to address these problems.

Where financial markets are imperfect or incomplete, households have been shown to employ a variety of methods to cope with unanticipated negative health and economic shocks (see, for example, Fafchamps 2003). One method is to reallocate the time of household members, for instance by taking children out of school to work in the household or elsewhere. This short-run coping mechanism can have long-run implications. Children leaving school rarely return, in which case an income shock may have permanent consequences for the child's human capital accumulation and lifetime earnings capacity. Children are less likely to drop out in response to household shocks when financial markets are complete and when optimal levels of human capital investment are based on market rates of return.

Shocks might also delay the enrollment of children not already in school. While it is unlikely that very young children would be required to work in response to a negative shock, such events may diminish the household's capacity to afford the costs associated with schooling. Aside from school fees, parents may have to pay for uniforms, books, and other expenses. Thus, during periods of economic stress, parents may choose to delay the enrollment of their children.

Studies from a range of developing countries have found evidence that school attendance falls and child labor increases in response to negative income shocks. The literature can be divided into those studies that consider the effects of household-level shocks, and those looking at the effects of macroeconomic shocks. Perhaps the most well known household-level study was conducted by Jacoby and Skoufias (1997), who found that children in India missed days at school to help out on the farm at home. Jensen (2000) used various indicators to establish that children in Côte d'Ivoire whose households suffered adverse rainfall shocks were less likely to attend school. Sawada and Lokshin (1999) found similar evidence for communities in Pakistan, where children left school in response to transitory income shocks. Studying Tanzanian households, Beegle et al. (2006) found that unexpected crop losses led to an increase in child labor, but also observed that this effect was smaller in households that had assets with which to absorb the shock. Finally, Duryea et al. (2007) used data from Brazil's monthly employment survey to establish that employment rates were higher and grade advancement rates lower for children whose fathers were unemployed.

In poor countries, macroeconomic shocks reduce the rate of school attendance by depressing household income. In their study of the Indonesian financial crisis of 1997-98, Thomas et al. (2004) found that school enrolment rates of 13- to 19-year-old children fell, but also noted that younger children were more likely to drop out than their older siblings. This suggests that parents were protecting their investments in the older children's education. When considering macroeconomic shocks, however, McKenzie (2003) showed that one must consider general equilibrium effects as well. In his study of the Mexican peso crisis, he found that school attendance rates of 15- to 18-year-old boys actually increased. His interpretation was that falling wages in the general economy reduced the opportunity cost of education during the crisis. Recent research by Ferreira and Schady (2009) is consistent with the results from Indonesia and Mexico, showing that in poorer countries, macroeconomic shocks tend to decrease school attendance, whereas they boost school attendance in middle-income and high-income countries.

Our paper contributes to the literature on education investment and risk by examining the dynamic response of school attendance in Madagascar to various types of idiosyncratic household shocks. We use a detailed, nationwide dataset on schooling and educational attainment in Madagascar that also includes recall data over a ten-year period on various shocks. We model the hazard function for schoolchildren leaving school (or equivalently, duration of schooling), and for pre-schoolers entering school, as a function of shocks experienced by the household and other covariates. Most the idiosyncratic shocks we include are negative, and capture events that are known to lead to economic stress. These include: illness and death of the household head and spouse; transitions into unemployment; the unanticipated loss of crops, land and livestock; and lower-than-expected business income. We explore a series of interactions between these shocks and various individual and household characteristics. We also examine the impacts on age at entry and on dropout of access to secondary schools, local primary school quality, and a government-sponsored health program, Secaline, which provides iron/folate supplementation, deworming and other types of nutrition to enrolled primary school children.

Another contribution of this paper is that we present a theoretical and empirical examination of the differing impacts of credit market and labor market constraints on schooling. It is typically assumed that if parents withdraw their children from school in response to shocks, this must be due to imperfect credit markets: they cannot borrow sufficiently to both sustain household consumption and continue investing in their children's human capital. However, such a response might also reflect labor market constraints. Namely, the family may be unable to hire (without significant costs, perhaps) external labor for family enterprises should the household's labor supply be diminished. Based on the notion that there is gender differentiation in household based tasks, we develop a simple, but partial, empirical test to distinguish credit market imperfections from labor market imperfections.

In Section 2, we develop a dynamic model of intertemporal choice to characterize the education investment decision. In Section 3, we translate this into an econometric framework for the subsequent analysis, using a unique dataset described in Section 4. Section 5 discusses the results, and Section 6 concludes.

2. A Model of Household Schooling Decisions

In this section we develop a model of household investment in children's education. The purpose of the model is to describe the process by which economic and health shocks might cause children to drop out of school or delay enrollment. The theory is then used to guide the specification of a hazard model, with which we estimate the impact of shocks on children's school attendance decisions. We also derive several testable predictions about the impact of family structure and credit and labor market rigidities on the propensity of children to drop out of school.

The seminal intertemporal model of human capital investment under uncertainty was developed by Jacoby and Skoufias (1997), who sought to describe the phenomenon of children in India skipping days of school to provide extra labor at home. Sawada and Lokshin (1999) and Sawada (2003) extended the model to allow for tradeoffs between multiple children. We develop a similar model here in order to motivate our econometric analysis. However, we tailor our model to examine how labor and credit market imperfections might alleviate or exacerbate the impact of shocks on school attendance.

Consider a household with one child, whose (unitary) planner aims to maximize the discounted utility of a single household consumption good, C_t, over the horizon $t = 1, ..., T$. In each period, the household receives an income of Y_t from sources other than the child's labor and interest on household assets. (Thus, Y_t includes parental income.) The child is endowed with one unit of time in each period, which can be spent either attending school or working.[1] Let $S_t \in [0, 1]$ denote the amount of time the child spends in school in period t. Schooling costs the household π_t per unit, so the household's total expenditure on schooling in period t is $\pi_t S_t$. Schooling increases the child's stock of human capital, H_t. The increment to human capital from schooling in period t is determined by the return function $f(S_t, \alpha_t)$, where f is strictly increasing in both its arguments and $f(0, \alpha_t) = 0$. The vector α_t contains variables that might increase or diminish the child's human capital returns from education, such as the child's age, ability and gender, and the quality of the school. Thus H_t evolves according to the law of motion,

$$H_{t+1} = H_t + f(S_t, \alpha_t). \qquad (1)$$

This specification differs from the one used by Jacoby and Skoufias (1997). Theirs allowed the return to schooling to depend on H_t, so that returns to schooling could increase as the stock of human capital increased. The specification we use treats the stock of human capital more as a measure of

[1] We omit leisure from the model, as is standard in the literature.

'effective years of schooling', adjusting for factors like individual ability and school quality.

For the fraction of time the child is not in school, she works for a wage W_t, which may vary both across children and across time. The household also holds a stock of assets A_t, which yields a per-period rate of return r. Accordingly, the household's budget constraint is

$$C_t \leq Y_t + W_t(1 - S_t) - \pi_t S_t + (1 + r)A_{t-1} - A_t. \qquad (2)$$

At the start of period t, the household realizes its earnings on assets from the previous period, and observes the value of Y_t. The household's decision problem is to choose vectors of schooling $\{S_j\}_{j=t}^{T}$, consumption $\{C_j\}_{j=t}^{T}$ and savings $\{A_j\}_{j=t}^{T}$ to maximize the present value of utility over the horizon, plus the discounted value of the stocks of human capital and assets remaining at time T + 1:

$$E_t\left[\sum_{j=0}^{T} \beta^j U\left(C_{t+j}\right) + \beta^{T-t}\phi(H_{T+1}, A_{T+1})\right], \qquad (3)$$

where $\phi(H_{T+1}, A_{T+1})$ is the value to the household of the child's human capital and household assets at time $T + 1$ and $\beta < 1$ is a discount factor.[2] We assume U is continuous, strictly increasing and strictly concave, and that ϕ is weakly concave in both arguments. This means that the household derives diminishing marginal utility from extra human capital, which we believe is a fair assumption except perhaps at education 'milestones' such as completion of secondary school. For simplicity we will not discuss such discontinuities in ϕ in our theoretical model, but we allow for them in the econometric model by including fixed effects for years of education.

It is important to note that in this model, the household derives no consumption benefit or psychic utility from schooling over the planning horizon. Decisions about the child's education are made solely with reference to the discounted value of the child's human capital at the end of period T. The model also excludes nonmonetary costs and benefits related to schooling, such as social norms or legislation, which might affect schooling decisions. We consider the single-child case here for simplicity, but the model generalizes trivially for multiple children provided there are no externalities in the return to education across children (leaving Equation 1 unchanged). The main effect of adding multiple children to the model is that a child's attendance at school reduces the resources available to other children in the household, reducing their likelihood of attending school.[3]

At an interior solution the optimal level of school attendance S_t^* satisfies the first-order necessary condition:

[2] Since the parents are assumed to be the decision makers here, the value to the household of the child's human capital at $T + 1$ might not be the child's entire discounted future income stream. Rather, it might consist of remittances and other benefits related to the child's future employment and welfare.

[3] For a proof of this claim, see Sawada (2003).

$$U'(C_t^*)(W_t + \pi_t) = \beta^{T-t} E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(S_t^*, \alpha_t) \text{ for } S_t^* \in (0,1), \quad (4)$$

where $\phi_H(H_{T+1}, A_{T+1})$ is the partial derivative of ϕ with respect to H_{T+1}, f_S is the partial derivative of f with respect to S, and C_t^* is the optimum level of consumption given S_t^*.[4] Equation 4 says that at an interior solution, the optimal amount of schooling S_t^* equates the marginal cost of schooling (the wage income forgone, plus marginal education expenses) to its discounted marginal benefit (the marginal effect of S on the salvage value of the child's human capital). A fall in income not offset by dissaving will depress the household's consumption level and thereby lead to a reduction in S_t^*, while a rise in the marginal value of human capital, or the marginal return to schooling will increase S_t^*. Increased costs of schooling or a rise in the child's wage, meanwhile, will decrease S_t^*.

In order to examine the household's decision about whether the child should attend school or work, we now recast the decision rule in Equation 4 in terms of the child's shadow wage of education. Let this shadow wage in period t be the value B_t that solves Equation 4:

$$U'(C_t)(B_t + \pi_t) = \beta^{T-t} E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(S_t, \alpha_t).$$

The shape of B_t depends on the return to schooling function f; we will assume for simplicity here that f is linear in S, so that f_S is constant with respect to S.[5] Accordingly, we can solve for B_t:

$$B_t = \beta^{T-t} U'(C_t)^{-1} E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(S_t, \alpha_t) - \pi_t.$$

Note that B_t will fall if consumption falls, since we assume the utility function is strictly concave. Furthermore, B_t is linear in the cost of schooling, π_t. Policies that lower the cost of schooling, or provide children attending school with consumption benefits like free meals, will accordingly have a positive effect on school attendance. Later, we will test the effect of a program called Secaline, which was introduced in schools in Madagascar to provide children with free meals, deworming and nutrition supplements.

Let us now consider the child's attendance decision. Given our assumption that f is linear in school attendance, the attendance decision is a binary one; either the child attends school full-time, or does not attend at all. The decision depends on B_t and the wage available to the child in the labor market, W_t. If $B_t \geq W_t$, the child will attend school full-time, since any time spent working will not compensate for the foregone human capital. If $B_t < W_t$, the child will work full-time and drop out of school. For a child initially not in school, but of

[4] See the Appendix for the derivation of this result.

[5] It is unclear what the shape of f should be, and indeed it may vary between children or between schools. If we measure human capital in terms of grade progression, and children need only attend class infrequently throughout the year to progress, then f will be concave. Conversely, if the child needs almost full attendance to progress to the next grade, f will be convex. Assuming f is linear implies that every day of school attended yields constant returns in terms of human capital, and has the simplifying feature of ruling out partial attendance.

school age, this implies that the parents will enroll the child as soon as $B_t \geq W_t$. Presumably W_t is not large for a young child, so the crucial factors determining the size of B_t will be the child's age (captured in the vector α_t), household consumption and the cost of schooling. Once a child is enrolled in school, each year's attendance decision is based on a re-evaluation of B_t and W_t. As the child gets older, W_t may rise (recalling that W_t is the child's potential outside wage). The cost of schooling may also increase. As the child's stock of human capital H_t increases, the marginal effect of continued attendance at school on future earnings, ϕ_H, will fall. These factors combined will eventually cause every child to leave school. However, a negative shock that reduces household consumption could cause early dropout if B_t falls below W_t. By increasing B_t, programs like Secaline may therefore reduce the likelihood that a child will drop out of school following a shock.

Credit Market Imperfections

Household consumption will only respond to transitory income shocks if the household is credit constrained. Thus the degree of credit constraint has a direct bearing on whether children will drop out in response to a transitory shock to household assets or income. To illustrate the effect of credit market imperfections, let us consider two polar cases: first, where the household has full access to credit at a fixed interest rate *r*; and second, where the household can neither borrow nor save.

First let us assume that the household can borrow or save all it wants at interest rate *r*. Then the household's decision problem must also satisfy the Euler condition,

$$U'(C_{t-1}^*) = E_{t-1}[\beta(1+r)U'(C_t^*)].$$

Households with full access to credit will prefer to smooth their consumption stream with borrowing, so a transitory income or asset shock in period *t* will not affect $U'(C_t)$. Since the child's shadow wage B_t will also be unchanged, the household's school entry and dropout decisions will be unaffected by transitory income or asset shocks. With an unconstrained ability to borrow or save, the household's education decisions are completely separable from its savings and consumption decisions. School attendance is determined solely by the market wage, the cost of schooling, returns to schooling and the market interest rate.[6]

Now consider the polar opposite case in which the household cannot borrow or save at all. In this case, a negative shock to Y_t will reduce C_t, since the household cannot borrow or dissave to offset the shock. If we substitute the budget constraint for C_t into (4) and set $A_{t-1} = A_t = \ldots = 0$, we have:

$$U'(Y_t + W_t(1 - S_t^*) - \pi_t S_t^*)(W_t + \pi_t) = \beta^{T-t} E_t[\phi_H(H_{T+1}, 0)] f_S(S_t^*, \alpha_t). \quad (5)$$

[6] Shocks that affect a household's permanent income would however cause C_t to change and thereby also affect schooling decisions. A large enough transitory shock would also affect permanent income, so this analysis applies only to small transitory shocks.

If the household is risk averse, then the utility function is strictly concave, and it is easy to verify that $\frac{\partial S_t^*}{\partial Y_t} > 0$.[7] Any negative shock to income – whether permanent or transitory – would lower the optimal level of schooling in the period, making dropout more likely.

The true situation for most households in Madagascar probably lies between the polar cases of perfect access to credit and no access to credit. The effects of a shock will be tempered for households with greater access to credit, such as those with more wealth and greater proximity to financial service providers.

Labor Market Imperfections

Even if there are perfect credit markets, negative shocks may lead to dropout in the presence of imperfections in the labor market, specifically, constraints on the household's ability to hire outside labor. To illustrate, suppose the child's parents are involved in productive activities in the home (e.g., a family business or farm) and also have the possibility of working elsewhere for wage w. If the household production function is concave, then the marginal product of labor for household production translates into a downward-sloping household labor demand curve (labeled MPL in Figure 1a). Suppose the supply of labor in the outside market is perfectly elastic at the equilibrium wage w. The household will maximize their firm's profit by producing at the intersection of the labor supply and demand curves, (w, L^*). If the household's labor supply exceeds L* (for instance, at L_p), then the surplus labor will be sold on the outside market at wage rate w. Likewise, if the household requires more labor than is available (e.g. at L_p'), the shortfall will be provided by outside labor hired at wage rate w.

If labor markets are perfectly competitive, the child's school attendance decision will be independent of household production. If $B_t \geq w$, the child's labor supply curve will lie above the market supply curve. The child attends school and the parents hire outside labor to assist with household duties. If $B_t < w$, the child will either work at home or in the labor market for wage w.[8]

Now consider a temporary shock, such as illness, that reduces the parents' labor supply from L_p to L_p' in Figure 1a. If labor markets are perfectly competitive, the household will simply hire $L^* - L_p'$ units of outside labor. The shock will reduce net household income by $w(L_p - L_p')$, because of the payments to outside workers and foregone earnings. If the household has full access to credit, it can borrow to offset these income effects, so consumption will be unchanged, and therefore B_t will also be unchanged. The school attendance decision, which is based only on comparison of the net benefit of the schooling investment to the market wage, will be unchanged. If the household is credit

[7] See the Appendix for a proof.

[8] Technically the child makes attendance decisions based on her own outside wage, W_t. For simplicity, we assume here that $W_t = w$. In this case, one needs simply to adjust the child's labor supply to the household to be in terms of effective units of labor. If the labor market is perfectly competitive aside from monitoring costs, W_t will be proportionately lower if the child is less productive than an adult.

constrained, however, B_t will fall. If it falls far enough that $B_t < w$, the child will drop out of school.

In the presence of labor market rigidities, the cost of hiring outside workers may be higher than the shadow price of household labor. For example, it may be necessary to monitor the activity of outside workers. Let $\tau > 0$ be the per-unit cost of monitoring each worker, so that the market-clearing price of a unit of hired labor is $w + \tau$ (of which the worker receives only w). The labor supply curve for hired workers is depicted by the segment EF in Figure 1b. Now suppose the head of the household becomes ill, curtailing the parents' labor supply from L_p to L'_p. If $w + \tau > B_t$, the child will be taken out of school to work at home, even though B_t has not changed. This is because the demand curve for household labor lies above the child's labor supply curve at B_t, but lies below the market labor supply curve at $w + \tau$. In the example in Figure 1b, even with the child working the household cannot maintain the previous level of domestic production. Thus income will fall. With full access to credit, the household could offset the fall in income by borrowing, but this would not change the decision to employ the child at home. If the household cannot borrow, the fall in income will cause B_t to fall, making dropout even more likely.

Distinguishing Between Labor and Credit Market Rigidities

We have described how shocks that affect household labor supply can still raise the probability of dropout in the presence of labor market rigidities, even when the household has full access to credit. However, if we observe a link between shocks and dropout, it appears difficult or impossible to distinguish whether labor or credit market imperfections are responsible, since major shocks such as illness and death affect both income and the household's labor supply. In fact, there is a way to distinguish between the two channels, under the plausible assumption that there is imperfect substitutability by gender in household tasks.

In our sample there are certainly gender differences in time use for household productive activities. This is illustrated in Figure 2, which shows the average hours of work per week spent on household chores and farming for men and women, girls and boys. Both men and boys spend slightly more time on farm work than women or girls, and significantly less on household chores. This pattern (especially in terms of household work) is common in developing countries, and suggests that girls would be more likely to substitute for the labor of their mother if the latter became ill or died, while boys would be more likely to substitute for their fathers. In other words, internal household labor markets tend to be at least partially segmented by gender.[9]

It is easy to see how this can lead to differential impacts of paternal and maternal health or mortality shocks on the household's demand for children's labor. First, however, note that there must be labor market rigidities preventing

[9] We should point out that gender based labor segmentation within the household does not imply anything about whether there are constraints on hiring outside labor. Gender based segmentation will not lead to dropout or differential dropout by gender unless there are also labor market imperfections as just defined.

the household from hiring outside labor in order for gender segmentation to have an effect on the education decision. First, consider the extreme case where there is no substitutability at all between male and female labor, and no possibility of hiring outside labor. Then if the father fell ill and reduced his labor supply, the only source of substitute labor will be from boys, so the likelihood of dropout will rise for boys but not girls. This will be the case even if there are no credit constraints. The converse would take place if the mother got sick. We can model the more general case of non-zero but imperfect substitutability across gender by assuming that additional costs are attached to boys' labor in the household's 'female labor market', and to girls' labor in the household's 'male labor market'. Referring to Figure 1, with imperfect substitutability by gender B_t would be higher for boys in the female labor market, but unchanged in the male labor market. Conversely, girls would have a higher value of B_t in the male labor market. In this case, a shock that reduces the mother's labor supply would be less likely to cause dropout for a boy than for a girl, other things equal. Note that imperfect substitutability by gender will only have an effect on school attendance if there are *also* labor market imperfections that preclude the family from hiring outside labor at a wage below B_t. Otherwise school attendance will not be affected (as in Figure 1a). In summary, shocks to mother's and father's labor supply will only precipitate different responses for boys and girls if labor market rigidities exist, and provided there is imperfect substitutability in household labor across gender.

Under the assumption that there is imperfect substitutability of household labor by gender, our prediction of differential responses to shocks for boys and girls means we can to some extent distinguish empirically between labor market and credit market rigidities. Table 1 summarizes the predicted effects for the four different cases. In the case of perfect credit markets and no labor market imperfections, B_t will be unchanged for boys and girls following a shock, so school attendance will not be affected for either sex (Case 1). If there are labor market rigidities but no credit constraints, shocks to the mother's labor supply will have a greater effect on girls' attendance than on boys', while shocks to the father's labor supply will more strongly affect boys (Case 2). In the presence of credit constraints, shocks will affect both boys and girls by reducing B_t (Cases 3 and 4). When there are also labor market rigidities (Case 4), the shock will have a greater effect on the child of the same sex as the parent experiencing the shock. However, since this is also what we observe for Case 2 (labor market constraints but no credit constraints), we cannot distinguish Cases 2 and 4 empirically. In sum, by comparing the schooling responses of sons and daughters to parental labor supply shocks we can identify situations where there are no binding constraints in either credit or labor markets (Case 1); there are credit market but not labor market constraints (Case 3); or there are labor market constraints (with or without credit constraints, Cases 2 and 4). When there are labor market constraints, we cannot say whether credit constraints are also operative.[10] We test for these cases in Section 4 by interacting the gender of

[10] It could be argued that rather than reflecting labor market imperfections, Cases 2 and 4 could represent differential income effects of the shock; indeed, a number of studies indicate higher income elasticities for girls' education (Glick 2008). However, in that case the difference between boys and

the child with mother's and father's illness and health shocks. Evidence of gender differences would support the hypothesis that labor market rigidities play a role in causing children to drop out of school in response to a shock. By extension (though not directly testable), we might also expect such rigidities to reduce schooling investments overall, not just in response to a health shock. In the case of labor market constraints, for example, the household would be unable to substitute for the child's domestic or enterprise labor to enable the child to enroll or stay in school longer.

3. Econometric Framework

One innovation of our paper is that we employ a discrete hazard model to capture school entry and dropout decisions as a function of time-varying negative and positive shocks. This is possible because our data provide annual observations, over a ten-year period, on children's school attendance and household-level shocks. The hazard model allows the annual school attendance decision to be modeled as a discrete choice based on shocks and other characteristics.

In the previous section we described the optimal schooling choice in year t as a function of income, child characteristics, the child's potential wage and the long-term benefit to the family of the child's education. Let us first consider the dropout decision and describe how we model it. A necessary condition for a child to drop out at time t, having attended school at time $t-1$, is the following:[11]

$$\beta U'(C_t^*)\frac{W_t+\pi_t}{f_S(0,\alpha_t)} \geq U'(C_{t-1}^*)\frac{W_{t-1}+\pi_{t-1}}{f_S(S_{t-1}^*,\alpha_{t-1})}. \qquad (6)$$

This condition translates directly into a hazard model of dropout conditional on attendance in the previous year, where the transition probability is:

$$\Pr(S_t^* = 0|S_{t-1}^* > 0) = \Pr\left[\beta U'(C_t^*)\frac{W_t+\pi_t}{f_S(0,\alpha_t)} \geq U'(C_{t-1}^*)\frac{W_{t-1}+\pi_{t-1}}{f_S(S_{t-1}^*,\alpha_{t-1})}\right].$$

If we assume for illustrative purposes that $U(C_t) = \ln(C_t)$, then we obtain:

$$\Pr(S_t^* = 0|S_{t-1}^* > 0) = \Pr\left[\ln\left(\frac{C_t^*}{C_{t-1}^*}\right) \leq \ln\beta + \ln\left(\frac{W_t+\pi_t}{W_{t-1}+\pi_{t-1}}\right) - \ln\left(\frac{f_S(0,\alpha_t)}{f_S(S_{t-1}^*,\alpha_{t-1})}\right)\right].$$

The probability of dropout conditional on previous enrollment is a non-linear function of the change in household consumption, the child's wage, the price of schooling and the return to schooling. The return to schooling in turn depends on other characteristics, α, which might include child ability and school quality. If the household does not have perfect access to credit, so that shocks to income cannot be fully smoothed, the change in consumption will be affected by these shocks.

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girls would be the same for mother's and father's shocks. In contrast, this model predicts that the attendance responses will differ based on the gender of the afflicted parent.

[11] For a proof, see the Appendix.

The school entry decision is analogous. From Equation 6, we can derive a hazard function:

$$\Pr(S_t^* > 0 | S_{t-1}^* = 0) = \Pr\left[\beta U'(C_t^*)\frac{W_t+\pi_t}{f_S(S_t^*,\alpha_t)} \leq U'(C_{t-1}^*)\frac{W_{t-1}+\pi_{t-1}}{f_S(0,\alpha_{t-1})}\right],$$

and assuming logarithmic utility, will obtain

$$\Pr(S_t^* > 0 | S_{t-1}^* = 0) = \Pr\left[\ln\left(\frac{C_t^*}{C_{t-1}^*}\right) \geq \ln\beta + \ln\left(\frac{W_t+\pi_t}{W_{t-1}+\pi_{t-1}}\right) - \ln\left(\frac{f_S(S_t^*,\alpha_t)}{f_S(0,\alpha_{t-1})}\right)\right].$$

The determinants of the school entry decision are therefore almost identical to those for dropout, but have the opposite effect. So we expect negative income shocks to reduce the probability of enrollment, while lower school costs and higher household wealth should increase it.

For child *i* in household *h*, we specify the transition probability as a function of individual child characteristics, X_{ih}; household characteristics (including wealth and household composition), Z_h; and a vector of shocks hitting the household in period t, Ω_{ht}. We included current as well as lagged values of the shocks (in the prior two years), to capture lags in adjustment or cumulative impacts, as well as to deal with possible recall errors in the precise year of specific events (the shocks or school dropout/entry), which would lead to a mismatch of the timing of the outcome and the events.[12] The shocks in Ω may have both price (shadow wage) and income effects; that is, the coefficients on shocks incorporate unanticipated changes in income, Y_t, and in the child's wage, W_t., We also include controls for age, λ_a, and years in school, ν_g.

For the dropout model, we specify the transition probability as a logit function with the following form:

$$\Pr(S_t^* = 0 | S_{t-1}^* > 0) = \Lambda\left[\alpha + X_{iht}\beta + Z_{ht}\gamma + \Omega_{ht}\delta + \lambda_a'\theta + \nu_g'\pi + \eta_{iht}\right],$$

where $\Lambda(z) = \frac{\exp(z)}{1+\exp(z)}$. We use a panel logit specification with child-specific random effects to control for unobserved time-invariant individual heterogeneity (the α variables in the theoretical model).[13] In the dropout models, each observation is one child year for a child attending school between 1995 and 2004. For example, if a certain child attended school for five years during this period, there would be five observations for that child. Including child random effects links these observations over time by a common heterogeneity component.

We estimate the model using conditional maximum likelihood, as described in Chamberlain (1983). This amounts to estimating a logit model of the

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[12] We also experimented with one-year leads and lags; the results were not substantially different.

[13] We also tried estimating a simple logit specification (with no random effects) and a model with household random effects. Results are available from the authors on request.

decision to drop out in a given period conditional on being enrolled at the start of the period—that is, a discrete-time hazard model. The dependent variable is an indicator taking the value one if the child dropped out of school in that year, and zero otherwise. The baseline hazard is captured by dummy variables representing years at risk—in this case, years in school since 1995. The enrollment model takes essentially the same form, except that the baseline hazard of years at risk refers to years since age 6 that the child has not yet enrolled and hence is 'at risk' of enrolling.

The explanatory variables of primary interest are the contemporaneous and lagged indicators of shocks reported by the household. We include shocks involving the health of the mother and father (death and illness), prolonged unemployment of the father or household head, income shocks (year or season of significantly lower or higher than normal business income or crop loss), and asset shocks (loss of livestock or land).

The models also include a household wealth index, constructed from various household assets using factor analysis along the lines of Sahn and Stifel (2003), and mother's and father's years of education. The latter may capture parental tastes for schooling, income effects, and effects through the human capital production function (e.g., better educated parents may be better able to assist their children with schoolwork). We also include the number of younger and older siblings by sex in an additional model. We do so despite acknowledging that the number of siblings is in part a function of household preferences for the quality and quantity of children. Nonetheless, the question of whether the presence of younger siblings contributes to earlier school withdrawal, and conversely for older siblings, and how these effects differ by gender, provides interesting insights in terms of these relationships, even if we cannot draw causal inferences from it.

The models also include a number of community characteristics: a dummy for being in an urban community, the distance to the nearest school, whether piped water and electricity are available to at least some residents, and the presence of a lower and/or upper secondary school in the community. We include the following school characteristics for the nearest primary school in the cluster: the average years of experience of the teachers, the proportion of classrooms with blackboards, and indicators for whether the school is private, part-time or has separated classes by grade. We also have information on whether the school participated in the Secaline nutrition program in year t (derived using information on date of initiation). Secaline provides school-based iron/folate supplementation, deworming and other school based nutrition related activities, and was created in part to boost primary school enrollments. We note that, given the non-experimental nature of the data, we are not able to control for potential endogeneity of placement of either the school or Secaline variables. That is, these variables may be correlated with the errors of the equations if there are unobserved factors affecting both program placement and the schooling outcomes, leading to bias in the estimates.

As indicated, we specify random effects for the child, allowing unmeasured determinants of schooling behavior (dropout or entry) to be correlated across time for multiple observations per child. By specifying dummy variables for age and years of schooling, we allow the baseline hazard to take a nonlinear form. We also test for the presence of labor market versus credit constraints by including interactions between the parental shock variables and the gender of the child.

4. Data

The data come from the Etude sur la Progression Scolaire et la Performance Academique en Madagascar (EPSPAM), a household and school-level survey conducted in 2004-5 covering 73 rural and urban communities in Madagascar. The survey consisted of 2,100 households, for each of which we have detailed data on the characteristics of household members, including educational attainment, health and employment, as well as household level data on housing, assets and other factors. Although the survey covered all the regions in Madagascar, it was not strictly nationally representative of all children in Madagascar. The reason is that the sample design involved returning to 48 communities from a larger education study, the 1998 PASEC (Programme d'Analyse des Systemes Educatifs de la CONFEMEN), conducted in 1998 in 120 clusters defined by the catchment areas of primary schools in which scholastic aptitude tests took place. While our sample was selected randomly from these clusters, the original PASEC communities themselves were randomly selected from schools with at least 20 students in both the 2nd and 5th grades; given schools are typically small in rural areas, the rural PASEC clusters thus tended to be larger-than-average communities. To partially address this issue, the 2004 survey supplemented the 48 PASEC clusters with an additional 12 clusters randomly selected from rural communities with small primary schools. 'Small' was defined as a school having fewer students than the national median of about 140. These additional schools were randomly selected from the list of schools in the education ministry database after stratifying on province.

In addition to the household-level data, the survey collected community and school-level data on the nature and characteristics of existing infrastructure. In total, 140 schools were interviewed in the 73 clusters (i.e., communities) where the survey was conducted. Information was gathered on the experience and credentials of the principal and management of the school, as well as the number of teachers, their qualifications, and pedagogical practices, and building and classroom conditions. These school characteristics are used as control variables in the analysis that follows; as noted, we use information on the nearest primary school for all children in a given community.

The survey took considerable care in measuring shocks using retrospective recall. The survey asked if each parent was living, and if not, asked for the year of death. With respect to illness shocks, all individuals were asked about any illnesses suffered in the previous ten years (1995-2004) that lasted more than a month and significantly impacted their ability to conduct their normal activities.[14] While the problem with self-reported illness is well documented, the focus on functional implications mitigates to some extent the somewhat arbitrary nature of self-reports. Respondents were asked to report spells of unemployment lasting at least one month, including the date of job loss and its duration. The date of the job loss was used to define the initial year of the unemployment shock for spells lasting more than one year. Questions were also asked about unanticipated losses of crops, livestock and land, and about years in which non-farm revenues were well below or well above average.

We restrict our sample for the dropout model to children aged between 10 and 17 in 2004, who were in school at age 10. Even though late entry is common in Madagascar, almost all children who eventually attend school have enrolled by age 10, so this restriction minimizes the risk of censoring the date of entry for some students. Similarly, 94 percent of the children in our sample had completed or dropped out of school by age 17. While we could have extended the age range beyond 17, many children leave home after age 18, introducing sample censoring that would likely not be random. Overall, our sample for the dropout model comprises 4,109 children. However, given that a child enters as one observation for each year they spent in school over the ten-year reference period, the sample contains a total of 28,264 child-year observations. For the enrollment model, all children aged 6 or above, and not in school, during the period 1995-2004 are included in the sample. The sample for that model contains 8,385 child-year observations.

Table 2 presents summary statistics for the variables of interest. Almost 13 percent of children in the sample had dropped out of school; this is the average of the low share of dropouts for younger children (just 1 percent for 10-year-olds) and much higher rates for older children (39 percent for 17-year-olds). Among those households with children aged 5 to 25 in 2004, the incidence of parental death during the previous ten years was 2.0 percent for mothers and 4.3 percent for fathers; the incidence of serious illness among parents was also fairly uncommon, which is not unexpected since the measure only captures debilitating illnesses. The variable 'income shock' takes the value 1 if the household experienced lower-than-expected crop or business income for the year. This is by far the most frequent shock reported. 'Asset shocks', which takes the value 1 if the household lost livestock or land during the period, is less frequent. Over the ten-year reference period, 35.5 percent of the children attended a school with the Secaline program. The dates of introduction (and in some cases, removal) of this program varied across children, however. Figure 3 shows the initial enrollment and dropout rates by age for the children in the sample. Almost all children enrolled between 6 and 8 years of age, with nearly half of the children enrolling as six-year-olds. Only around 5 percent of children began school after age 8. As expected, the distribution of dropouts is much less concentrated. The modal age of dropout is at 13.5 for boys and 13 for girls. Only 1.6 percent of children dropped out after age 18. Many of these late dropouts started school at a later age and/or repeated grades.

[14] A concern with recall data is that more recent events are likely to be better remembered, leading to underreporting of earlier shocks. This is apparently the case with our data, as suggested by the lower number of shocks reported in earlier years, particularly 1995 through 1999.

5. Results

The results of the hazard model estimation are presented in Table 3 for dropout and Table 4 for school entry. We estimated a simple logit model as well as household-level and child-level random effects models. Since the coefficient estimates from these three specifications are very similar, and have roughly the same levels of significance, we present only the results for the child-level random effects model, our preferred specification.

Impacts of Health and Economic Shocks

We find significant effects on the probability of dropout for a number of negative household events. The death of a child's mother or father significantly raises the probability of them dropping out in the following year. Father's death also has a lagged effect; that is, deaths occurring at time *t*-2 or *t*-1 increase the chance of dropout at time *t*. The magnitude of the lagged effect is around one half that of the contemporaneous effect. The impacts of paternal and maternal death on dropout are roughly similar; even though the coefficient on father's death is slightly larger, the coefficients are not significantly different.

The effect of father's and mother's illness on dropout are also strongly significant and of similar magnitude to the death shocks. Unlike the death shock, however, illness does not have a lagged effect on dropout. This presumably reflects that such shocks are reasonably short-term, and have no ongoing effect on school attendance once the parent's health improves.

Unemployment and asset shocks both have a lagged positive effect on the probability of dropout. However, income shocks, which were defined in terms of a bad harvest or an unexpected decline in household revenue, do not have any impact on leaving school. The lack of significance of the income shock variable may be due to the subjective nature of the question, in part because defining a bad revenue year relative to normal is more subjective than say, defining a debilitating illness. It is also possible, however, that households make efforts to compensate for temporary income shocks and are initially reluctant to pull children out of school in the face of adversity. Loss of assets may have a more serious and long-term effect on household income, and consequently a greater impact on schooling.[15]

In contrast to dropout, we find little impact of shocks on the enrollment decision. The exception is father's illness, which appears to induce children to enroll in school earlier. At first glance, this result (essentially the opposite of the corresponding result for dropout) seems counter-intuitive. Note, however, that young children are unlikely to be effective substitutes for an adult worker who falls ill. On the contrary, they are more likely to be a net burden on others in the household, in terms of care and supervision. A sick father might also require care and attention from

[15] It is interesting to note that it is the lagged rather than contemporaneous asset shocks that are significantly associated with dropout in time *t*. While this could simply reflect imprecisions in the timing of events as discussed earlier, it may also suggest that households initially attempt to avoid withdrawing a child from school (or before completing a grade) when a loss of assets occurs.

the mother or other adults in the household, in which case parents may be induced to send their child to school in order to have more time to care for the invalid.

We present the marginal effects of the shocks (or, more precisely, changes in probabilities) in Table 5, in order to convey the economic significance of the results. For the dropout model, we present the marginal effects for children aged 14 to 16, while for the enrollment model the marginal effects are presented for children aged 6 to 8. The marginal effects of the shocks are calculated holding other covariates constant at their sample means. The death of a 15-year-old child's mother raises the probability of her dropping out of school in the next year by 10.4 percentage points. Similarly, the death of a 15-year-old's father raises the probability of dropout by 15.8 percentage points in the subsequent year. But that is not the entire effect, given the statistically significant coefficient on lagged parental death in the hazard model. The likelihood of dropout in the second year following the shock rises by 5.4 and 2.9 percentage points, respectively, in response to a father's and mother's death. Illness among parents also has a large impact on the likelihood of dropout. Among 15-year-olds, for example, a child is 13.1 percentage points more likely to drop out if her father has a prolonged illness that interferes with work and other normal activities. The comparable number for the mother is 14.8 percentage points. We do not find a statistically significant contemporaneous impact of parental job loss, but the lagged shock raises the likelihood of dropout by 4.3 percentage points.

As discussed previously, the only significant shock in the enrollment model is illness of the father. For a 7-year-old, such a shock raises the conditional probability of enrollment by 19 percentage points. This large effect may be in part explained by the mother and others normally engaged in child care having greater demands on their time caring for a sick spouse. Sending a child to school therefore becomes a way a reducing the childcare burdens in the household.

Community and School Characteristics

Several community characteristics are included in the models. The presence in the nearest primary school of the health and nutrition program Secaline, which as noted is time indexed using information on the year of its introduction, has a significant and negative effect on the probability of dropping out of school (Table 3). The presence of Secaline also leads to earlier school entry (Table 4). Presumably, parents are responding to the additional incentive of access to a free health and nutrition program at the school. Despite the statistically significant parameters, the marginal effects suggest that the size of the influence of Secaline on the dropout decision is not large. For example, having Secaline in a child's school reduces her probability of dropout is cumulatively eight percentage points over the three years from age 14 to age 16. The impact on school enrollments is more substantial, however. For example, among six-year-olds, the presence of Secaline increases the probability of school enrollment by 6.22 percentage points. The program thus seems to act as a strong incentive for school entry. One possible explanation for the smaller effect of Secaline on dropout is that children dropping out are doing so for significant reasons (such as negative shocks, or low scholastic ability), which might outweigh the benefits of the program in their decision process.

We also examined the impact of other community covariates, including the presence of a lower and/or upper secondary school in the community. This also appears to encourage earlier enrollment and discourage dropout. Again focusing on the impact on 15-year-olds, the presence of a secondary school will reduce the probability of dropout by 4.1 percentage points, and have a similar impact of the probability of enrollment among children between 6 and 8 years of age. These results are plausible in that having an easily accessible secondary school would encourage children to continue their schooling beyond primary level (Appleton, Hoddinott and Knight, 1996) and thereby increase the expected duration of schooling at the time of enrollment. For both the Secaline and presence of secondary school results, however, we should note that unmeasured community level heterogeneity may influence both placement as well the outcomes; hence these results need to be interpreted with caution.

In a similar vein, we included a variable capturing whether or not there was a private school alternative in the cluster. The presence of such an institution is associated with both earlier school entry and later dropout, although the impact is somewhat smaller than the presence of a secondary school. Interpreted causally (though subject to similar caveats as just expressed for other community covariates), this points to the benefits of having more—and possibly better—school options. In combination, these community and policy factors (existence of a secondary school, private school alternative, and Secaline) are associated with an increase of over 13 percentage points in the probability of school entry each year from age 6, in addition to the baseline probability of 38 percent.

We also included two other control variables for the general level of infrastructure: whether or not the community had electricity and piped water. Neither variable was significant in any of the dropout or school entry models.

To capture the effect of school quality, our models included a range of characteristics of the closest primary school, including information on the experience and education of the principal and teacher, the proportion of classrooms with blackboards, whether the school had part-time classes, whether there were separate toilets for boys and girls, and an interaction of separate toilets with the gender of the student. By and large these school variables have little or no impact on either school entry or dropout. This is perhaps surprising, but may reflect the fact that we include characteristics of the nearest primary school, which is not necessarily the one attended by the child (including the latter would clearly imply endogeneity issues). We do find large regional and district level effects on the probability of enrollment, but not on dropout. In particular, living in a rural area is associated with a higher probability of enrolling in school earlier, a somewhat unexpected finding.

Household Characteristics

We included a range of household characteristics in the models. As expected, parents' education (both mother’s and father’s) is positively related to earlier enrollment and negatively related to dropout, in accord with standard findings in the literature. The magnitude of the marginal effects is relatively large for the enrollment decision: each additional year of education of the mother raises the probability of the child starting school by 1.5 percent among six-year-olds. So, for example, a child whose mother has completed primary school is more than 15 percentage points more likely to enter school at age six than if the mother has no education. This important effect contrasts with the dropout models where the marginal effects of education are smaller. Over the three-year period from age 14 to 16, a mother's having completed primary school reduces the probability of her child dropping out by a modest 6.7 percentage points.

Like parental education, household assets are positively related to early enrollment and reduce the probability of dropping out. These effects are consistent with education being a normal good. Associations between schooling and wealth (or income) are also frequently interpreted as evidence of credit constraints, since such constraints are more likely be binding on poorer households with fewer assets (Jacoby 1994, Jacoby and Skoufias 1997). We interacted assets with the shock variables to see if households with more assets are better able to cope with shocks and less likely to take their children out of school. None of these interactions were significant.

We also run a set of models that include covariates on the number of older and younger siblings, differentiated by gender, and report the coefficients in Table 6. We do so being cognizant of the issues of parental preferences influencing the number of children and investments in their human capital. Thus, we advise caution in examining these results as they cannot be interpreted causally. The results suggest that there are large and significant sibling effects. The presence of older brothers and sisters in the household is associated with a reduced probability of dropping out. This effect is approximately twice as large for older brothers than older sisters. In contrast, the presence of younger siblings increases the probability of dropping out. One plausible explanation for the latter is that the presence of younger siblings increases the demand for childcare, for which schoolchildren may be suitable. In contrast, older siblings may already be providing the needed labor for home production and family enterprises. The enrollment models tell a similar story, with the presence of older siblings contributing to earlier school entry, while the opposite is the case for the presence of younger siblings.

Individual Characteristics

The gender of the child does not appear to impact the age at enrollment, but the dropout model indicates that conditional on having attended school at time t-1, girls are more likely to withdraw from school at time t. While the latter finding is consistent with evidence from many other developing countries of gender disparities in education in favor of boys, it is somewhat unexpected here given that Madagascar generally does not display serious gender inequality in education.

Finally, we tried exploring several other nonlinearities, including interacting age with shocks in the dropout model, in order to see whether older children were more or less likely to drop out following a shock. We found no significant relationships at the 10 percent level.

Credit or Labor Market Imperfections?

As discussed in Section 2, it is possible with our data to (partially) distinguish credit as opposed to labor market constraints as a reason for dropout in response to negative shocks, by interacting illness or death shocks for each parent with the gender of the child. As noted, given imperfect substitutability across gender in productive activities such that it is easier for girls to substitute for mothers and boys for fathers, we would expect, give imperfect markets for hired labor, to find a stronger response of girls' schooling to maternal shocks and a stronger response of boy's schooling to paternal shocks. In contrast, no such differences would be observed if credit constraints alone were responsible for the connection between schooling decisions and transitory shocks.

To test this hypothesis, we re-estimated the models including interactions of the shock variables with the gender of the child. The results (presented in Table 7) indicate that for both mother's and father's illness and death events, there are no significant differences in the (positive) responses of boys and girls dropout to the shocks. This suggests that labor market rigidities are not a significant factor in conditioning responses to parental shocks, but that credit constraints are a factor (since the shocks do induce dropout for both girls and boys). These results, in other words, are consistent with Case 3 in Table 1. To the extent that these findings demonstrate the presence of significant credit market failures, they imply that school attainment in general, not just the response to income shocks, may also be constrained by lack of access to credit (and not by labor market imperfections).

6. Conclusion

In this paper we estimated hazard models for school enrollment and dropout in Madagascar using an unusually rich dataset with information on educational attainment and retrospective data on economic and health shocks experienced by households. We find that negative shocks generally do precipitate withdrawal from school: the hazard of dropout increases in response to parental death, illness and unemployment, and to asset shocks including loss of livestock or land. Age at school entry appears generally to be less affected by such events, likely reflecting the fact that young children have little to contribute to household income or production to compensate for negative shocks to household resources, and possibly that the direct costs of schooling in the initial primary years are relatively small. On the other hand, we find that community and school characteristics, such as the presence of health and nutrition programs in school, the existence of private school alternatives and secondary schools in the community, have more significant impacts on the decision of whether to enroll a child than on older children's school withdrawal. Among other factors, higher parental education and household wealth increase the duration of schooling.

We also developed a straightforward test for distinguishing the relative importance of credit market and labor market imperfections as constraints on schooling, where labor market imperfections refer to difficulties in hiring outside labor for family enterprises or home production. We find that the likelihood of girls and boys dropping out of school in response to a parent's illness or death shock is similar in size, suggesting that labor market imperfections are not a binding constraint on households' schooling investments, but rather, that credit constraints are likely the major factor. The test should be regarded as suggestive. It does not directly show that credit constraints affect schooling, only that labor market imperfections do not seem to play a role. Still, both results, as well as the negative association of early school leaving and household wealth, are consistent with the presence of binding credit constraints on the education investment decisions of households.

The results of this study contribute to existing evidence that households in developing countries use their children as a risk-coping mechanism, pulling them out of school in response to large negative idiosyncratic shocks. Early dropout can have permanent impacts on human capital and earnings capacity, potentially creating an intergenerational poverty trap. Policies that assist households to smooth income in times of stress—as well as providing credit to allow households to make long-term investments in education—may lead to higher rates of school attendance and educational attainment and increased welfare in the long run.

Appendix

Derivation of Equation 4

At an interior solution the optimal level of school attendance S_t^* satisfies the first-order necessary condition:

$$U'(C_t^*)(W_t + \pi_t) = \beta^{T-t} E_t \left[\phi_H(H_{T+1}, A_{T+1}) \frac{\partial H_{T+1}}{\partial S_t} |_{S_t = S_t^*}\right], \quad \text{(A1)}$$

where $\phi_H(H_{T+1}, A_{T+1})$ is the partial derivative of ϕ with respect to H_{T+1}, and C_t^* is the optimum level of consumption given S_t^*. Applying the chain rule, we can write

$$\begin{aligned} & E_t \left[\phi_H(H_{T+1}, A_{T+1}) \frac{\partial H_{T+1}}{\partial S_t} |_{S_t = S_t^*}\right] \\ & = E_t \left[\phi_H(H_{T+1}, A_{T+1}) \frac{\partial H_{T+1}}{\partial H_T} \cdots \frac{\partial H_{t+2}}{\partial H_{t+1}} \frac{\partial H_{t+1}}{\partial S_t} |_{S_t = S_t^*}\right] \\ & = E_t \left[\phi_H(H_{T+1}, A_{T+1}) \frac{\partial H_{t+1}}{\partial S_t} |_{S_t = S_t^*}\right] \text{ since } \frac{\partial H_{T+1}}{\partial H_T} \cdots \frac{\partial H_{t+2}}{\partial H_{t+1}} = 1 \\ & = E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(S_t^*, \alpha_t), \end{aligned}$$

where f_S is the partial derivative of f with respect to S. Therefore, (A1) becomes

$$U'(C_t^*)(W_t + \pi_t) = \beta^{T-t} E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(S_t^*, \alpha_t) \text{ for } S_t^* \in (0,1). \quad \square$$

Proof of claim that $\frac{\partial S_t^*}{\partial Y_t} > 0$

Taking the partial derivative of both sides of Equation 5 with respect to Y_t and rearranging yields

$$\frac{\partial S_t^*}{\partial Y_t} = \frac{U''(C_t)(W_t + \pi_t)}{\beta^{T-t} E_t[\phi_{HH}(H_{T+1}, 0) f_S(S_t, \alpha_t)^2 + \phi_H(H_{T+1}, 0) f_{SS}(S_t, \alpha_t)] + U''(C_t)(W_t + \pi_t)^2}$$

where ϕ_{HH} is the second partial derivative of ϕ with respect to H, and f_{SS} is the second derivative of f with respect to S. By the strict concavity of U and ϕ, and since $f_{SS} = 0$, both numerator and denominator of the right hand side are negative and therefore the quotient is positive. $\square$

Derivation of Equation 6

For the child to have attended in period $t - 1$ and drop out at t, it must be the case that

$$U'(C_t^*)(W_t + \pi_t) \geq \beta^{T-t} E_t[\phi_H(H_{T+1}, A_{T+1})] f_S(0, \alpha_t) \quad \text{(A2)}$$

And

$$U'(C_{t-1}^*)(W_{t-1} + \pi_{t-1}) \leq \beta^{T-t+1} E_{t-1}[\phi_H(H_{T+1}, A_{T+1})] f_S(S_{t-1}^*, \alpha_{t-1}) \quad \text{(A3)}$$

where S_{t-1}^* is the level of attendance in period $t - 1$, and C_{t-1}^* is the corresponding level of consumption. Equations A2 and A3 derive from the first-order condition (4), substituting $S_t^* = 0$ and $S_{t-1}^* > 0$. For dropout to be optimal at t, the marginal utility of increasing S_t^* above zero must be negative (A2). The inequality in (A3) comes from the possibility of a corner solution at $S_{t-1}^* = 1$, in which case the household would prefer more than one unit of schooling in period $t - 1$.

Since the child is dropping out of school, the expected value of H_{T+1} will have either stayed the same or fallen from $t - 1$ to t, so that $E_t[\phi_H(H_{T+1}, A_{T+1})] \geq E_{t-1}[\phi_H(H_{T+1}, A_{T+1})]$ by the concavity of ϕ. Applying this result to (A2) and (A3) and rearranging, we obtain the following necessary condition for dropout in period t:

$$\beta U'(C_t^*) \frac{W_t + \pi_t}{f_S(0, \alpha_t)} \geq U'(C_{t-1}^*) \frac{W_{t-1} + \pi_{t-1}}{f_S(S_{t-1}^*, \alpha_{t-1})}$$

Note that if we allow for breakpoints in ϕ, such as at the completion of high school, then it is possible that the previously-planned final stock of human capital, $E_{t-1}(H_{T+1})$, is just above such a breakpoint and the stock in the event of dropout is just below. In such a case, $E_t[\phi_H(H_{T+1}, A_{T+1})]$ could be much larger than $E_{t-1}[\phi_H(H_{T+1}, A_{T+1})]$, so the left-hand side of Equation 6 would need to be substantially higher than the right-hand side in order for the child to drop out rather than stay in school and graduate. In such situations, the household would be prepared to absorb much larger shocks to consumption before making the sacrifice of taking their child out of school.

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Table 1. Effects of parental health or mortality shocks on schooling, by market rigidity

		Credit market constraints	
		No	Yes
Labor market rigidities	No	1. No effect of mother's or father's shock on boys or girls	3. Equal effects of mother's and father's shocks on boys and girls
	Yes	2. Father's shock has a greater effect on boys, mother's shock a greater effect on girls	4. Father's shock has a greater effect on boys, mother's shock a greater effect on girls

Table 2. Summary Statistics

	Dropout Sample					Enrollment Sample				
Variable	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Dropped out / Enrolled	4109	0.128	0.334	0	1	3511	0.900	0.300	0	1
Demographic variables										
Male	4109	0.481	0.500	0	1	3511	0.493	0.500	0	1
Mother yrs education	4110	4.654	3.522	0	17	3512	4.370	3.467	0	17
Father yrs education	4110	5.412	3.864	0	17	3512	5.164	3.828	0	17
Asset index	4109	0.046	0.948	-0.69	4.18	3511	-0.061	0.855	-0.69	4.14
Older brothers	3947	0.857	1.054	0	7	3511	1.204	1.197	0	8
Older sisters	3947	0.747	0.915	0	5	3511	1.198	1.128	0	7
Younger brothers	3947	0.921	0.959	0	7	3511	0.441	0.671	0	5
Younger sisters	3947	0.935	0.976	0	7	3511	0.430	0.665	0	5
Shock variables										
Mother died	4109	0.020	0.142	0	1	3511	0.008	0.087	0	1
Father died	4109	0.043	0.203	0	1	3511	0.016	0.125	0	1
Mother sick	4109	0.012	0.107	0	1	3511	0.003	0.056	0	1
Father sick	4109	0.021	0.143	0	1	3511	0.008	0.089	0	1
Parent lost job	4110	0.052	0.223	0	1	3511	0.017	0.130	0	1
Income shock	4109	0.282	0.450	0	1	3511	0.121	0.326	0	1
Asset shock	4109	0.056	0.230	0	1	3511	0.027	0.162	0	1
School characteristics										
Principal yrs experience	4109	11.340	8.702	0	36	3511	11.010	8.986	0	36
Principal yrs education	4109	10.881	1.878	9	18	3511	10.885	1.829	9	18
Private school	4109	0.201	0.395	0	1	3511	0.180	0.378	0	1
Part-time school	4109	0.048	0.210	0	1	3511	0.060	0.234	0	1
Separate boys/girls toilets	4109	0.379	0.485	0	1	3511	0.165	0.371	0	1
Teacher yrs experience	4109	0.727	0.265	0	1	3511	0.701	0.292	0	1
Teacher yrs education	4109	0.535	0.335	0	1	3511	0.551	0.330	0	1
Proportion of classrooms with blackboards	4109	0.954	0.174	0	1	3511	0.950	0.191	0	1
Village characteristics										
Urban	4109	0.261	0.439	0	1	3511	0.232	0.422	0	1
Secaline	4109	0.354	0.478	0	1	3511	0.259	0.438	0	1
Access to piped water	4110	0.500	0.481	0	1	3512	0.460	0.483	0	1
Access to electricity	4110	0.123	0.297	0	1	3512	0.108	0.284	0	1
Upper school in area	4110	0.820	0.358	0	1	3512	0.785	0.391	0	1
Regions										
Tana	4109	0.224	0.417	0	1	3512	0.225	0.417	0	1
Fianar	4109	0.233	0.423	0	1	3512	0.219	0.413	0	1
Toamasina	4109	0.167	0.373	0	1	3512	0.171	0.377	0	1
Mahajanga	4109	0.131	0.337	0	1	3512	0.134	0.341	0	1
Toliara	4109	0.152	0.359	0	1	3512	0.152	0.359	0	1
Antsiranana	4109	0.094	0.292	0	1	3512	0.099	0.298	0	1

Dropout sample: Children aged 10-17 in 2004 who attended school in any of the ten years 1995 to 2004.
Enrollment sample: Children aged 6-12 who had not yet enrolled in any of the ten years 1995 to 2004.

Shock statistics are the proportion of children whose households experienced the shock at least once over the 10-year reference period.

Table 3. Dropout model estimates

Variable	Coef	SE
Male	-0.303**	0.147
Mother's years education	-0.088***	0.029
Father's years education	-0.123***	0.031
Asset index	-0.410***	0.127
Secaline	-0.528***	0.156
Access to piped water	-0.165	0.142
Access to electricity	0.572	0.356
Upper school in area	-0.803***	0.213
Urban	-0.196	0.210
Mother died at t	1.287**	0.514
Mother died at t-1	0.484	0.600
Father died at t	1.519***	0.411
Father died at t-1	0.802**	0.407
Mother sick at t	1.640**	0.757
Father sick at t	1.561***	0.542
Parent lost job at t	-0.116	0.558
Parent lost job at t-1	0.671*	0.383
Income shock at t	-0.212	0.183
Income shock at t-1	0.005	0.174
Asset shock at t	0.284	0.352
Asset shock at t-1	0.962***	0.298
Principal years experience	0.009	0.009
Principal years education	0.058	0.050
Private school	-0.659***	0.237
Part-time school	0.480*	0.263
Separate toilets	0.073	0.197
Separate toilets × female	-0.102	0.239
Teacher's years experience	-0.439	0.274
Teacher's years education	-0.237	0.250
Proportion blackboards	0.615*	0.372
Observations	28,264	
Groups	4,109	

Individual-level random-effects logit model. Dependent variable: dropped out during year.

Sample includes all children enrolled in a given year, with one observation for each child enrolled in the ten years 1995 to 2004.

Includes controls for village, age and year at risk.

*** denotes significant at 1%, ** at 5% and * at 10%.

Table 4. Enrollment model estimates

Variable	Coef	SE
Male	-0.049	0.057
Mother's years education	0.063***	0.011
Father's years education	0.050***	0.009
Asset index	0.198***	0.046
Secaline	0.265***	0.075
Access to piped water	0.041	0.063
Access to electricity	-0.053	0.128
Upper school in area	0.175**	0.079
Urban	-0.195**	0.091
Mother died at t	-0.078	0.448
Mother died at t-1	0.093	0.314
Father died at t	-0.083	0.305
Father died at t-1	0.080	0.225
Mother sick at t	0.457	0.666
Father sick at t	0.978**	0.460
Parent lost job at t	0.191	0.296
Parent lost job at t-1	0.194	0.246
Income shock at t	0.151	0.105
Income shock at t-1	-0.160	0.104
Asset shock at t	0.293	0.230
Asset shock at t-1	0.291	0.186
Principal years experience	0.002	0.004
Principal years education	-0.044**	0.021
Private school	0.234**	0.091
Part-time school	-0.190	0.124
Separate toilets	0.164	0.103
Separate toilets × female	-0.005	0.138
Teacher's years experience	-0.187*	0.113
Teacher's years education	-0.078	0.104
Proportion blackboards	0.010	0.152
Observations	8,385	
Groups	3,511	

Individual-level random-effects logit model. Dependent variable: enrolled during year.

Sample includes all unenrolled children aged 6-12, with one observation for each unenrolled child in this age category for each of the ten years 1995 to 2004.

Includes controls for village, age and year at risk.

*** denotes significant at 1%, ** at 5% and * at 10%.

Table 5. Contemporaneous marginal effects of shocks and characteristics

	Enrollment model				Dropout model			
	All	Age			All	Age		
Variable	ages	6	7	8	ages	14	15	16
Mother died	-1.5	-1.8	-1.8	-1.8	2.7*	7.7*	10.4*	12.6*
Father died	-1.6	-1.9	-1.9	-1.9	3.5**	9.8**	13.1**	15.8**
Mother sick	9.1	10.6	9.7	9.6	4.0	11.2	14.8	17.7
Father sick	19.6**	21.8**	19.0***	18.6***	3.6*	10.3*	13.7*	16.5**
Parent lost job	3.8	4.5	4.2	4.2	-0.1	-0.4	-0.6	-0.7
Income shock	3.0	3.6	3.4	3.3	-0.2	-0.7	-1.0	-1.3
Asset shock	5.8	6.9	6.4	6.3	0.4	1.1	1.6	2.0
Mother's education	1.2***	1.5***	1.4***	1.4***	-0.1***	-0.3***	-0.4***	-0.6***
Father's education	1.0***	1.2***	1.1***	1.1***	-0.2***	-0.4***	-0.6***	-0.8***
Secaline	5.2***	6.2***	5.9***	5.8***	-0.6***	-1.9**	-2.7***	-3.4***
Upper school	3.4**	4.1**	3.9**	3.9**	-1.0***	-2.8***	-4.1***	-5.2***
Private school	4.6**	5.5**	5.3***	5.2***	-0.8***	-2.3***	-3.3***	-4.2**

The marginal effects are point estimates of the percentage point increase in the probability of enrollment/dropout (*over* the baseline) for children whose household suffered that shock in the current period. In calculating the marginal effects we set all other regressors to their sample averages.

*** denotes significant at 1%, ** at 5% and * at 10%.

Table 6. Coefficient estimates for sibling variables

	Enrollment model		Dropout model	
Variable	**Coef**	**SE**	**Coef**	**SE**
Older brothers	0.042	0.026	-0.360***	0.092
Older sisters	0.064**	0.029	-0.182**	0.092
Younger brothers	-0.114**	0.049	0.199***	0.068
Younger sisters	-0.110**	0.047	0.218***	0.066
Observations	8,385		28,102	
Groups	3,511		3,947	

Individual-level random-effects logit model. Dependent variable: dropped out during year.

Sample includes all children enrolled in a given year, with one observation for each child enrolled in the ten years 1995 to 2004.

Includes controls for village, age and year at risk.

*** denotes significant at 1%, ** at 5% and * at 10%.

Table 7. Coefficient estimates for gender--shock interactions

	Enrollment model		Dropout model	
Variable	Coef	SE	Coef	SE
Mother died at t	0.142	0.607	1.617***	0.598
interacted with female	-0.450	0.892	-1.090	1.038
Mother died at t-1	0.165	0.497	0.378	0.806
interacted with female	-0.114	0.640	0.072	1.142
Father died at t	0.088	0.453	1.666***	0.598
interacted with female	-0.300	0.612	-0.283	0.774
Father died at t-1	0.018	0.340	0.708	0.581
interacted with female	0.120	0.454	0.101	0.735
Mother sick at t	-16.910	2763.0	1.195	1.198
interacted with female	18.440	2763.0	0.682	1.492
Father sick at t	1.600***	0.612	1.957***	0.742
interacted with female	-1.403	0.918	-0.816	1.053
Parent lost job at t	0.385	0.371	-0.101	0.776
interacted with female	-0.383	0.634	-0.261	1.130
Parent lost job at t-1	0.101	0.327	-0.239	0.767
interacted with female	0.125	0.498	1.307	0.869
Income shock at t	0.249*	0.152	-0.003	0.251
interacted with female	-0.204	0.210	-0.407	0.360
Income shock at t-1	-0.163	0.146	0.233	0.242
interacted with female	0.016	0.206	-0.422	0.341
Asset shock at t	0.601*	0.315	-0.600	0.650
interacted with female	-0.644	0.460	1.439*	0.776
Asset shock at t-1	0.435	0.285	0.897**	0.394
interacted with female	-0.246	0.370	0.042	0.521
Observations	8,385		28,102	
Groups	3,511		3,947	

Individual-level random-effects logit model. Dependent variable: dropped out during year.

Sample includes all children enrolled in a given year, with one observation for each child enrolled in the ten years 1995 to 2004.

Includes controls for village, age and year at risk, and the school-specific variables used in Table 7 (excluded here for parsimony).

*** denotes significant at 1%, ** at 5% and * at 10%.

Figure 1. Effect of labor market rigidities

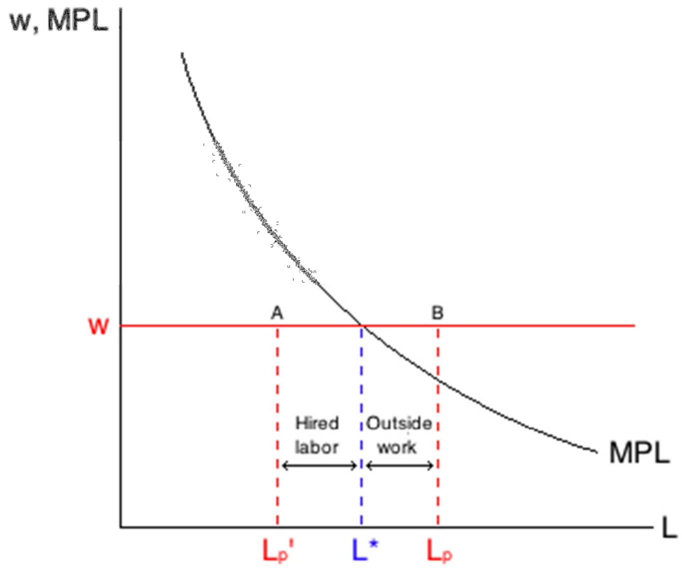


Figure 1a

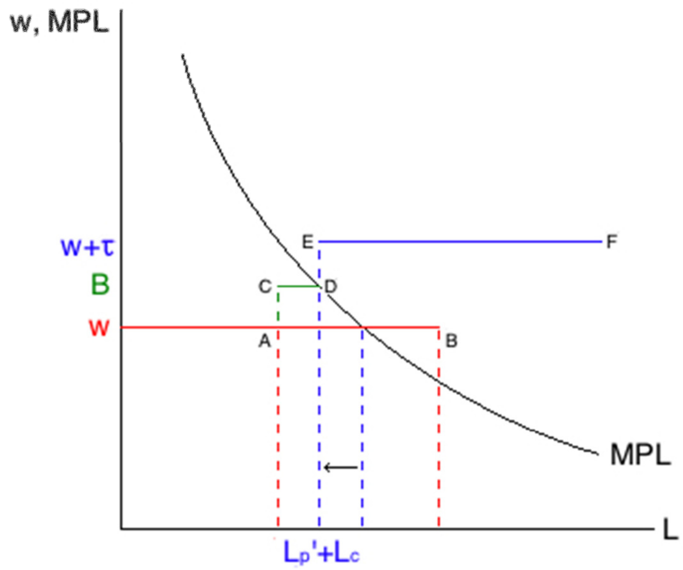
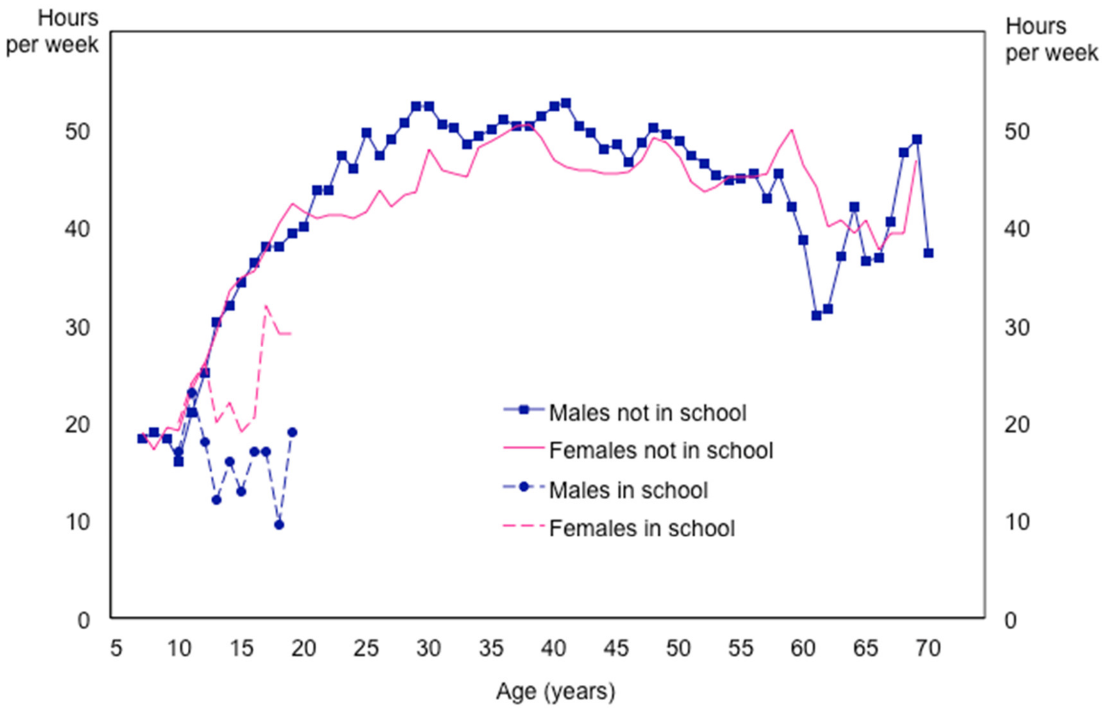


Figure 1b

Figure 2. Time use by gender and school attendance status

2a. All work



2b. Farm work

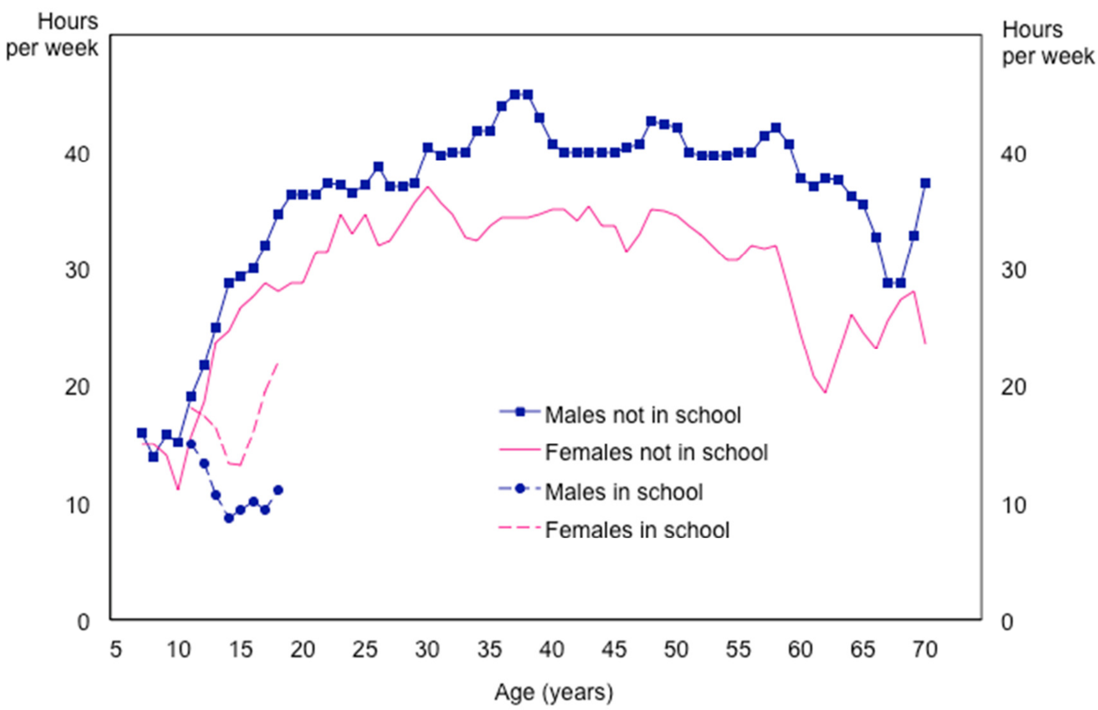


Figure 2, continued

2c. House work

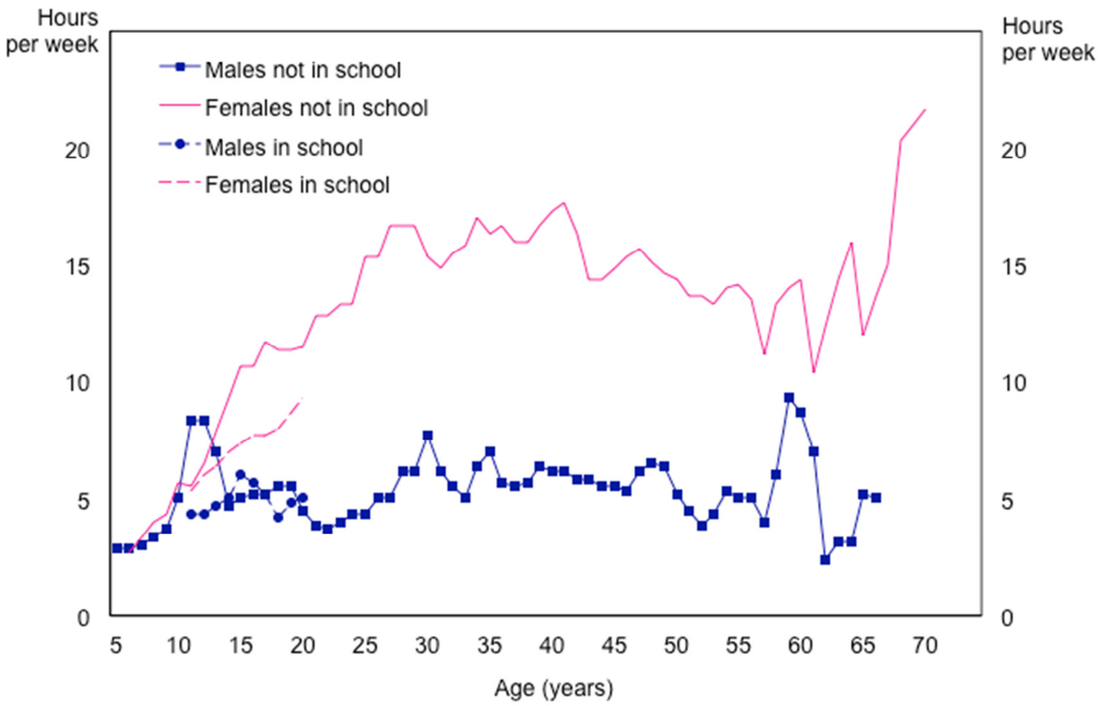
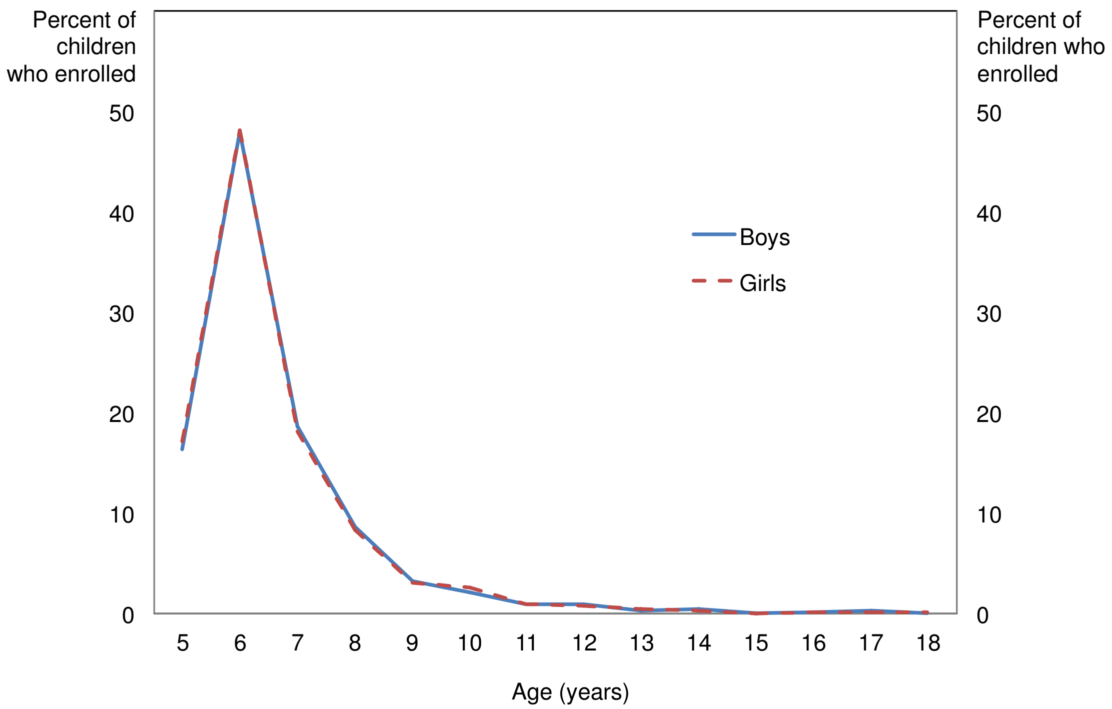


Figure 3. Conditional probabilities of school enrolment and dropout, by age

3a. Age enrolled in school



3b. Age left school