Risk and Household Structure: Another Look at the Determinants of Fertility*

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Abstract

Most households in developing countries face significant income risks but at the same time have very few means of mitigating these risks or responding to shocks. Hence, the households have to rely on self-insurance and coping mechanisms that may be suboptimal in the long run, especially for the poorest households. A household may, for example, decide to have more children in order to command more labour when replanting is needed after a natural disaster, even though this may mean a very low average consumption and lower educational attainment for the children. Despite years of analysing the determinants of fertility the effects of income risks on fertility have, however, received little attention. This paper examines the hypothesis that children can act as imperfect substitutes for insurance, by estimating the effects of the risks of various natural disasters on fertility and education using data from Guatemala. The results show that increased risk of disasters that requires command of manpower to handle increase fertility and lower the education of children, while disasters where a larger family is of little use have a negative effect on fertility.

1 Introduction

Most households in developing countries face significant risks and uncertainty in almost all aspect of daily life, from income generation to basic survival, and have often little or no access to insurance against these risks. The economies are too poor to allow for governmentally provided insurance and most private insurance companies find the returns too low to make it attractive to offer their services to the poor. This means that household have to find alternative means of insurance against declines in income and expenditure after a shock. Especially poor households are often forced to rely on methods of self-insurance that may be suboptimal in the long run. They may, for example, sell off assets, such as land or livestock, upon which their livelihoods depend, as discussed by Cain (1981) and Rosenzweig and Wolpin (1993), respectively. They may also send their children to work rather than to school as illustrated by Jacoby and Skoufias (1997) and Guarcello, Mealli, and Rosati (2002).

A potential substitute for insurance may be the structure of the household itself. It has been suggested, for example, that children may act as an imperfect substitute for insurance (Cain 1983; Pörtner 2001). The purpose of this study is to analyse the relationship between decisions on household structure, especially fertility, and risks. There are, at least, three reasons why this is important. First, we still have relatively little knowledge about how households cope with the risks they face. Secondly, most of the possible substitutes for insurance that households have access to is likely to reduce the average income substantially. This is also likely to be the case for fertility. It has often been noted that larger families tend to be more likely to be poor, which is consistent with families giving up the possibility of higher per capita consumption for a more secure, but substantially lower consumption. Hence, reducing risks may lead to higher average consumption through lower fertility. Finally, there is a well-know negative relationship between the number of children in a family and the children's education, as discussed in the survey by Schultz (1997). Hence, if there is an insurance element to the fertility decision of the household then reducing uncertainty may lead to lower fertility and hence rising human capital accumulation.

The outline of this paper is as follows. The next section reviews the literature on how household cope with a lack of access to formal insurance instruments. Section 3 discusses the theory and its implications. The estimation strategy is presented in Section 4, the data in Section 5 and Section 6 discuss the variables. Section 7 has the results for fertility, while Section 8 presents the results of estimating the effects of shocks on actual schooling outcomes. In Section 9 we estimate the effects on fertility and schooling of providing insurance against negative income shocks. Section 10 concludes with a discussion of the implications of the results and suggestions for future research.

2 Methods for Self-Insurance

This section reviews the literature on substitutes for incomplete or non-existing insurance markets.

Disruption of a household's income stream may result from disability or death of a person who provides a significant labour input or adverse weather conditions, such as flooding or drought. Furthermore, there are risk which are primarily faced by the rural population in developing countries such as depredation and patriarchal risks. Patriarchal risk is the special risks faced by women and include risk of widowhood, divorce or abandonment. Cain (1981) considers the different types of risks in more detail. Although households in developed countries and in parts of the urban areas in developing countries have ready access to insurance, either from private companies or through state-funded initiatives, poor households in the urban areas and most of the people living in the rural areas of developing countries do not. Nugent (1985) discusses why insurance companies find it unprofitable to operate in these areas.

With absent or incomplete insurance markets households need to find alternative strategies. While it is unlikely that a household will rely solely on one strategy they are presented separately here. There are five strategies: Saving, borrowing, public sector support, "traditional" systems of support and children. Cain (1981) and Nugent (1985) examine these strategies and their effectiveness in more detail.

For saving or borrowing to be a viable means of insurance a household needs a surplus in the other periods. If there is a surplus, accumulation can take place in cash, commodities, livestock or land. The first three are subject to depreciation of value, theft and costly storage, and since the duration of the adverse condition is normally unknown there is a risk of using up savings and money borrowed before conditions improve. Hence, borrowing and saving can only provide a relatively short-term relief.

Land can generate income but yields vary with the weather and do therefore not provide insurance against weather-induced risks. Furthermore, markets for land tend to be thin or nonexistent and sale of land leads to lower future income. Finally, land must be closely managed and acquiring large amounts of land means that the household must either be large or hire outside labour. Cain (1983, 1985) examines the problems associated with investing in land for security purposes. If a household relies on borrowing and uses land as collateral it faces extra hardship if it defaults on the loan since its earnings capacity will diminish. The household can also rely on the public sector, but public support varies from setting to setting and may be very unreliable or directly absent (Cain 1981).

The fourth strategy is to use the "traditional" systems of support. These include the village, the commons, and the extended family. Townsend (1994) examines whether the village as an institution can insure its inhabitants against bad weather conditions or other adverse conditions, but fails to find any strong support for the hypothesis. For both the village and the commons a high degree of co-variation in risks is likely, making it difficult to provide support when it is most needed. With respect to the extended family Rosenzweig (1988) shows that while it has little effect on the *ex post* reduction of risk, it does seems to be preferred over outside sources for help. Cain (1981) finds, however, that a large part of the distress sale of land is to closely related kin, such as a brother. Since he could buy the land, it is also likely that he would have the money to help the relative in need, but decided not to.

The final possibility is to use children as a substitute for insurance. Children can help either by working at home or as wage labour. In many less developed countries children from poor families begin to work a substantial number of hours per day from age 5-6 (Cain 1977, 1982; Dasgupta 1993, p 359). Both Jacoby and Skoufias (1997) and Guarcello, Mealli, and Rosati (2002) present evidence that parents' decisions on their children's schooling and work depends on the shocks experienced by the household. In a similar vein Beegle, Dehejia, and Gatti (2003) show that credit-constrained households in Tanzania respond to transitory income shocks by making their children work more. That children work more as a response to shocks is, of course, a necessary but not sufficient condition for children to serve as substitutes for insurance. It is worth noting that none of these papers address the issue of fertility responding to perceived risks. Beside having the younger children work more it is also possible that older children who either have their own household or have migrated can make transfers to their parents. Another possibility is that children can be used to create connections with other families, thereby forging an mutual insurance relationship. An example of this is Rosenzweig and Stark (1989), who find that daughters migrate to other villages to marry into households which face risks which are not correlated with their own family's risks. Related to this idea is the use of the timing of marriage and payment of bride wealth as a response to income shocks. Hoogeveen, Klaauw, and Lomwel (2002) do find some evidence for this in Zimbabwe, although the results are somewhat mixed possible owing to the small sample used.[1]

It is important to note that even if wages are depressed a household still gain from a large number of working children, provided that the income covers the cost. A child's consumption can also be reduced in case of adverse conditions, implying that the net return need not decrease much even with lower wages. Empirical evidence on the effects of adverse conditions on the consumption of children is not conclusive. The intra-household distribution of food varies between different locations as well as with the severity of the situation (Rosenzweig and Schultz 1982; Harriss 1990; Dasgupta 1993).

The most obvious reason why children with their own household or migrated family members want to remit money is family ties, altruism or what Nugent (1985) calls loyalty. It follows that children are likely to be more reliable as a means for insurance than more distant family. For further discussion of why migrants remit, such as altruism and self-enforcing contracts,

[1] Dekker and Hoogeveen (2002), in a related paper, finds that the timing of the *payment* of the bride wealth also responds to income shocks.

see Lucas and Stark (1985), Stark (1991, ch. 15), Cox and Stark (1994) and Lillard and Willis (1997).

Finally, if the household is in dire straits the parents may actually “sell” their children as bounded labour. There is usually an underlying presumption that children should be of a certain age and in some societies of a specific sex to serve as a substitute for insurance. Nevertheless, the argument that only boys can act as insurance carries less weight if one accepts the hypothesis of Rosenzweig and Stark (1989), because a larger number of girls lead to more connections with other households.

Children, when seen as a substitute for insurance, have three special properties. First, the expected net return of an additional child need clearly not be positive for risk averse parents to have another child, since by definition they are willing to give up some of their income in order to reduce the risk. Hence, the insurance argument can explain why studies, such as Cain (1982) and Lindert (1983), of the net return to children have failed to find any large positive return to children.

Secondly, children are a very general means of risk diversification, as indicated by the above discussion, and are not “used up” to the same extent as savings or borrowed money. This means that children are in some aspects more like an annuity than an insurance policy, but both consumption and work effort of the children can change, making them closer to standard insurance. If parents derive utility from their children’s consumption and education it is likely that if the family is well off the children will work less, consume more and possibly go to school. The parents can then increase the workload of the children and decrease the consumption as discussed above if needed.

Thirdly, children are only an incomplete substitute for insurance. They have a long maturing time, during which they are potentially very expensive, they may die before being able to provide any return to their parents[2], and there is no way *a priori* of knowing the sex or ability of the child. Furthermore, the number of children can take only discrete values. Hence, children are a crude substitute for insurance, but probably better than the alternatives.

Three studies provide empirical support for the hypothesis that children provide general insurance against various risks. De Vany and Sanchez (1977) analyse the effect of land reform in rural Mexico and find that the uncertain land tenure rights associated with the ejido system, in which land is granted to individual families on a usufruct basis and where land cannot be bought, sold, leased or mortgaged, leads to high fertility. They conclude that: "Children function as surrogate capital instruments, or securities, which permit parents to partially bridge the incompleteness of markets in claims to uncertain, future states" (De Vany and Sanchez 1977, p 761).

Cain (1990) analyses the relation between risk and fertility in two villages in Northern India. It is shown that although weather induced risk is relatively small and common property resources are available there are con-

[2]See Reher (1995) for a discussion of the effects of childhood mortality.

siderable predatory and patriarchal risks. This combined with semi-feudal social relations, which means poor access to credit and little effect of state interventions, leads to a higher demand for sons compared with the villages in Southern India, studied in Cain (1981), where the risk environment is more benign and access to insurance substitutes are easier.

Finally, Das Gupta (1995) examines fertility decline in the Ludhiana District, Punjab. Total fertility began to decline around 1940; well before the onset of family planning programmes and the Green Revolution that began in 1966. According to Das Gupta (1995, p 495, 499) this decline in fertility came about as a result of an increased security against mortality peaks and food shortages. The improvement is partially due to the expansion of irrigation, which meant that "...both the *level* and the *variance* of yields were improved" (Das Gupta 1995, p 494).

3 Theory

This section discusses the results of a dynamic model of parents' decisions on fertility, when children can serve as an incomplete insurance substitute.[3] Although the model is not without shortcomings it is of interest since it is one of the few that have tried to address the potential relationship between fertility and the lack of access to insurance. The model is presented and examined in greater detail in Pörtner (1998, 2001).

[3] This section will be replace soon by a model which incorporates both parents' need for insurance and their utility of children's education.

Consider a two-period decision problem for a household that faces a certain income in the first period and uncertainty about income and child survival in the second period. The household decides on the number of births in period one. In the second period the household's income is revealed together with the number of surviving children.

The number of births and the number of surviving children are discrete variables. Let $N \in \{0, 1, 2, \ldots\}$ denote the number of births and $n \in \{0, 1, \ldots, N\}$ the number of surviving children in period two. The survival probability of each child is $s \in [0, 1]$, with s independent of the number of children and taken as given by the household. Hence, the probability that n children out of N births survive follows a binomial distribution with the density function

$$b(n, N, s) \equiv \binom{N}{n} s^n (1-s)^{N-n}. \tag{1}$$

First period household income is given by y_1. In the second period there are two states of the world $x \in \{1, 2\}$, and household income is

$$y_2(x) = \begin{cases} \overline{y} & \text{if } x = 1 \\ \underline{y} & \text{if } x = 2 \end{cases}$$

The probability of state 1 is $p(1)$ and the probability of state 2 is $p(2) = 1 - p(1)$.

Each birth carries with it a constant cost h, so that the total cost of N births in the first period is hN. In the second period income minus expenditures for each surviving child is h. Hence, total income from n surviving children is hn. Since the cost and income factors are assumed to be equal, there can never be a pecuniary gain from having children even if they all survive. This corresponds to a stochastic rate of interest that is either zero or negative. If the second period income is known this implies that the household demands children only if the second period income is sufficiently lower than the first period income, assuming that the two period utility functions are identical.[4] It follows that if the expected second period income is equal to the first period income then any demand for children is due to the uncertainty of future income, again assuming that the two period utility functions are identical. It is in this sense that children serve as insurance.[5]

The choice of N determines consumption in period one as

$$c_1 = y_1 - hN. \tag{2}$$

The maximum number of births the household can have in the first period is $\left[\frac{y_1}{h}\right]$ or the biological maximum, which for simplicity is assumed to be higher than the budget constrained maximum. Consumption in the second period is the stochastic variable

$$c_2(x, n) = y_2(x) + hn. \tag{3}$$

[4] There would also be a demand for children if the income factor was sufficiently higher than the cost factor or if the utility function allowed for direct utility of children.

[5] This is also known as precautionary saving, which is defined "...as the extra saving caused by future income being random..." Leland (1968, p 465). See also Kimball (1990).

The household is assumed to have a von Neumann-Morgenstern expected utility function

$$\overline{U}\left(c_1, c_2\left(x, n\right)\right) = \sum_{x,n} \overline{u}\left(c_1, c_2\left(x, n\right)\right) p\left(x\right) b\left(n, N, s\right). \tag{4}$$

Assuming additive separability in consumption in the two periods, expected utility is

$$\widetilde{U}(c_1, c_2\left(x, n\right)) = u^1(c_1) + \sum_x p(x) \sum_n b(n, N, s) u^2(c_2\left(x, n\right)). \tag{5}$$

Furthermore, both the first $u^1\left(c_1\right)$ and second period utility function $u^2\left(c_2\left(x, n\right)\right)$, defined on sure amounts of consumption in each period, are assumed to be strictly increasing and concave in consumption. The household decides on the number of births rather than directly on consumption. Therefore, the expected utility of N births, for given s and p, is

$$U\left(N; s, p\right) = u^1(y_1 - hN) + \sum_x p(x) \sum_n b(n, N, s) u^2(y_2(x) + hn). \tag{6}$$

The household maximises (6) subject to the first period budget constraint (2).

The main problem in finding a solution to the household's problem is that one cannot use the standard arguments on derivatives. Hence, to analyse the optimal choice of the household one needs the discrete equivalent of the first and second order derivatives. Fortunately, these are well-behaved and it can be shown that one can find an expression, which is close to the standard first order condition in a maximisation problem. In this "first order condition" the household trade off the cost of a child against the expected return in the next period. An additional birth leads to a cost in foregone first period utility. If this additional child does not survive to the second period there is no second period utility gain, but if the child survives the household has one extra child in each of the possible income states. The optimal number of births depends on, among other variables, the household's present and future income and its degree of risk aversion. With respect to future income two effects are of interest here: The effect of a change in the level of income and the effect of a change in the dispersion of income.

The first result on income is that the optimal number of births is non-increasing for increasing probability of higher second period income. Ruling out the case where changes in the level of expected income has no effect on the number of births the interpretation of this is that an increased probability of high future income leads to less demand for insurance and therefore fewer births. A similar effect can be shown to arise if the probability distribution remains the same, but either the income in the low income state, the income in the high income state or both are increased. The higher the expected future income, relative to the present income, the more willing the household is to take the risk of a low future income. Hence, there is less need for insurance. While an increase in the probability of high income or an increase in either low or high income may increase or decrease the variance of income, this effect is always dominated by the level effect, at least as long as the lower income is not decreased. Nevertheless, the dispersion of future income can also affect the demand for children.

The second result on income is that a mean-preserving spread of future income cannot lead to a lower optimal number of births. Clearly, the result would be the same if the high income is increased and the low income is decreased, keeping the mean constant. Furthermore, it can be shown that the more risk averse the household is (i.e. the more concave the second period utility function is), the higher is the likelihood that the optimal number of births will increase.

It is likely that adverse conditions in developing countries can lead to a future income so low that it threatens the very survival of the household. The effect of this possibility on the demand for children depends on the characteristics of the utility function as consumption approaches zero. Assuming that the marginal utility goes to infinity as future consumption goes to zero it would appear that the household would demand an infinite number of children or in the real world have as many children as biologically possible. The maximum number of births is, however, also constrained by the first period budget constraint, so the marginal utility of consumption in the first period would also increase substantially as N approaches $\left[\frac{y_1}{h}\right]$. The result from above still holds but it is less likely that an increase in the high income would generate any observable effect on the observed number of births.

The implication is that even families who are relatively richer in the sense that their high second period income is higher than others would tend to have a large number of children if they faced a risk of zero or very low income in some periods. This would seem to support the conclusion by Cain (1986) that in rural Bangladesh, where the important sources of risk are endemic, "...one should not expect fertility to vary systematically across region or economic status". If everybody experiences a high risk of a very low income no matter their status there would not be much difference between fertility levels due to security considerations.

Families differ not only with respect to their expected income but also with respect to their present income. The model can also be used to analyse the impact of present income on fertility. and the result is that for a given expectation of second period income the optimal number of births cannot be higher for a lower first period income than for a higher first period income. Ruling out the uninteresting case where first period income has no effect on N, the optimal number of births is lower if the present income is lower. Mostly, in empirical analyses of the demand for children, only present income or some proxy for income is observed together with the number of children. According to this result there should be a positive relation between income and fertility in a given period, but the result on expected income above predicts a negative relation between future expected income and the number of births. Hence, to determine the demand for children it is not sufficient to observe present income, one also needs some assessment of the risks a household faces or in other word the expected income and its variability.

Beside the level and variance of income discussed above, the survival probability of the children is also important in determining the optimal number of births, since it influences the return on children. For a sufficiently risk averse household, the optimal number of births is first non-decreasing and then non-increasing in the survival probability. An increase in the survival probability of children has two effects on the demand for children as insurance. First, increased survival probability is equivalent to a higher return to births (less wasted resources). Secondly, the higher expected number of survivors leads to a higher expected consumption in the future. While the substitution effect tends to raise the optimal number of births the income effect has the opposite effect. If the income effect dominates the optimal number of births will decrease. The more risk averse a household is the more likely it is that the income effect will at one point dominate the substitution effect when the survival probability is increased. Hence, the model is able to illustrate the observed fall in fertility following a decline in infant and child mortality, provided households are indeed risk averse.

3.1 Extension to a Multi-period Model

The household may have some overall idea about the number of surviving children it wants, but the decisions on timing and number of births are influenced by present income and the number of surviving children. It follows that the household's fertility choice is potentially better described as a stochastic dynamic programme. As shown in Pörtner (1998) the results for the two-period model do carry over into the three-period model, where the parents can have children in the first two periods and where income is uncertain for the last two periods.[6]

Besides the results equivalent to the ones in the two-period model, one can show that the optimal number of second period births is non-increasing in the number of surviving children from the first period. There are two effects from an extra surviving child in the second period. First, the child will increase the expected income in both the low and the high income states. This would tend to reduce the demand for children in the second period. Secondly, with the additional child the household has a higher present income, which implies a higher demand for children. When the utility functions for period two and three are identical the first effects dominates the second.

Finally, it is possible to show that the optimal number of births in the first period is non-increasing in both the survival rate of the second period births and in the probability of a high third period income. This assumes that a unit decrease in the number of surviving children from the first period does not lead to more than a unit increase in the optimal number of births in the second period. These results are the natural extensions of the propositions dealing with the effects of changes in expected income and survival in the next period. They indicate that a change in expectations will have the same qualitative effect whether the change concerns the next period or one of the

[6]This also assumes that there cannot be a pecuniary return to having children. Furthermore, it is assumed that children are only at risk in their first period of life.

following periods.

4 Estimation Strategy

This section discusses the estimation methods and the possible econometric issues. Based on the model above there are two ways of estimating the relationship between household structure and risks. First, if detailed panel data with information on fertility, consumption, risks and shocks were available it would be possible to estimate whether households with a higher number of children were able to better smooth their consumption. Beside the obvious problem of availability of longitudinal data this method cannot easily be used to test whether risks affect the fertility decision, but would rather be an indirect test. Secondly, one can directly estimate the determinants of fertility, using measures of the risk environment and shocks faced by households and other household characteristics as explanatory variables. This is the approach we use here. Even though the data requirements of this approach are smaller a household-level data set together with substantial information on the risks and shocks faced by households are required.

Before continuing it is important to clarify the use the words, risks and shocks. Risks here refers to the probability or likelihood of a specific outcome or event, which is generally perceive to be negative in nature, such as a hurricane or an earthquake. Shocks instead refers to the actual occurrence of the event. Hence, risks affect the future expected income, while shocks affect the current period's income.

Even though the fertility decision process itself can be thought of as a decision on the degree of contraception use, as discussed in Arroyo and Zhang (1997), that is not practical here because of data limitation.[7] Instead, we use the outcomes of the fertility decision. What is important then is that the number of children is discrete and cannot be less than zero. Estimating the effects of risks and shocks on fertility using OLS may lead to predicted values which are less than zero, which is a violation of the non-negative constraint on the number of children (or pregnancies). This combined with the discreteness of the outcome and that a substantial number of zero outcomes are likely suggest using a count model. There are a number of suitable models that can be used. Probably the most popular model is the Poisson regression model, which is used here since it is robust to distributional misspecification.[8] The interpretation of parameter estimates is as semi-elasticities, so that for a small change in an explanatory variable the percentage change in the dependent variable is roughly one-hundred times the multiplication of the estimated parameter and the change in the explanatory variable.

Because of the potential effect of increasing fertility on children's schooling we also estimate the effects of risks and shocks on education. The main econometric problem here is the censoring of the education variable, which leads to inconsistency if OLS is used. The standard method of dealing with

[7]See Section 5 for a discussion of the data used here.

[8]See **?**, Chapter 19 for a discussion of count models.

a substantial number of zero outcomes for education is to use a tobit model. This is, however, not appropriate here since there is also a large number of children who are still enrolled in school and hence subject to right censoring. Instead we use a censored normal regression model.

For both fertility and education two models are estimated. The first focused on risks (and the other exogenous explanatory variables). The second includes shocks in addition to risks. How risks and shocks are measured are discussed in Section 6.

5 Data

As mentioned above two types of data are required for this analysis. The first is household data with information on fertility and children's education. The second is information on the risk environment and shocks occurred which can be linked to households (or at least a well-specified and preferable small geographical area in which the household resides). We discuss each in turn.

The household data are from ENCOVI 2000, which is a LSMS-style nationwide household survey from Guatemala collected in 2000. The survey covered 7,276 households, of which 3,852 were rural and 3,424 were urban. It was designed to be representative both at national and regional levels and in urban and rural areas. From the model above and the references to the original literature it is clear that the theory appear to be more applicable to rural areas than to urban areas. We therefore restrict the sample to only rural areas.

Beside the standard household information collected in LSMS surveys, ENCOVI 2000 collected information on fertility history from all women between 12 and 49 years of age. Although the quality of data is unlikely to be comparable with the fertility information from, for example, a Demographic and Health Survey it appears to be acceptable. One major drawback is the lack of information on the timing of births, which is restricted to a question about when the last birth took place. It is possible to get more information on this if the child is alive and still living. For children who have died or left the household there is no information. Each implies that the sample of children on which we have educational information is not a complete sample of all children born. Even though the fertility and education information may not be optimal there is one major advantage of this survey: There is a substantial amount of secondary data available, which can provide information the risks associated with the district.[9]

The secondary data we use were created in connection with a report, UNICEF (2000), on natural disasters and vulnerability in Guatemala. Beside a general measure of vulnerability, it includes a number of variables that measure specific events, although some of these are often closely connected. What is interesting here is that for most of the variables there is information

[9] The household survey itself does contain information on exposure to shocks, but these only cover the 12 month period prior to the survey date. There are, however, also information in the community questionnaire about whether the community has been affected by shocks between 1995 and 2000. These periods are, however, not long enough for our purposes.

on the number of occurrences for extended periods; the longest period covered is for earthquakes and volcanos, which covers the period 1530-1999. Although there clearly are problems with a measure that claims to go back to 1530 this is one of few ways to get a reasonable measure of the risks in an area (or rather the perceived risk by people). The main problem is that some areas and therefore some events are likely to be underreported since people need to be present in order to record the events. Hence, areas which were previously very sparsely population may have a lower risk measure than the true one, although this also may mean that people moving in to the area has less reason to expect a high level of risk. Furthermore, only major events are likely to be reflected and this problem become more pronounced the further back in time one tries to get information on. A major advantage of these data is that they have information on municipality level allowing a relatively precise measure of the risks and shocks a household is exposed to. There are a total of 331 municipalities in Guatemala, although we only use the information for the 171 rural municipalities in the survey.

6 Variables

This section describes the dependent and independent variables we use in our estimations. We begin with the dependent variables and then the explanatory variables. The descriptive statistics are shown in Tables 1 and 2.

[Table 1 about here.]

[Table 2 about here.]

6.1 Dependent Variables

The first choice is how to specific the dependent variables, fertility and children's education. ENCOVI 2000 includes three measures of fertility for each women: The number of pregnancies, the number of live births and the number of children alive at the time of the survey. Each of these have their advantages and drawbacks. The number of live births obviously comes closest to the variable of interest in the model, but the number of pregnancies may provide a good indication of the demand for children and the number of surviving children is the best indicator of how much "insurance" is available to the household. Hence, all estimations are done for all three variables, although our prefered dependent variables are the birth and children alive. The number of pregnancies is probably less precisely measured and might indicate the health status of the mother.[10] The majority of women were still in their fertile years, 15-44 years of age, at the time of the survey and hence, what is used are not the completed fertility measures, but the cummulative. We discuss who to deal with this below. To allow for risks and shocks to have an effect on fertility we only use observations for women who are 20 years or older.

There are two main issues with this set of dependent variables, mortality

[10] A less healthy mother is likely to have more pregnancies per life birth than a healthy mother.

and timing. For two families with the same "target fertility" we would expect the family facing higher mortality to be more likely to have more pregnancies and births. Currently the risk of infant and child mortality is not addressed directly, but comparison of the results from the three measures of fertility can provide some information about its effect. Higher mortality risks can also lead to changes in the timing of fertility; this issue will be addressed below.

The second dependent variable is the educational attainment of children. We use only children for whom we can identify and have information on their mother in the survey. As mentioned above this is not the complete sample of children born since the survey does not collect information on children how have either left the household or died. Given a substantial migration it is likely that the education level of our sample is lower than the true population. There is, however, very little that can be done about this problem. Education is measured as years of completed education. There is a total of 5894 useable observations on children's education. Of those, 1003 are left-censored, 3452 right-censored and 1439 are uncensored. We consider all children who are currently enrolled in school as being right-censored even if their present educational attainment is zero.

6.2 Independent Variables

The main explanatory variables of interest are the measures of risks and shocks. We discuss each in turn. It is unlikely that all risks have the same effect on fertility. Generally, one would expect an increase in the risk of events that requires man-power to recover from, for example through replanting of crops, to have a strong and positive effect on fertility and a corresponding negative impact on schooling of children. On the other hand, the risk of events that either so completely destroys capital and/or land that the amount of labour that the household has available would not make a difference or are otherwise of a nature while labour does not matter, should not have much of an effect on fertility or may even have a negative effect. As a representative of the first category we use the risk of a hurricane, while the risk of earthquake may be thought of as a risk against which a larger family size is of less or no importance.

For both we measure risk as the percentage probability of an event occurring in a given year. This is calculated based on all available events for the two risk. The first recorded hurricane in the data set is in 1880 and the data runs to 1999. The first recorded earthquake is from 1530 and surprisingly their appears to be relative few gaps in the following years. A likely reason for this is that the former capital (and the current one) are both in a relative active volcanic area. It is worth noting that an earthquake is only categories as such if it is sufficiently strong to cause substantial damage.[11] Tables 1 and 2 show that the average risk of a hurricane is about 1.6 percent, although some communities have a risk as low as 0.83 and some as high as 5 percent

[11] There are also information on tremors, which are those that do not cause any significant damage, and volcanic eruptions in the data set.

per year, while there is a lower risk of earthquakes, around 0.8 percent per year with a minimum of 0.4 and maximum of 3.4 percent per year.

While different types of risks may have different effects on fertility and education the hypothesis based on the model is that all significant shocks would negatively impact both fertility and education. In the analysis of the determinants of fertility shocks are measured as the number of occurances between the year the woman enters her fertility period (taken to be 15 years) and her 35th year or survey year, whatever is first. The reason for the 35 year cutoff is that the majority of women have most of their children before they turn 35, although there are a number of women who continue having children until their are 45.

For the analysis of the determinants of children's education deciding on a measure of shocks is more involved because of the substantial amount of censoring. We use the number of shocks that have occurred between the child's sixth year and when they leave school or the survey year, whatever is first. Children begin school at age 7, so shocks that occur during their sixth year can negatively influence their probability of going to school. Furthermore, shocks that occur after they have left school are implicitly assumed to have no effect on years of schooling. One could argue that a shock would decrease the chance of going back to school, but finding a suitable cutoff point would be just as arbitrary. Given the low average education of the children in the sample, which is due partly to low levels of schooling and the high number of censored observation, it is difficult to independently identify the effect of hurricanes and earthquakes. Since initial results and theory indicate that the two types of shocks have similar effects on education, shocks are measured as the combined number of occurrences for the shocks. Even then the average number of shocks experienced during school years is only 0.06, which indicates that it will probably be difficult to precisely identify the effects of shocks.

The remaining independent variables can be divided into individual and household and area characteristics. The individual and household characteristics are age, education, sex, ethnicity and land access, while the information on area are on geographical region and the civil war. Clearly not all explanatory variables mentioned are relevant for both models. We discuss each variable in turn.

Since the fertility measures are cummulative and not completed fertility we include age and age square of the mother as explanatory variables in the fertility estimations. Beside the direct effect of age on fertility which is that everything else equal we would expect older women to have had more pregnancies and births, being older also mean that a woman would have had longer to compensate for the negative impacts on fertility from the shocks she has experienced. We therefore interact the mother's age with the number of shocks occurred for both types of shocks. Clearly this ignores the exact timing of the shocks, but on average we would expect that older women would be better able to compensate for a given number of shocks.

In the education models the relevant age is not the mother's but the child's. We use three variables to capture the effect of age: Age, age squared and a dummy for the child being 13 years or older. Education is expected to increase with age, but since relatively few make it past primary school (six years of education) we also include the dummy to capture this pattern. As for the fertility estimation an older child may have had longer to compensate for a shock and we therefore also interact age with the number of shocks.[12]

Education is an obvious important variable for both fertility and children's education. First, typically the more educated a person is, the higher the expected future income.[13] Secondly, more education is likely to lead to less variation in expected future income, even if it should not substantially increase expected income. Finally, since education provides people with the ability to collect and process information, they are in a better position to asses their future income and to take steps to prevent a very low income state occurring. Furthermore, various studies have shown a negative relation between infant and child mortality and the education of mothers.[14] Hence, education has two effects that both tend to lower the number of births. First, higher education means less need for insurance because of higher expected income and lower variation in income. Secondly, the household needs fewer birth since child mortality decreases with education. Correspondingly, we expect the mother's education to have a positive effect on children's schooling

[12] As discussed above the shocks are combined into one measure.

[13] Foster and Rosenzweig (1996) analyse the return to schooling during the green revolution in India. See also the discussion of the effects of schooling in Rosenzweig (1995).

[14] Examples are Bhuiya and Streatfield (1991) and Sandiford, Cassel, Montenegro, and Sanchez (1995).

for exactly the same reasons. We use the education of the mother measured in years of schooling completed and its square. A potential reason why the average education is lower for the mother's in the education model than in the fertility model is that the women in the education sample are generally older than in the fertility sample. For both, however, the average education level is very low.

The last individual characteristics we include are the sex of the child in the education regressions and the ethnicity of the mother. The reason for including the sex of the child should be obvious. Note that only 46 percent of the sample are girls, which may be because boys are more likely to stay in the parental household while older girls move away when married and are therefore not surveyed or because of differential mortality risk. Ethnicity is here captured by a dummy for belonging to an indigenous group with the excluded group being the ones who classify themselves as "ladino". The majority of the indigenous are various groups of Mayan with a very small number who are Garifuna or Xinka.

The main household characteristics we include is access to land. There are two variables in the survey that capture how much own land a household has access to: The area owned and the (self-evaluated) value of this land. The value of land may, however, change over time and land may be purchased or sold. Furthermore, the quality of land can vary widely even within small geographical areas. Hence, we use a dummy variable for whether the household own land (although this obviously does not get around the problem of when the land was purchased). Since there might also be differences in the response to risks and shocks among different types of household who do not own land, we also include a dummy for whether a household rents land. This is equal to one if the household does rent land but does not own any land, and zero otherwise.[15] For both analyses a little more than half of the sample owns land, while about one-fifth rents land (but does not own, leaving about 25 percent with no access to land.

Beside the direct effects of access to land on fertility and education we expect that both risks and shocks have different effects on the three groups. Following the arguments above children will generally serve best as insurance if a household has access to land, so we would expect those households with land to show a positive effect on fertility of hurricane, while it is less clear whether there will be a differential effect of earthquakes. To capture these effects we interact the risk and shocks measures with the two land dummy variables for both the fertility and education models. In addition we interact age with the shock interactions for the fertility model to examine whether there is a difference in the compensation in fertility after a shock between the three groups.

The two area characteristics we use are the type of geographical region that the household is in and an indicator for the impact of the civil war. We divide Guatemala into three types of area: Coastal, Jungle and High-

[15]There is information in the survey on the "rental agreement" for the land (leased or usufruct) and how the household pay for the land rental, but we have not included this information.

land. This is obviously a relative rough categorisation, but in the absense of more detailed information about geographical characteristics of the household's area this at least captures some of the main differences. The coastal departments consists of the western departments of Retalhuleu, Suchitepequez and Escuintla and the eastern department of Izabal. The jungle is the department of Peten, which is the northenmost and biggest department. The 16 remaining departments are categorised as highland areas and are the excluded category.[16]

The civil war began in 1960 and lasted 36 years and resulted in more than 200,000 dead. The disruption and turmoil resulting from the civil may have a substantial impact on both fertility and education, but finding a suitable way of capturing these effects is difficult. We use a dummy for the five departments that experienced the highest number of massacres.

Before moving on to the results is it worth discussing some of the explanatory variables which are not included and why. In the individual and household characteristics some would consider whether a woman is married to be a relevant variable. Marital status is, however, not be an appropriate explanatory variable since it is closely connected with the decision to have children and it therefore determined by the same factors. Including an endogenous variable may lead to bias in both the affected parameter *and* the

[16]The departments of San Marcos, Santa Rosa and Jutiapa all have coast line, but are mostly highland, so until information is available by municipality they are included in the highland category. Introducing the three departments into the coastal category makes it less significant and leaves the remaining results unchanged.

other estimated parameters. A similar argument can be used for most other individual and household variables not included. In fact, given that the parents of the women surveyed were likely faced with the same circumstances as the women are now one could consider both education and land access, especially ownership, to be endogenous. Having rented land may also be endogenous but for different reasons and the same is the type of crops grown. Although there is no easy way to deal with the potential endegeneity of land access one could use the parental education of the mothers in the survey as instrument.

What might be more controversial is that a number of community variables, except type of region and the civil war dummy, have been left out. The argument for that is that the risk environment is likely to have a significant effect on how a community develops. A community which has a significant risk of earthquakes or volcanic eruptions may, for example, be less likely to have a well developed infrastructure. Hence, if we included infrastructure as an explanatory variable we would not capture the full effect of risks and shocks on mothers' behaviour.[17]

7 The Effects of Risks and Shocks on Fertility

This section examines the results for the two different specifications of the determinants of fertility model. First, we present the result without shocks.

[17] [Current discussion in growth literature on climate and institutions]

Second, to examine whether exposure to shocks have a negative effect on fertility as predicted we then include the number of shocks the household's area has been exposed.

Table 3 presents results for the three measure of fertility with the risks and the remaining explanatory variables discussed above. The main parameters of interest are the two risk measures and their interactions. As expected the two risks affect fertility differently. Increasing the risk of a hurricane leads to a significant increase in fertility for households that own land, while there is no significant effect for those who either have no land or only leased access to land. This pattern is consisten over the three fertility variables used, except that none of the parameters are significant in the pregnancies model, which is the least prefered specification as discussed above. To provide an idea of the magnitude of the effect consider a one percentage point increase in the risk of a hurricane (average risk is 1.6 percent and maximum is 5 percent). This change would lead to a six percent increase in the number of children.

The risk of earthquakes also have a significant effect, but it is negative and does not vary by access to land. While this may seem to contradict the theory that is not necessarily the case. Earthquake activity seems to be closely related to volcanic activity and in case of a shock of this type it is unlikely that having a larger family will have any beneficial effect on a household's ability to recover. There are two reasons for this. First, a shock of this type is likely to result in damage to property rather than crops and therefore the rationale which underpinned the model does not apply. Second, in the case of volcanic eruption the destruction is likely to be so significant that there are few employment opportunities outside the household and hence no benefit from having a larger household. In fact, a large household might be detrimental for exactly these reasons. Hurricanes are also likely to hit a large number of households in an area, but the important effect here is that it depletes the available labour from other households and the risk is of a type for which a household can recover if it has a sufficient command of labour.

The mothers' characteristics, education, age and their squares, are all significant and have the expected signs. Ethnicity show a significant negative effect for the number of children alive, while for the two other outcomes it is insignificant. This suggests that child mortality is higher among the indigenous, mostly Mayan, population than for the rest of the population. Neither of the land dummies show any significant effect on their own. The civil war dummy has a very significant effect with the five departments that experienced the highest number of massacres also having a significantly higher fertility. Of the two remaining variables, the dummies for the coastal and jungle regions, the Jungle dummy is positive and significant.

[Table 3 about here.]

Table 4 presents the results when including shocks. Recall that shocks are measured as the number of occurrences of a specific event during the mother's main childbearing years (15 to 35 years of age). The effects of the background variables are virtually identical to those in Table 3. Furthermore, the effects of risks are also essentially the same, with a significant positive effect of the risk of hurricanes on fertility for land owning household and a negative significant effect of the risk of earthquakes on all types of households.

As explained above the the expected sign for all shocks are negative. For hurricane shocks the general effect is negative and significant. The interaction with age shows that the mother is able to compensate for the reduction in fertility following the shock by having the child later, so that at age 45 the two term essentially cancel each other. Note, however, that since we have included only shocks that occur between 15 and 35 years of age if there are shocks that take place later it becomes less likely that the mother will be able to fully compensate for the reduction in fertility. None of the interactions for owned land are significant, but both are for land rented. The latter results are somewhat puzzling since there appear to be a positive effect of a hurricane shock on fertility for the households that rents land. None of the estimated parameters for earthquake shocks are significant, although they are jointly significant at the ten percent level.

[Table 4 about here.]

8 Education and the Effects of Risks and Shocks

This section presents results of the effects of risks and shocks on the education of children. There are two possible factors of interest that are likely to affect children's education. First, although the theoretical model presented above does not explicitly allow for parental investments in their children's human capital it is reasonable to expect there is a negative relationship between the number of children and the level of their education. Hence, since the results above indicate that increased risk, at least for hurricanes, lead to higher fertility we should expect that a higher level of risks also leads to lower education. Secondly, the occurrence of a shock is likely to negatively affect schooling of children as discussed in Section 2. Table 5 presents the results. The first column show the results with risks, while the second column includes shocks as well.

[Table 5 about here.]

The results for education are less clear than the ones for fertility. The hurricane risk has a significant and positive effect on schooling for those children who are from households without any land, while the effect is significant and negative for both households that own land and those that rent. The positive effect for land owning households is in line with what we would expect given the results of the fertility estimation, but the other two are not since there was no significant effect on fertility in those cases. Essentially the same pattern is repeated for earthquake risks with increasing education in the risk of earthquake for those households without land and decreasing for those with access to land.

As expected there is a significant and negative effect of shocks, which is the combined occurrence of hurricanes and earthquakes, on education.

The effect is less for those households who own land, but not enough to fully compensate for the reduction in education. It also appears that some compensation is possible with age.

As for the previous models a number of background variables are included. The results are essentially as expected: girls receive significant less education than boys; the mother's education has a significant and positive effect on her children's education; and years of education increase with age of the child. Indigenous children have on average a lower level of education, while land owned and land rented have significant positive effects on schooling.

9 Effects of Providing Formal Insurance

[This section will analyse the predicted effects on fertility and schooling from "eliminating" or insuring against the various risk. The purpose is to see how much lower fertility would be and how much higher schooling would be if a policy that provided insurance against short-falls in income was introduced.]

10 Conclusion

This paper presents a model of fertility decisions in which children serve as potential (imperfect) substitutes for absent or poorly functioning insurance markets and test this model using data from Guatemala. Three main results emerge from the model, which features uncertain future income and child survival and a discrete representation of the number of children. First, for risk averse households the number of births is decreasing in the survival probability for realistic levels of survival probabilities. Secondly, a higher expected future income leads to a lower number of births. Thirdly, for a given expectation of future income the number of births in a period is increasing in income.

The empirical analysis uses data from Guatemala, with the information on household coming from the ENCOVI 2000 data set and information on the risks households are exposed to from a UNICEF study of natural disasters. Overall the results support the theory in that increases in a risk of event which can be aleviated with enough man power have a positive effect on fertility, while risks where this is arguably not the case have a negative effect on fertility.

[to be expanded]

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Table 1: Descriptive Statistics — Fertility

Variable	Mean	Std. Dev.	Min	Max
Pregnancies	4.4479	3.3287	0.00	19.00
Births	4.0657	3.1309	0.00	19.00
Alive	3.6560	2.7765	0.00	14.00
Education in years	2.2363	3.1920	0.00	24.00
Education in years squared	15.1869	39.0054	0.00	576.00
Age	31.9420	8.4886	20.00	49.00
Age squared	1092.3277	570.2722	400.00	2401.00
Indigenous	0.4768	0.4995	0.00	1.00
Owns land	0.5306	0.4991	0.00	1.00
Rents land (excl. owns land)	0.1949	0.3962	0.00	1.00
Civil war dummy	0.4206	0.4937	0.00	1.00
Coastal region	0.1615	0.3680	0.00	1.00
Jungle region	0.0772	0.2669	0.00	1.00
Risk of hurricane (percent)	1.5824	0.7134	0.83	5.00
Hurricane risk × owns land	0.8427	0.9058	0.00	5.00
Hurricane risk × rents land	0.3322	0.7725	0.00	5.00
Risk of earthquake (percent)	0.8047	0.4506	0.43	3.40
Earthquake risk × owns land	0.3719	0.4485	0.00	2.13
Earthquake risk × rents land	0.1610	0.3847	0.00	2.13
Hurricane shocks (number until age 35)	0.4428	0.9053	0.00	7.00
Hurricane shocks × age	19.7504	41.3710	0.00	343.00
Hurricane shocks × owns land	0.2482	0.6725	0.00	5.00
Hurricane shocks × owns land × age	11.0186	30.4505	0.00	245.00
Hurricane shocks × rents land	0.0875	0.4717	0.00	5.00
Hurricane shocks × rents land × age	3.9545	21.6601	0.00	245.00
Earthquake shocks (number until age 35)	0.7090	0.9877	0.00	3.00
Earthquake shocks × age	29.3106	42.1829	0.00	147.00
Earthquake shocks × owns land	0.3570	0.7792	0.00	3.00
Earthquake shocks × owns land × age	15.1094	33.4140	0.00	147.00
Earthquake shocks × rents land	0.1423	0.5314	0.00	3.00
Earthquake shocks × rents land × age	5.8341	22.4216	0.00	147.00

Table 2: Descriptive Statistics — Children's Education

Variable	Mean	Std. Dev.	Min	Max
Education (years)	2.5609	2.7271	0.00	18.00
Sex (female = 1)	0.4610	0.4985	0.00	1.00
Age	12.6676	4.4830	7.00	33.00
Age square	180.5624	133.5560	49.00	1089.00
Age 13 or older (yes = 1)	0.4483	0.4974	0.00	1.00
Mother's education (years)	1.4060	2.3969	0.00	24.00
Mother's education squared	7.7212	25.7960	0.00	576.00
Indigenous	0.4868	0.4999	0.00	1.00
Owns land (yes = 1)	0.5741	0.4945	0.00	1.00
Rents land (excl. owns land)	0.2004	0.4003	0.00	1.00
Civil war dummy	0.4299	0.4951	0.00	1.00
Coastal region	0.1558	0.3627	0.00	1.00
Jungle region	0.0892	0.2851	0.00	1.00
Risk of hurricane (percent)	1.6101	0.7101	0.83	5.00
Hurricane risk × owns land	0.9323	0.9254	0.00	5.00
Hurricane risk × rents land	0.3426	0.7788	0.00	5.00
Risk of earthquakes (percent)	0.7761	0.4328	0.43	3.40
Earthquake risk × owns land	0.3997	0.4483	0.00	2.13
Earthquake risk × rents land	0.1566	0.3606	0.00	2.13
Number of shocks (hurricane and earthquakes comb.)	0.0587	0.2415	0.00	3.00
Number of shocks × owns land	0.0221	0.1558	0.00	3.00
Number of shocks × rents land	0.0124	0.1106	0.00	1.00
Number of shocks × age	1.0131	4.5904	0.00	99.00

Table 3: Effects of Risks on Fertility

	Pregnancies	Births	Alive
Education in years	−0.0369***	−0.0376***	−0.0319***
	(0.0072)	(0.0076)	(0.0080)
Education in years squared	−0.0018***	−0.0021***	−0.0023***
	(0.0007)	(0.0008)	(0.0008)
Age	0.2400***	0.2485***	0.2593***
	(0.0092)	(0.0097)	(0.0102)
Age squared	−0.0027***	−0.0028***	−0.0031***
	(0.0001)	(0.0001)	(0.0001)
Indigenous	−0.0130	−0.0196	−0.0553**
	(0.0211)	(0.0220)	(0.0232)
Owns land	−0.0541	−0.0829	−0.0597
	(0.0748)	(0.0787)	(0.0822)
Rents land (excl. owns land)	0.0906	0.0554	0.0438
	(0.0899)	(0.0950)	(0.0994)
Civil war dummy	0.0643***	0.0943***	0.0714***
	(0.0220)	(0.0230)	(0.0243)
Coastal region	0.0339	0.0399	0.0291
	(0.0281)	(0.0297)	(0.0310)
Jungle region	0.1922***	0.1848***	0.1700***
	(0.0352)	(0.0370)	(0.0388)
Risk of hurricane (percent)	0.0072	0.0007	0.0089
	(0.0239)	(0.0253)	(0.0262)
Hurricane risk × owns land	0.0400	0.0616**	0.0595*
	(0.0294)	(0.0309)	(0.0322)
Hurricane risk × rents land	−0.0081	−0.0014	0.0098
	(0.0323)	(0.0342)	(0.0356)
Risk of earthquake (percent)	−0.0948**	−0.1171***	−0.0894**
	(0.0392)	(0.0416)	(0.0429)
Earthquake risk × owns land	0.0375	0.0568	0.0289
	(0.0488)	(0.0514)	(0.0536)
Earthquake risk × rents land	0.0350	0.0527	0.0399
	(0.0591)	(0.0626)	(0.0653)
Constant	−3.2696***	−3.4813***	−3.7034***
	(0.1706)	(0.1793)	(0.1881)
Observations	3378	3381	3381
Pseudo R-squared	0.22	0.21	0.18
Log-Likelihood	−7497.32	−7308.51	−7006.53

NOTE: * significant at 10%; ** significant at 5%; *** significant at 1%
Standard errors in parentheses

Table 4: Effect of Risks and Shocks on Fertility

	Pregnancies	Births	Alive
Education in years	−0.0363∗∗∗	−0.0371∗∗∗	−0.0315∗∗∗
	(0.0072)	(0.0077)	(0.0080)
Education in years squared	−0.0019∗∗∗	−0.0022∗∗∗	−0.0024∗∗∗
	(0.0007)	(0.0008)	(0.0008)
Age	0.2228∗∗∗	0.2463∗∗∗	0.2519∗∗∗
	(0.0190)	(0.0200)	(0.0211)
Age squared	−0.0024∗∗∗	−0.0028∗∗∗	−0.0029∗∗∗
	(0.0003)	(0.0003)	(0.0004)
Indigenous	−0.0127	−0.0184	−0.0540 ∗∗
	(0.0212)	(0.0221)	(0.0233)
Owns land	−0.1106	−0.1429∗	−0.1216
	(0.0791)	(0.0831)	(0.0865)
Rents land (excl. owns land)	0.0518	0.0195	0.0047
	(0.0942)	(0.0995)	(0.1037)
Civil war dummy	0.0612∗∗∗	0.0907∗∗∗	0.0674∗∗∗
	(0.0222)	(0.0232)	(0.0244)
Coastal region	0.0317	0.0396	0.0333
	(0.0313)	(0.0330)	(0.0346)
Jungle region	0.1928∗∗∗	0.1846∗∗∗	0.1715∗∗∗
	(0.0363)	(0.0381)	(0.0399)
Risk of hurricane (percent)	0.0030	−0.0086	0.0021
	(0.0259)	(0.0275)	(0.0284)
Hurricane risk × owns land	0.0469	0.0731 ∗∗	0.0689 ∗∗
	(0.0313)	(0.0329)	(0.0341)
Hurricane risk × rents land	−0.0071	0.0023	0.0065
	(0.0347)	(0.0368)	(0.0381)
Risk of earthquake (percent)	−0.0890 ∗∗	−0.1155∗∗∗	−0.0839∗
	(0.0395)	(0.0419)	(0.0432)
Earthquake risk × owns land	0.0311	0.0546	0.0226
	(0.0492)	(0.0518)	(0.0539)
Earthquake risk × rents land	0.0387	0.0635	0.0467
	(0.0603)	(0.0639)	(0.0666)
Hurricane shocks (number until age 35)	−0.5345 ∗∗	−0.6086 ∗∗	−0.4954∗
	(0.2454)	(0.2572)	(0.2736)
Hurricane shocks × age	0.0117 ∗∗	0.0138 ∗∗	0.0110∗
	(0.0054)	(0.0056)	(0.0060)
Hurricane shocks × owns land	0.3164	0.4023	0.2881
	(0.3011)	(0.3153)	(0.3358)
Hurricane shocks × owns land × age	−0.0074	−0.0097	−0.0071
	(0.0067)	(0.0070)	(0.0075)
Hurricane shocks × rents land	0.7126 ∗∗	0.9046 ∗∗	0.9895 ∗∗
	(0.3549)	(0.3761)	(0.3991)
Hurricane shocks × rents land × age	−0.0153 ∗∗	−0.0196 ∗∗	−0.0208 ∗∗
	(0.0078)	(0.0082)	(0.0087)
Earthquake shocks (number until age 35)	0.1571	0.1513	0.0951
	(0.1755)	(0.1850)	(0.1940)
Earthquake shocks × age	−0.0055	−0.0052	−0.0040
	(0.0045)	(0.0048)	(0.0050)
Earthquake shocks × owns land	0.0203	−0.2234	−0.1708
	(0.2184)	(0.2302)	(0.2436)
Earthquake shocks × owns land × age	0.0010	0.0068	0.0057
	(0.0055)	(0.0058)	(0.0061)
Earthquake shocks × rents land	0.1216	0.1364	0.2758
	(0.2285)	(0.2426)	(0.2555)
Earthquake shocks × rents land × age	−0.0025	−0.0031	−0.0065
	(0.0057)	(0.0061)	(0.0064)
Constant	−3.0237∗∗∗	−3.4426∗∗∗	−3.5909∗∗∗
	(0.2796)	(0.2947)	(0.3097)
Observations	3378	3381	3381
Pseudo R-sq	0.22	0.21	0.19
Log-Likelihood	−7485.35	−7295.50	−6992.84

NOTE: * significant at 10%; ** significant at 5%; *** significant at 1%
Standard errors in parentheses

Table 5: Effect of Risks and Shocks on Children's Education

	Risks	Risks & Shocks
Sex (female = 1)	−1.0757 * **	−1.0781 * **
	(0.1513)	(0.1513)
Age	1.5889 * **	1.6584 * **
	(0.1157)	(0.1191)
Age square	−0.0448 * **	−0.0473 * **
	(0.0033)	(0.0034)
Age 13 or older (yes = 1)	−2.9087 * **	−2.9200 * **
	(0.3173)	(0.3178)
Mother's education (years)	0.8770 * **	0.8842 * **
	(0.0672)	(0.0674)
Mother's education squared	−0.0245 * **	−0.0249 * **
	(0.0065)	(0.0065)
Indigenous	−0.4028 * *	−0.4106 * *
	(0.1881)	(0.1883)
Owns land (yes = 1)	3.6337 * **	3.5609 * **
	(0.7349)	(0.7367)
Rents land (excl. owns land)	2.8088 * **	2.7836 * **
	(0.8721)	(0.8735)
Civil war dummy	−1.4825 * **	−1.4387 * **
	(0.2020)	(0.2029)
Coastal region	−0.4204	−0.4049
	(0.2597)	(0.3002)
Jungle region	−1.2735 * **	−1.2377 * **
	(0.3284)	(0.3314)
Risk of hurricane (percent)	1.2682 * **	1.2182 * **
	(0.2497)	(0.2535)
Hurricane risk × owns land	−1.0684 * **	−1.0076 * **
	(0.2972)	(0.2986)
Hurricane risk × rents land	−1.5016 * **	−1.4718 * **
	(0.3198)	(0.3215)
Risk of earthquakes (percent)	2.4059 * **	2.5173 * **
	(0.3975)	(0.4070)
Earthquake risk × owns land	−2.0380 * **	−2.2086 * **
	(0.4732)	(0.4827)
Earthquake risk × rents land	−0.9341	−1.0085*
	(0.5954)	(0.6115)
Number of shocks (combined)		−2.3145 * *
		(1.0676)
Number of shocks × owns land		1.4772 * *
		(0.6506)
Number of shocks × rents land		0.2339
		(0.7929)
Number of shocks × age		0.0966*
		(0.0517)
Constant	−9.1544 * **	−9.5443 * **
	(1.0303)	(1.0409)
Observations	5894	5894
Pseudo R-squared	0.06	0.06
Log-Likelihood	−6784.86	−6779.74

NOTE: * significant at 10%; ** significant at 5%; *** significant at 1%
Standard errors in parentheses