The impact of income shocks on children education: the 1987-1989 locust plague in Mali*

Philippe De Vreyer†, Nathalie Guilbert‡ and Sandrine Mesple-Somps§

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Abstract

This paper estimates the long run impact of a large income shock, by exploiting the regional variation of the 1987-1989 locust invasion in Mali. Using exhaustive Population Census data, we construct birth cohorts of individuals and compare those born and living in the years and villages affected by locust plagues with other cohorts. We assert that in-utero and early childhood exposure to income shock had a larger negative effects on the probability to go to school than later childhood exposure. Indeed, the proportion of boys born during the shock and who later enrolled at school is reduced by 4.9% if they lived in a community invaded by locusts, and by 3.5% for girls. This impact goes up to 6% for boys and 5% for girls living in rural areas. Concerning the number of years of education and the probability to achieve primary school, no real impact is found for boys while girls who lived in a community affected by locusts have completed between 0.25 and 0.67 lower grades than if they had lived in another community. Finally, we find that children living in rural localities and belonging to farmer households appear to have been much more affected than other children, living in urban localities or belonging to cattle breeder or shopkeeper households.

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JEL classification codes: I21, O12, O55.

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†Universite Paris Dauphine, LEDA, and UMR 225 DIAL. E-mail: Devreyer@dial.prd.fr
‡Universite Paris Dauphine, LEDA. E-mail: guilbert@dial.prd.fr
§Institut de Recherche pour le Developpement (IRD), UMR 225 DIAL, Universite Paris Dauphine. E-mail: mesple@dial.prd.fr

"This is what the LORD, the God of the Hebrews, says: 'How long will you refuse to humble yourself before me? Let my people go, so that they may worship me. If you refuse to let them go, I will bring locusts into your country tomorrow. They will cover the face of the ground so that it cannot be seen. They will devour what little you have left after the hail, including every tree that is growing in your fields. They will fill your houses and those of all your officials and all the Egyptians, something neither your fathers nor your forefathers have ever seen from the day they settled in this land till now." EXODUS, 10:3-6

1 Introduction

The consequences of shocks undergone during early-life on human capital formation and on the well-being of adults have attracted considerable academic and policy interest. If economic shocks reduce child human capital investment, they may transmit poverty between generations and maintain people in poverty for a long time. Numerous shocks can impact human capital investment of children living in low income countries ranging from idiosyncratic shocks due, for instance, to job loss or death of adult family members to large macroeconomic shocks, such as those caused by macroeconomic crisis or natural disasters.

Recent papers have documented long-lasting effects of such shocks on adult outcomes such as educational attainment, socio-economic status, income, cognitive ability, disease, height or life expectancy. They confirm the fetal origins hypothesis (Barker, 1992): poor environmental conditions in-utero and early childhood inducing shocks to nutrition can have permanent effects on physiology and adverse consequences on later life outcomes. Evidence has been gathered in developed countries (Almond, 2006; Banerjee *et al.*, 2007; Currie and Moretti, 2007) as well as in developing countries (Dercon, 2004; Case *et al.*, 2005; Alderman *et al.*, 2006; Maccini and Yang, 2009; Gorgens *et al.* (2011); Leon, 2009; Grimard and Laszlo, 2010). Ferreira and Schady (2009) provide a literature review on the impact of aggregate economic shocks on child schooling and health, whereas Alderman (2011) produces a synthesis of recent works on the impacts of shocks in early childhood development.

Establishing a causality between conditions during early life and outcomes later in life is the main concern of most of the recent research papers. A promising way to identify any causal link is to analyze the consequence of exogenous shocks, like pandemics, extreme drought or civil war and exploiting the variation in the temporal and geographical incidence of these exogenous shocks. Almond (2006) uses the 1918 influenza pandemic as a natural experiment for testing the long term effects on in-utero influenza exposure on several American adult outcomes. He estimates that children whose mother has been infected had a probability to graduate from high school up to 15% lower than other children, men wages were reduced by 5 to 9% and the probability of being poor increased by 15% for affected cohorts. Banerjee *et al.* (2007) identify the impact of Phylloxera, an insect that attacks the roots of grape wine and destroyed 40% of French vineyards between 1863 and 1890, on height and health outcomes of young male adults. They estimate that children of wine-growing families born during Phylloxera crisis were 0.6 to 0.9 centimeters shorter than others by age 20. Gorgens *et al.* (2011) estimate the long run impact of the China's Great Famine on survivor health outcomes and exploit a source of variation in the regional intensity of food shortage derived from an institutional determinant of the Great Famine. Controlling for selection, they found that rural famine survivors who were exposed to shortages in the first 5 years of life are stunted between 1 and 2 cm. They also measure the selection effects and estimate that height-related selection has increased the average height of rural women survivors by about 2 cm. Leon (2009) and Grimard and Laszlo (2010) use the variation in the incidence of civil conflict in Peru from 1993 to 2007 to analyze the impacts of such a conflict on educational attainment and health outcomes. They show that cohorts of women in-utero during the conflict are smaller than the other ones. Maccini and Yang (2008) examine less extreme and unusual early-life conditions, *i.e.* rainfall shocks in Indonesia, on health, educational and labor outcomes of adults. The authors report striking results for women: those born in places experiencing a 20% higher rainfall than normal at their time of birth are 0.57 centimeters taller, 3.8% less likely to report poor or very poor health status, complete 0.22 more grades of schooling, and live in households that score 0.12 standard deviations higher on an asset index. Finally, Alderman *et al.* (2006) exploit civil war as well as drought shocks to identify the long term consequences of early childhood malnutrition on schooling in Zimbabwe. They show that children that were stunted at pre-school age were also 3.4 cm smaller young adults, started school 6 months later and completed less grades of schooling (0.85 grades) than other children.

In this paper, we consider the effects of a natural disaster that has made a lasting impression in the mind of generations of people: desert locust invasions. Surprisingly very little is known about the impacts of such a natural disaster, though it occurs regularly in Africa, the Middle East and South-West Asia and concerns a total of 65 countries. This maybe due to the lack of adequate data and to the fact that locust swarms are more likely when rainfalls are high, so that their impact is mitigated by the higher crop yields that come with good rains. However, even if at the macroeconomic level the impact of locust invasions appears small, at the household level it can be very high for farmers which crops have been eaten. We estimate the long run impact of the 1987-1989 locust invasion in Mali on educational attainment outcomes using its regional variation inside the Malian territory. As the 1987-1989 locust invasion induced large crop shortages in specific affected regions but not national famine, we are able to identify non affected villages. Using the 1998 exhaustive Population Census data, we construct birth cohorts of individuals and compare those born and living in the years and villages affected by locust plagues with other cohorts., while controlling for rainfall variations, using historical climate data.

Beyond estimating the impact of locust invasion, the main contribution of our paper is to offer some insight on the likely impact of local or idiosyncratic shocks to which households in developing countries are frequently submitted, but that are difficult to observe in surveys. Locust invasions, because they strike randomly and are of a limited scope, but at the same time concern a large enough number of people, can be used as a natural experiment to analyze households ability to reduce the impact of such shocks.

We find that children whose household has been exposed to locust invasion while they were in-utero or aged less than six years have a lower probability of going to school and a lower number of completed years of schooling than other children. Indeed, the proportion of boys born during the shock and who later enrolled at school is reduced by 4.9% and by 3.5% for girls. This impact goes up to 6% for boys and 5% for girls living in rural areas. These negative impacts are also significant for children from two to five years old but a little bit less important. For boys, we do not find any real impact neither on the number of years of education nor on the probability to achieve primary school, while for girls, those who lived in a community affected by locusts invasions have completed between 0.25 and 0.67 lower grades than if they had lived in another community. This impact is significant for children who were in-utero during the shock as well as for those aged from one to twelve years old. Using information about the household occupation in 1998, we also identify another heterogeneous impact of the locust plague depending on this criteria: children belonging to farmer households have been much more affected than other children.

Our paper is organized as follows. Section 2 discusses the causes and consequences of locust invasions. Section 3 presents the empirical strategy, section 4 the data. Section 5 presents the results and some robustness checks. Finally section 6 concludes.

2 Locust invasions: origins and consequences

Mali is a large (1,242,000 square kilometers), sparsely populated (13 millions inhabitants in 2009) and low income (GDP per capita was $691 in 2009) country between the 10th and the 25th parallel. As such a large part of its territory is located in the Saharan part of Africa, a region threatened by drought and desertification that can hardly be used for agriculture. Poverty is high (headcount index was 61% in 2001 at the $1,25/day/capita absolute poverty line) and life expectancy very low (48 years in 2008), together with the literacy rate (26% in 2006, but in rapid progression, since it was only 19% in 1998). Malnutrition remains at a very high level: in 2006, 38,5% children under five had a height for age Z-score more than two standard deviations below the median for the international reference population. Agriculture employs about 40% of the active population and brings 37% of GDP (in 2007).[1] The country is very much submitted to natural and other external shocks due to its high dependence upon agriculture and the concentration of its exports on three commodities (gold, cotton and livestock).

Among these shocks, locusts invasion maybe the less frequent, but one of the most impressive, as exemplified by the citation at the top of this paper. The locust plague is "the curse of good rains" as it generally comes when precipitations are higher than average. The Desert Locusts (DL) live as harmless solitarious individuals in areas that are not, or only minimally, used for agriculture and have average annual precipitation of no more than 200 mm. These areas (called recession area) are distributed across several Sahel countries (see figure 1). When environmental conditions become favorable, mainly adequate, evenly distributed rainfall over a period of several years (Duranton and Lecoq, 1990), mass reproduction takes place. The increasing density then changes the insect's behavior and stimulates a gregarious phase which results in swarms of billions of insects. Those bands are able to migrate very long distances outside the recession area and pose a threat on agricultural productions in 65 countries of Africa, Middle East and South-West Asia, covering 29 millions square kilometers. Swarm size can be very large, varying between less than one square kilometer to several hundred square kilometers. Since there can be at least 40 millions and sometimes as many as 80 millions locust adults in each square kilometer of swarm and since a Desert Locust adult can consume roughly its own weight in fresh food per day, that is about two grams every day, one gets an idea of the amount of damage an average size swarm can indulge on a rural locality. A one square kilometer swarm, with 60 million insects can eat about 120 tons of food, that is enough to feed 2500 people during about 4 months. Fortunately, the Desert Locust diet is not limited to the fruits, cereals and vegetables human being eat, so that the damage might not be as bad as could be feared. Latchininsky and Launois-Luong (1997), in a monographic study of Desert Locusts in Central Asia and Transcaucasia, give a detailed list of more than 150 botanical species of all kinds. They mention other studies reporting as much as 400 species.

[insert figure 1 about here]

In the absence of preventive control, locust invasions can succeed with a high frequency and last for as many as 22 years. From 1860 to 2004, a total of nine invasions have taken place: 1860-1867, 1869-1881, 1888-1910, 1912-1919, 1926-1935, 1940-1947, 1949-1962, 1987-1989 and 2003-2004 (Lecoq, 2004). The costs of these invasions is not easy to estimate precisely, mainly because of lack of adequate data, and because invasions occur when rainfall are higher than average. Thus, in Mali, the 1987-1989 invasion did not result in major crop losses, at a macroeconomic level. On the contrary, in 1988, which is the year with the highest number of areas reporting locust swarms, yields for cereals were also at their highest (see figure 2). According to Thomson and Miers (2002), even when net damage is reported it does not go beyond 2 to 5% of total

[1] Source: World Development Indicators, World Bank 2009. The share of the active population employed in the agricultural sector is extracted from national accounts. It seems to be underestimated compared to the 1998 Population Census data that estimates this share around 81%.

production. In face of this, a debate has emerged about the opportunity to prevent and control the locust plague and how this should be done. Prevention supposes a close monitoring of the recession areas. As these are remote, sparsely populated areas, such control is costly to enforce. If successful, locust activity can be controlled before it threatens crop production. The second possibility is to wait until swarms have developed and are numerous, at which point a greater impact can be obtained, because of the greater density of locusts. At this point the massive chemical spraying of large areas remains the preferred weapon, in spite of its cost (300 millions euros spent in 1988, Lecoq 2004) and of its negative impact on the environment and on the health of farmers. Joffe (1997) attempts to present a cost-benefit analysis of Desert Locust Control. According to his results, preventive campaigns do not bring enough benefits in regard of their cost. The main argument in support of this conclusion being that even in the worst case scenario of massive destructions by swarms the cost of the lost productions barely amounts to that of preventive control. Moreover, as locust swarms cross borders, the benefits of one country's efforts to control locusts can be annihilated if neighboring countries do not invest at the same level. These considerations militate in favor of an insurance scheme, that would protect farmers against the risk of locust swarms, without incurring the monetary, health and environmental costs of chemical warfare.

The need for Desert Locust Control or for the compensation of invaded farmers can only be assessed through a better knowledge of the incurred costs. Indeed, even if low at the macroeconomic level, the impact of locust invasions can be high at a local or regional level. Swarms invasions are local by nature and there could be severely affected regions, or villages, in which major problems have been caused by the destruction of all or part of the harvest. But difficulties in this case do not come from aggregate shortages, but rather from distribution problems. This is confirmed by the Famine Early Warning System for Mali which reports that food shortages experienced during those years were caused not by pests, but rather by unequal distribution of food (Herok and Krall, 1995). Thomson and Miers (2002) have used field interviews to evaluate the impacts of swarms invasions in Mauritania and Eritrea. Peasants in both countries mention the lack of water as the first impediment to their farming activities. When talking about pests, farmers in Mauritania appeared more worried by the small, but regular, losses incurred due to birds, caterpillars, termites, ticks, rats, plant louse, squirrels, snakes, scorpions, jackals and monkeys. However, *"when the subject of locusts was raised, it became clear that these are regarded as an altogether different type of hazard, a periodic shock causing total destruction to an extent that is incomparable with the regular damage of other pests. A locust plague will eat an entire harvest and will leave no pasture for animals to graze. Most respondents (...) used vocabulary such as "catastrophe", "crisis", "disaster", reflecting the severity of the destruction and placing it on the same level as the last major drought. There is a saying that if a locust lands on a stone it will eat the stone"* (Thomson and Miers, page 11). These interviews confirm that farmers that lost part or all of their harvest due to locusts can be severely hit. In this paper, we shall look at the long term impacts of such shocks, focusing on the human capital building of young children.

[insert figure 2 about here]

The expected consequences of locust invasions at the household level are not completely straightforward. Theoretically locust invasions can have negative consequences for the entire population if a significant proportion of the available food is destroyed by the swarms and if it results in increasing inflation. But, as we have seen, it does not seem likely. Hence, the impact sign and size will depend mainly upon the household location and activity on the labor market. Farmers in invaded villages are expected to be more concerned than teachers in non invaded villages for instance. Locally, in invaded villages, some households could profit from locusts, but it will depend on the markets village integration. If access to the food market is easy, then the destruction of harvests in a given village should not result in an increasing price of food. Only the farmers whose production has been destroyed should suffer through a reduction of their income. Those who exert their activity in the transport or commercial sector could benefit from the invasion, since the demand for their services increases. In case the village has no access to the food market, the local price of food would increase following the invasion. Household with low income and with low mobility would then suffer from the price increase even if they are not farmers. Besides farmers, breeders are another category at risk since locusts eat the same food as their cattle, but the size of the impact on this category will also depend upon their ability to access outside markets. There is also the possibility that the food destruction may be partly compensated by the increasing availability of protein that is brought by locust swarms. Indeed, locusts can be stir-fried, boiled or roasted and in many countries people eat locusts, particularly during outbreaks. However this can only be done when the swarms are not sprayed by chemicals.

As concerns our outcome variable, educational enrollment or attainment, it could be impacted by locust swarms in several ways. First of all, if locust invasions result in lack of food, education of young children could be impacted because of a deteriorated nutritional status. Young children suffering from a reduced diet maybe stunted or wasted, which could have a negative impact on their cognitive capacities. If invasion occurs during the in-utero life of the child, it could have long lasting effects on its health if the pregnant mother's health or nutritional status is impacted (Barker, 1992). Second, the reduced income impact that swarms can have on the household, could induce the poorest of these households to withdraw their children from school or to delay their school enrollment, in order to smooth consumption (Jacoby and Skoufias, 1997).

3 Empirical strategy

We assimilate locust invasions to a "treatment" administered to the invaded villages. The effect of this treatment is estimated using a difference in difference estimator. The fact that locust invasions have no observable impacts at the macroeconomic level provides us with an appropriate setting for evaluating their impact at the local level. Impact evaluation is based on the comparison of outcomes between invaded (so-called "treated") and non invaded ("untreated") areas. If locust invasions have non negligible macroeconomic impacts, then the comparison between treated and untreated units will tend to under-evaluate their impact, as non invaded areas could be "contaminated" through market price effects. The fact that global food availability does not decrease significantly during invasion years, guarantees that non invaded areas are not affected by the reduction in farms yields that occur in invaded areas.

Let S_{cv} be a measure of educational investment (eg. enrollment) or outcome (eg. grade) for people born in year c in village v. Let T_v be a dummy that equals 1 if village v has been invaded by locusts and C the birth date of the observed individuals. The basic regression for evaluating the impact of locust invasions on educational investment or outcome of cohort c in village v is written:

$$S_{cv} = \alpha + \beta_c.1_{\{C=c\}} + \gamma.T_v + \delta_c.1_{\{C=c\}}.T_v + \varepsilon_{cv} \quad (1)$$

where δ_c measures the impact of the locust invasion on cohort c, γ accounts for fixed differences between treated and untreated villages and β_c for differences between cohorts that are common to all villages.

One important feature for our concern is that locust invasions are more likely when rainfalls have been high for many years. This does not necessarily mean that villages that have been attacked by locusts have themselves benefited from high rains, because the breeding areas in which locust reproduce are not the same as the invasion areas. As concerns Mali for instance, this means that locust swarms form in the Saharan part of the country, but that harvests are more likely to be destroyed in the Sudanese-Saharan part of the country. Thus, though rainfall levels in the recession area are positively correlated with the probability of insects mass reproduction and swarms formation, there is no direct association between rainfall levels in a given village and the probability of a locust invasion in that village. However, when rainfall levels are higher than average in the Saharan part of Mali, there is a good chance that it will be also the case in the southern part of the country. For this reason we complete the model and control for precipitation levels around the birth date and the date of schooling of observed individuals in order to make sure that we do not confound the effects of rainfalls with those of locusts. We also add a village fixed effect in order to account for differences between villages in the availability of schools and other relevant infrastructure.

$$S_{cv} = \alpha + \beta_c.1_{\{C=c\}} + \gamma.T_v + \delta_c.1_{\{C=c\}}.T_v + \sum_{l=1}^{L}(\eta_{-l}.R_{c-l} + \eta_{+l}.R_{c+l}) + \eta.R_c + \mu_v + \varepsilon_{cv} \quad (2)$$

where R_t is the measure of precipitations in year t. The fixed effect model does not allow the identification of the impact of fixed differences between treated and untreated villages. But it remains possible to identify the treatment effect.

Though we observe the outcome variable for each inhabitant in the treated and untreated villages, the dependent variable in the model is the village average of this variable for each birth cohort. This choice is dictated by the fact that the treatment variable, together with other covariates, are observed at the village level and our choice of individual level variables is very restricted. Moreover, working with individual observations has it own disadvantages as one should hold account of the correlation of residuals between inhabitants of the same village. On the other hand, the use of averages introduces heteroskedasticity, since the number of inhabitants over which averages are computed varies from one village to another, and autocorrelation in the residuals cannot be excluded, due to potential intertemporal correlation of village-level aggregate shocks. In order to hold account of this heteroskedasticity we employ robust estimates of the variance-coviance matrix.

4 Data

4.1 Locust localization and rainfall data

The information on locust swarms localization are extracted from the FAO's Desert Locust Bulletins, produced by the Desert Locust Information Service (DLIS) and publicly available.[2] In each Bulletin, there are detailed information on locust swarms identification and localization followed by forecasts. During periods of increased locust activity, bulletins are supplemented with alerts and updates. We code each Malian locality listed by these bulletins as having been affected by locust swarms between June 1987 to June 1989. Figure 3 places the 979 villages identified. The locust invasion spreads over an area on the middle of Mali that stretches from the East border to the West border of the country. Some areas seem particularly affected by locust swarms whereas others much less. Unfortunately, we cannot assert that these differences are entirely due to locust invasion variations and not to regional variations in the warning system. In the 80's, reporting of locusts attacks was mainly based on phone calls of people that observed locust swarms in the place they live. It is possible that, in some areas, observations are less exhaustive than in other places or that people declare only the name of the village they live in. It could also be the case that people reporting were better informed than others about the existence of the Desert Locust Information Service or were expecting help from the government following the attack. The fact that we observe that the locusts affected villages group is, on average and in 1998, more urban and less agricultural than others confirms this last hypothesis (see below). This could create a self reporting bias for two reasons. First, the fact that reporting areas are more urban could lead to a reduction in the estimated size of the impact if, as is likely the case, children in urban areas are more likely to go to school than those in rural areas. Second, incomplete observation of swarms attacks will lead to the same kind of bias, as some of the villages taken as controls will also be affected by the

[2] http://www.fao.org/ag/locusts/en/archives/archive/index.html

locust plague. The fixed effects estimate will control for the first source of bias, but not for the second. Thus our estimates should be considered as a lower bound of the true impact of locust swarms attacks.

[insert Figure 3 about here]

Thanks to the geo-referencing of each locality,[3] we match its coordinates with rainfall data from the Climate Research Unit (CRU) at the University of East Anglia. Precipitation levels are available from 1901 to 2006 on month-by-month basis with a precision of 0.5x0.5 degree. We compute annual rainfall shocks for each locality, as the difference between the natural log of precipitation at time t of a given village and the natural log of mean annual precipitations in the given village calculated over 1940-1998 period. Given that rainfalls are likely to affect the welfare of households, particularly in the rural areas, and to control for the potential correlation between locust invasion and high precipitations during years around the birth date we compute the rainfall shock variables ten years in a row, starting three years before the birth date and ending seven years after the birth date.[4]

4.2 Educational variables

We construct a panel of birth cohorts using the exhaustive 1998 Population Census of Mali matched with GIS data on locust plague. The Malian 1998 Population Census data give information on the place and duration of residence, the age and the place of birth for each individual. The place of residence is known at the locality level (there are around 10,000 localities in Mali) whereas the place of birth is collected at the *cercle* level (50 *cercles*). We then restrict our sample to individuals that never moved from their place. This could lead to an under-estimation of the impact of locust invasions if migration is more likely after a locust shock.

We limit the sample to individuals from 37 to 7 years-old in 1998, that is to say individuals born from 1961 to 1991. For the sake of comparability, we exclude from the control group Bamako, the capital city that concentrates a huge part of the urban population of the country. As Mali is a very poor country with a very low rate of literacy and inefficient birth certificate administration, individuals do not declare their date of birth but simply their age. This lack of precise data on birth date first prevents us identifying exactly when individuals have been affected by locust invasions, and, second, does not make possible to know if they were born during the dry or wet seasons that could influence the rainfall impact on educational attainment (Maccini and Yang, 2009).

Table 1 gives the number of villages per cohort in the treatment group, control group, as well as the average number of individuals per cohort and group. It can be seen first that, due to mortality, the oldest cohorts are less numerous than the youngest ones. Second, due to errors in the declaration of age and approximation around 10, 15, 20, etc. years old, cohorts 1988, 1983, 1978, 1973, 1968 and 1963 are more numerous than the cohorts close to them. For instance, the average number of 25 years old people (cohort 1973) per locality is 16 individuals compared to 9 individuals for the 1972 or 1974 cohorts. Nevertheless, the cohorts 1990 to 1986 have been potentially affected by the 1987-89 locust plagues during the in-utero or early childhood, whereas the children born between 1985 to 1976 were at the age of primary schooling during the 1987-89 locust invasions.

To assess, as far as possible, the heterogeneity of the impact, we distinguish rural and urban localities and, among them 3 sub-groups of individuals depending on the household head occupation declared in 1998:

[3] Actually, the 1998 census data does not provide the coordinates of 1,200 localities (among 10,000) mostly located in northern Mali. We complete the coordinates of the dataset only for localities affected by locust plagues.

[4] Since children enter school at around six or seven years old, we control for up to seven years after the birth date, in order to account for any impact that rainfall variations might have on school enrollment.

farmer, breeder, shopkeeper. In doing this, we implicitly assume that people had lived in the same household since their birth and that the household head occupation had not change since then. We recognize that these needed hypotheses are quite strong. Table 2 shows the sample size of each group for the cohort 1988. Localities affected by locust invasions are, compared to the control group and in proportion more urban than rural. Moreover, in these localities, the proportion of farmers is lower than in Mali at large, both in the urban and rural areas. For instance, people belonging to farmer households represent 63% of the sample in rural localities affected by locust invasions whereas this proportion is equal on average to 82% in the other rural localities. There are also more people belonging to breeder households in rural localities affected by locust invasion than in the other ones (10% *versus* 3%). This suggests the existence of an urban bias in the declarations of locust invasions, that, as we mentioned in the previous section, might lead to an underestimation of the true impact of locusts swarms.

[insert table 1 and 2 about here]

To measure educational attainment, we extract three variables: the enrollment rate (the proportion of individuals that have been at school), the number of classes attended at the primary school level by people attending school and the proportion of individuals that have achieved the primary level (among people that attended primary school). All these outcomes are computed for girls and boys separately. The graphs below (figures 4 and 5) plot the means of the three educational variables by cohort (born from 1961 to 1991) for all villages included in this analysis and separately for villages affected and not affected by locust invasions. As can be seen, the educational level of the cohorts before 1982 is very low. Enrollment rates at the primary level started to increase only for cohorts born after 1982. Within five years, it has doubled for boys and almost tripled for girls. In fact, Diara *et al.* (2001) reports a "non linear evolution" of gross enrollment rate in Mali since independence, mainly due to lack of investment. First, it has increased in a large way during the 60-70's, then slowed down until decreasing during the 80's before improving again during the 90's until now. This is illustrated by the breakpoint occurring at cohort 1983, i.e. the cohort in age to enter school in 1990, on the enrollment rate graph. Nevertheless enrollment rates are at best equal to 25% for boys and 16% for girls at the middle of the 1990s (people born between 1986 and 91). Moreover, whatever the cohort of birth, less than 40% of people that attended primary school have achieved the Primary level (see the third graphs of figures 4 and 5). Since in Mali school starts at seven and primary level is composed of six grades, only cohorts born before 1987 could have achieved primary level in 1998. The three education variables follow similar trends in locusts affected and non affected areas, for boys and girls. Indicators for girls in locusts areas are slightly over those for non locusts areas, which is coherent with the high proportion of urban localities inside identified locusts areas. A sizable divergence emerges nonetheless between locust affected and non affected areas from cohort 1983: locusts affected localities experiment a much lower increase in enrollment rates. The gap between the two trends started for children aged 5 or 6 during the shock and keeps increasing for children born at the time of invasion.

[insert Figure 4 and Figure 5 about here]

5 Results

Results are presented in tables 3 to 7. In order to save space, we chose to report only the coefficients of the cohort times locust invasion dummy variable. All regressions include controls for rainfalls up to three years before the birth date and seven years after, together with birth cohort dummies.[5] Robust standard errors are reported whereas village fixed effects are not shown.

[5]Rainfall coefficients are reported in tables 8 and 9 and will be commented later.

Columns 1 and 3 report the estimated coefficients for the village/community average school enrollment regression for boys and girls; column 2 and 4 for the average number of years of schooling among enrolled boys and girls respectively and column 3 and 6 for the proportion of boys and girls that completed primary school, also among those enrolled.

For boys and girls in Mali as a whole, the striking result is the strong and significant negative impact of locust swarms on the enrollment of children born after 1982 (tables 3, columns 1 and 3). The strongest impact is found for cohorts 1988, 1989 and 1990, that is for children that were in-utero or less than one year during the locusts invasion. [6] For boys, the proportion of children born in 1988-1989 that were or had been enrolled at school in 1998 is reduced by 4.9 percentage points if they lived in a community invaded by locusts. For girls the impact size is smaller: 3.5% but remains significant. To fully understand the amplitude of this gender gap, we have to put it in light of the Malian educational context. In fact, as mentioned in section 4.2, school enrollment in Mali is very low and for children born in 1988 we globally observe a school enrollment rate of 23% for boys and 14% for girls. This means that a 5% decrease translates into a 21% reduction of the school enrollment rate. For girls the reduction is even larger, in relative means, since the 3.5% drop in enrollment rate translates into a 25% reduction in the proportion of enrolled children, which is coherent with the gender gap reality observed in the country. Indeed, when we look at the first graphs in figures 4 and 5 we note that the boys' enrollment rate is approximately twice that of girls' over the whole cohorts. In Mali, as in many other developing countries, boys are fully responsible of their family needs, and are in charge of providing income; therefore their education is considered more of a priority's than girls'. Moreover, some religious and traditional values, like early wedding and domestic works, do not promote girls school enrollment and attainment but keep them mainly in charge of household's activities (Soumare, 1994; Diarra and Lange, 2000). Hence, in times of economic difficulties, girls' education is more inclined to be affected than that of their "brothers", either because priority in food allocation would be given to boys, leading to girls' deteriorated cognitive capacities, or because girls manpower is requested to increase the earning capacities of the household.

Also striking is the fact that before 1983, the cohort times locust invasion interaction dummy coefficient is never found significant for girls and sometimes positive for boys (in 1972, 1977, 1979, 1980 and 1982). In Mali school normally starts at 7. Children born in 1983 were at most 6 in 1988 and 7 in 1989, so it is not obvious to explain why their school enrollment should be lower than that of children born one year earlier. However, as we have seen, people are relatively imprecise when reporting their age and we observe peaks in the age distribution around multiples of 5. People born in 1983 were 15 in 1998. Because of reporting mistakes, many of those that declared being 15 in 1998 were in fact born earlier than 1983. This could explain why the 1983 cohort coefficient is found negative if locust invasion have a negative effect on the probability to enter school. Such reporting mistakes could also explain why those that were declared born in 1990 are also found negatively impacted, though the swarms attack occurred after their reported birth date. The other possibility being a strong and negative impact on those children that were in-utero when the invasion happened.

What could explain these results ? The channels through which locust swarms could impact school enrollment are twofold. First, impoverished, stricken households could decide to keep their child at home in response to a need for labor. If this is the case, then we should observe that older children have a lower educational attainment, as they are also likely to be withdrawn from school. Second, the lack of food that could follow from the locusts invasion might have a negative and durable impact on the strength and cognitive abilities of children. In face of this, household might decide not to enroll them. For girls, the results

[6] The equality hypothesis between coefficients of cohorts 1990-88 and 1983-85 is rejected which corroborates the fact that the locusts plague had a heterogeneous impact on the enrollment of children, diminishing with age. These results are observed for boys and for girls at the full sample level, as well as at more disaggregated ones (tests not shown).

for educational attainment (column 5, table 3), validates the first line of explanation, without excluding the second. We find that for all cohorts born after 1977, the number of completed years of schooling is lower if in 1988-1989 they lived in a community attacked by locusts. A negative sign is also found for earlier born girls and for the proportion completing primary school, but the coefficient is generally of a smaller size and less significant. The major significant effect at 5% level is found for cohort 1981 i.e girls in age of entering school during the plague, who completed 0.67 lower grades. Significant impact on primary level completion is also reported for girls who were in age of entering school in 1987-1989: 10% of those enrolled at school have not achieved their primary level. Enrolled boys educational attainment, on the other hand, does not seem much impacted (columns 2 and 3, table 3). Girls schooling achievement seems to be more sensitive to the shock than boys'.

As locusts eat the harvests of farmers and the food of cattle one expects their impact to be higher in rural than in urban areas. This is what we find, as can be seen for boys and girls in tables 4 to 7. No effect is found in urban areas (table 4), which confirms that the partial destruction of harvests had no sizable macroeconomic effect. In rural areas on the contrary (table 5), the effect is found stronger than in Mali at large, with locust swarms reducing the proportion of enrolled children by 5 to 6 percentage points for children born in 1988 or 1989. Between cohort and outcomes the same pattern is found than when urban and rural areas are pooled.

We look now at the results obtained when the rural population is split by the household head occupation (tables 6 and 7). As cohorts of children belonging to breeder household or shopkeeper households were too thin, we pool boys and girls together (table 7). We find that, as expected, farmers are impacted (table 6). The effects are similar to those obtained when all occupations are pooled. On the contrary, no significant impact is found on cattle breeders (columns 1 to 3, table 7). This result might be a consequence of the reduction in the reference population over which means are computed, when we look at occupation categories separately. Another possibility is that breeders in villages invaded by swarms are able to get food for their cattle from outside markets. Finally, the possibility that swarms attacks open new profit opportunities for those engaged in trade is not obvious, as children living in household which head is employed in the commercial sector do not seem to fare better than others, whether they live in rural localities (columns 4 to 6, table 7) or in cities (results not shown).

Rainfall shocks coefficients are reported in table 8 for boys and in table 9 for girls, both for rural localities. At first sight, these coefficients reveal a large and significant impact on school enrollment of rainfall shocks occurring from three years prior to four years after the birth date. Coefficients are chronologically decreasing, the major effect being found for rainfall shocks happening three years prior to birth and affecting boys' school enrollment rate by 3.2% and girls' by 2.7%. Increasing trend in rainfall shocks coefficients should not be due to difference in shocks magnitude as a shock occurring one year prior birth for a cohort will be the shock occurring one year after birth for the cohort born two years later.

The fact that rainfall shocks occurring during in-utero or early childhood periods are strongly significant confirm that rainfalls play a large part in children development and affect education mainly through the nutritional channel. However, rainfall shocks at the time of school admission also affect significantly children school enrollment but in a much smaller way. We find no impact of rainfalls on boys' grade achievement, but detect one for girls while in-utero or at age three. Rainfall shocks occurring on children in age to enter school impact children belonging to a farmer's household more than others. Whether we should expect this difference to be positive or negative is not obvious. On the one hand, good rainfalls might have a negative effect on school enrollment if it results in an increasing demand for labor in farmer households. On the other hand, it could be that farmer households, more than others, benefit from an increase in resources following rainfalls levels higher than usual, and that this translates in an increasing demand for schooling. But this is not confirmed by the estimated coefficients for rainfalls variations occurring during in-utero and early childhood years, as they appear very similar between samples, even slightly smaller for farmers.

When we look at treatment effect coefficients, both with and without controlling for rainfalls shocks around the time of birth (table A.1), we notice a very large difference: coefficients without control for rainfalls overestimate the treatment effect by more than 60% for rural boys of cohort 1988. This confirms Maccini and Yang (2008) findings and certifies that rainfall shocks at the time of birth can have a considerable impact on later cognitive outcomes. Controlling for rainfalls is therefore a necessary condition when dealing with long run impacts of economic shocks in developing countries.

In light of previous results and especially with regard to the amplitude of rainfall shocks effects on education, we decide to test the robustness of our results by adding rainfalls shocks that occurred at the time of invasion (1987-1989) for all cohorts in our specification. These shocks happened at a different time in life for each cohort. We find that adding control for rainfalls shocks during the locusts plague does not alter our results. The treatment effect coefficients are slightly stronger, still in a negative way, which confirms the "curse of good rains".

To further test our specification, we run a placebo test. This procedure consists in generating a new variable, placebo of the treatment variable, which has same properties than the treatment variable. In our case, we drop the locusts affected localities dummy and generate a new binomial random variable with a probability of occurrence of 0.092, equal to the proportion of locusts affected localities identified in the original database. We substitute the locusts affected localities variable with the placebo one in our specification and run it several times. None of the coefficients associated with the placebo variable are significant, confirming the validity of our identification of the long run impact of locusts plague on children education.

6 Conclusion

This paper finds that the large and negative income shock induced by the 1987-1989 locust plague in Mali has long run impact on educational enrollment and completion of children who experienced the shock at a critical time of their childhood.

The identification strategy is defined at the village level and assimilates the shock as a "treatment". Therefore, we propose a difference in difference within village strategy which allows us to identify the impact of the locust plague on average educational outcomes per village, exploiting the geographical variation of locust invasions.

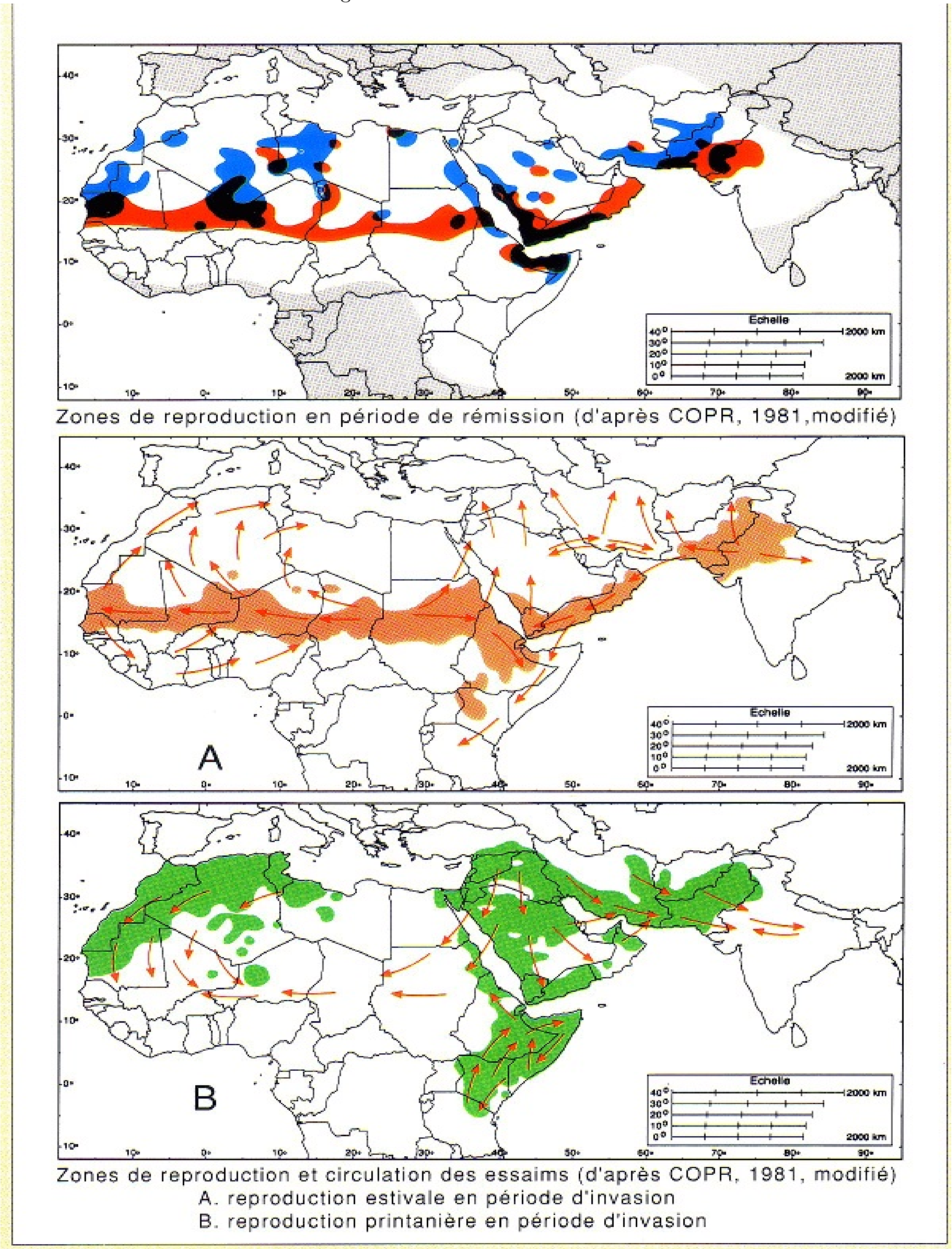
We find a clear and strong impact on school enrollment of children born or aged less than seven years old at the time of shock. Children born in 1988, the main year of invasion, are those whose school enrollment has been the most affected by the plague. Boys are more strongly affected than girls, but on the other hand, girls schooling achievement seems to be more sensitive to the shock as we find a significant and negative impact on the grade achieved for them but not for boys. We can attribute this mitigated impact to the fact that boys' education is considered more of a priority than girls'. Therefore girls' education might be more impacted than that of their "brothers" in times of food scarcity, either because priority is given to boys in the food allocation, leading to girls' deteriorated cognitive capacities, or because girls manpower is requested to increase the earning capacities of the household.

In our study, we allow for a heterogeneous impact of shocks along age, sex and household head occupation and pay particular attention to the difference between urban and rural households. As we expected the impact in rural areas is much stronger and significant than that in urban areas, which confirms the low macroeconomic impact of locust invasions. The impact is also found much stronger for farmer household, whereas cattle breeders as well as shopkeeper households have not been affected at all by the locust plagues.

Our results suggest that at least part of the adjustment seems to have happened at the nutritional level, impacting on the long run children who were at an early stage of development and girls who are more vulnerable members within a household. The difference in impacts between boys and girls claims that some consequences could have been lowered and even avoided if discrimination had not happened and if insurance scheme had been provided to vulnerable households. This paper contributes to the literature by showing that consumption smoothing is not completely possible even when facing an idiosyncratic shock, as this is the case for the 1987-1989 locust plague (Skoufias *et al.*, 1997).

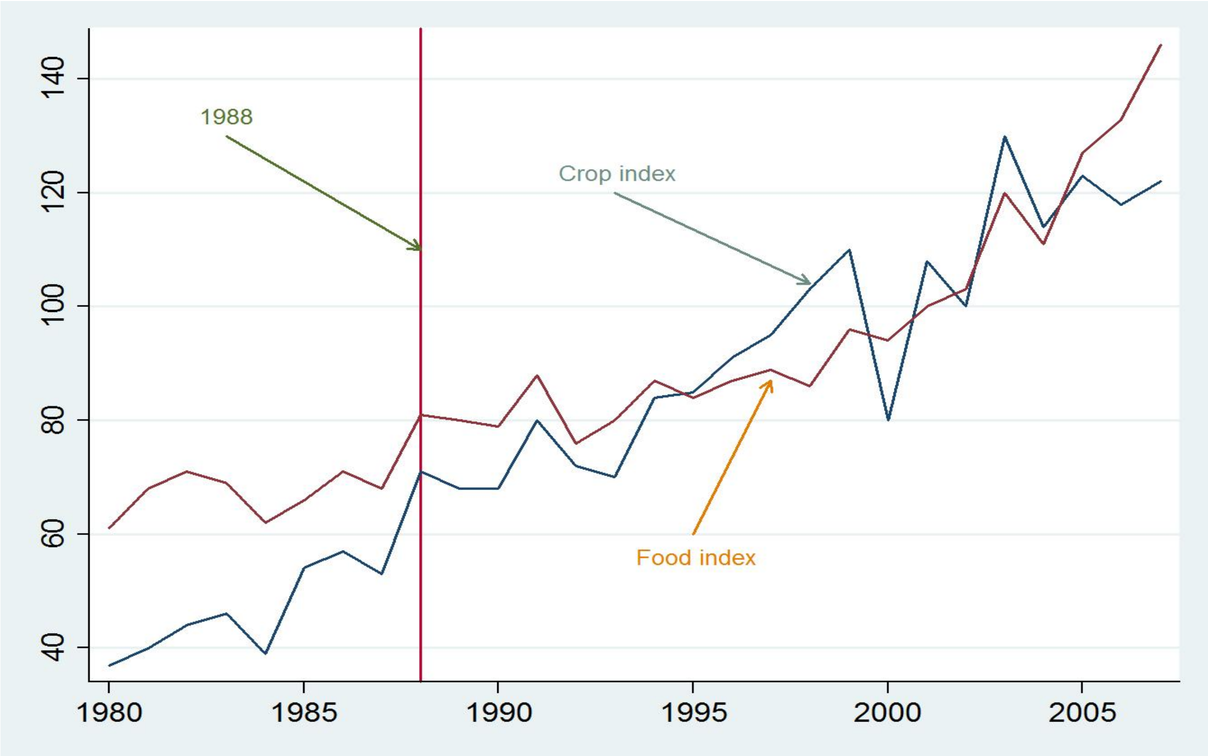
Further work, using data on health and nutrition status, will help to precise these results, as it will allow to better identify the channels through which locust invasions impact education.

Figure 1: Locust invasion in Africa



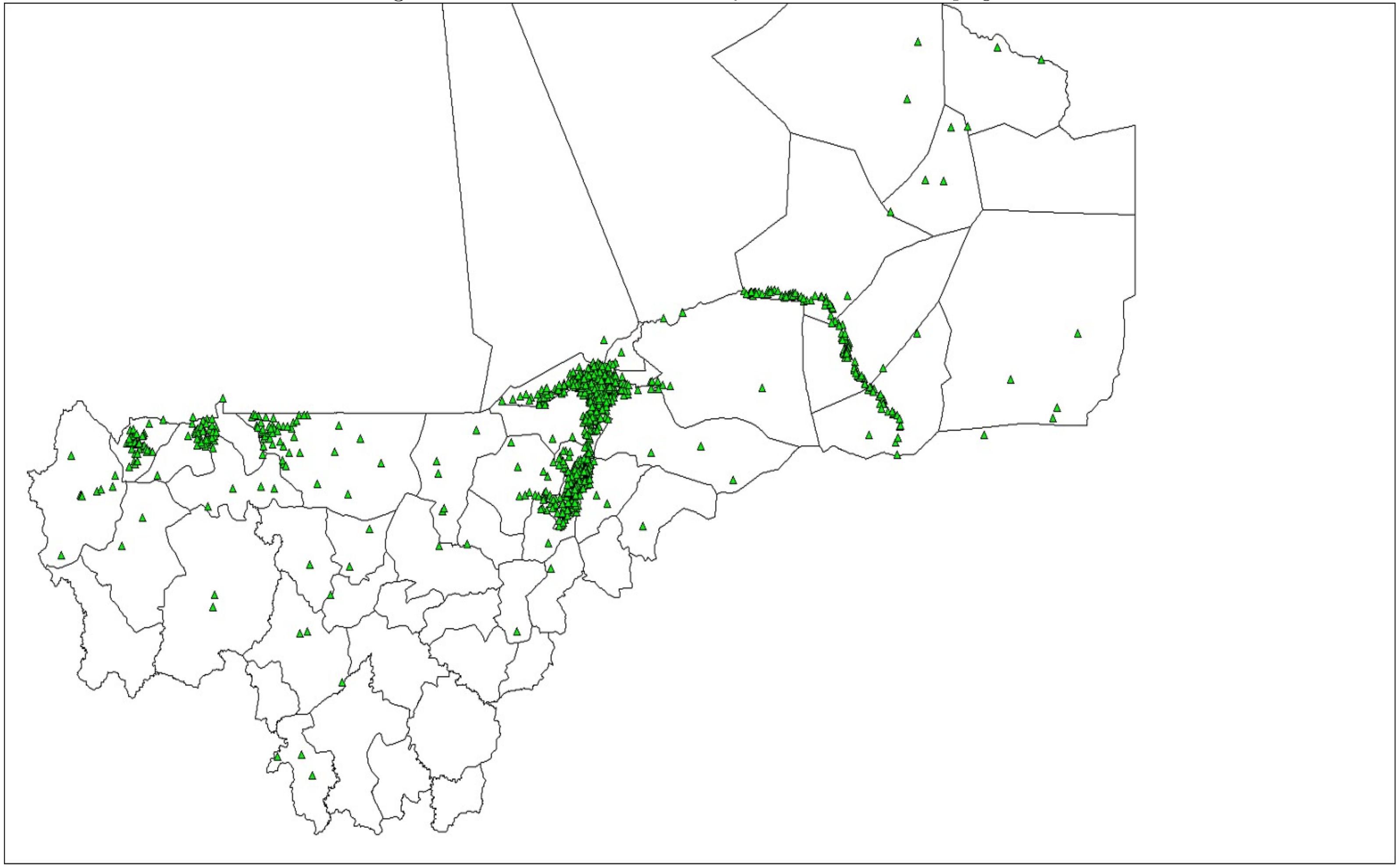
Source: http://www.cnlcp.net/

Figure 2: Crop and food production indexes



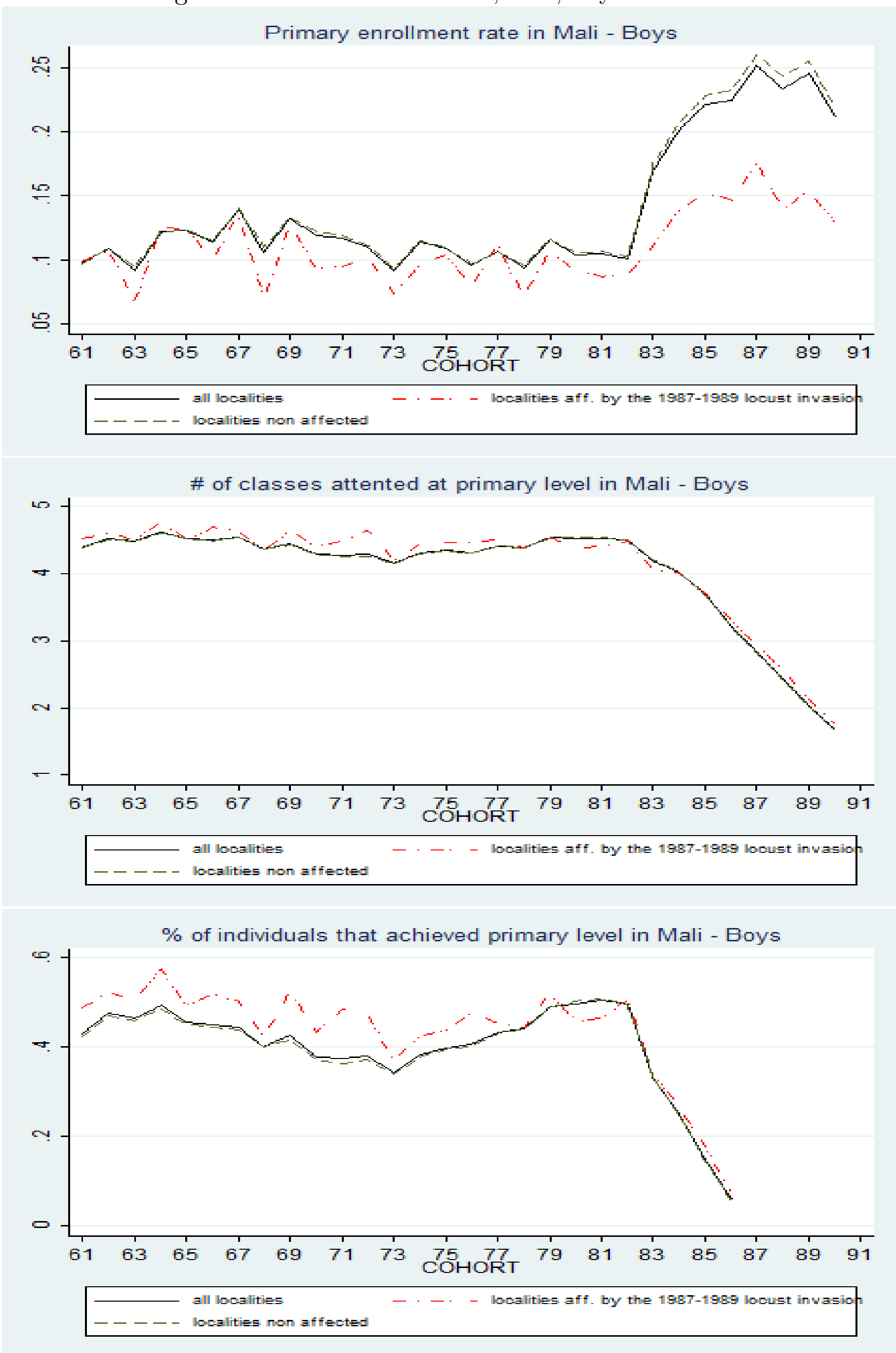
Source:http://countrystat.org/mli/cont/pxwebquery/ma/133cpd010/fr, authors' calculations.

Figure 3: Malian Localities affected by the 1987-1988 locust plagues



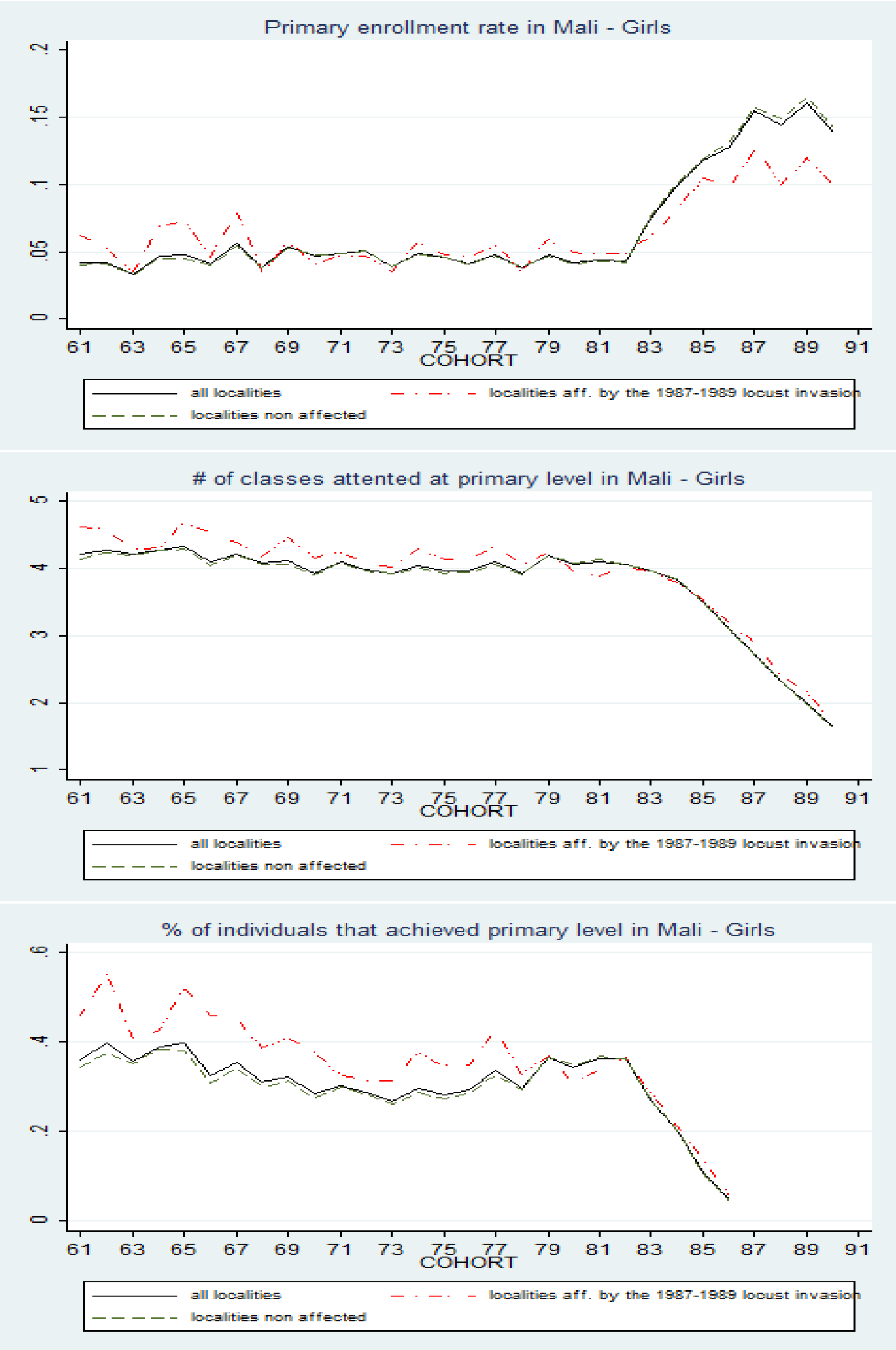
Reading: Each dot corresponds to a Malian locality listed by the FAO's Desert Locust Information Service (DLIS) as affected by locust swarms between 1987 and 1989.

Figure 4: Educational variables, Mali, Boys 1961 - 1991



Note: These graphs are computed on people that never moved from the place they live in 1998. Moreover, people that live in Bamako are excluded from the sample.
Source: Malian Population Census data, 1998, our own calculation.

Figure 5: Educational variables, Mali, Girls 1961 - 1991



Note: These graphs are computed on people that never moved from the place they live in 1998. Moreover, people that live in Bamako are excluded from the sample.
Source: Malian Population Census data, 1998, our own calculation.

Table 1: Number of treated and controlled localities and average number of individuals by cohort.

Cohort	Locust localities /Treatment group	Other localities /Control group	Total
1991	954 (37)	9,048 (28)	10,003 (29)
1990	957 (37)	9,040 (27)	9,997 (28)
1989	932 (25)	8,948 (20)	9,880 (20)
1988	960 (35)	9,024 (24)	9,984 (25)
1987	879 (21)	8,827 (16)	9706 (16)
1986	938 (31)	8,942 (22)	9,880 (23)
1985	899 (23)	8,903 (17)	9,802 (18)
1984	908 (24)	8,879 (17)	9,787 (18)
1983	943 (29)	8,989 (20)	9,932 (21)
1982	901 (24)	8,852 (16)	9,757 (16)
1981	905 (20)	8,786 (14)	9,687 (14)
1980	942 (27)	8,930 (18)	9,872 (19)
1979	826 (27)	8,459 (18)	9,285 (10)
1978	952 (32)	8,965 (19)	9,917 (20)
1977	789 (12)	8,262 (9)	9,917 (9)

Notes: Average number of individuals per cohort are in brackets (boys and girls aggregated).

Table 1 continued

Cohort	Locust localities /Treatment group	Other localities /Control group	Total
1976	909 (17)	8,733 (12)	9,642 (13)
1975	826 (12)	8,406 (9)	9,232 (9)
1974	815 (11)	8,210 (8)	9,025 (9)
1973	944 (26)	8,838 (15)	9,782 (16)
1972	839 (12)	8,391 (8)	9,230 (9)
1971	855 (12)	8,411 (8)	9,266 (9)
1970	891 (16)	8,628 (10)	9,519 (11)
1969	742 (8)	7,650 (6)	8,392 (6)
1968	951 (31)	8,934 (16)	9,885 (18)
1967	681 (7)	7,525 (6)	8,206 (6)
1966	876 (12)	8,410 (8)	9,286 (9)
1965	751 (9)	7,847 (6)	8,598 (7)
1964	738 (9)	7,825 (6)	8,563 (6)
1963	940 (20)	8,680 (11)	9,620 (12)
1962	807 (9)	8,008 (7)	8,815 (7)
1961	782 (9)	7,892 (6)	8,674 (6)

Notes: Average number of individuals per cohort are in brackets (boys and girls aggregated).

Table 2: Breakdown of the sample according to urban and rural areas and household head occupation[(a)].

	Locust localities /Treatment group	Other localities /Control group	Total
urban localities	74 (168)	263 (113)	337 (125)
among			
Farmers	29%	40%	
Cattle farmers	3%	1%	
Shopkeeper	14%	14%	
Rural localities	886 (24)	8761 (22)	9647 (22)
among			
Farmers	63%	82%	
Cattle farmers	10%	3%	
Shopkeeper	2%	2%	

Notes: Average number of individuals are in brackets (boys and girls aggregated).
(a): Cohort 1988.

Table 3: Impact of locust invasion on education, boys and girls.

	(1)	(2)	(3)	(4)	(5)	(6)
	Boys	Boys	Boys	Girls	Girls	Girls
VARIABLES	School enrol.	Grade	Comp. prim.	School enrol.	Grade	Comp. prim.
Born in locust loc. year 91	-0.00550	-0.0572		-0.0195**	-0.495***	
	(0.00866)	(0.127)		(0.00762)	(0.140)	
Born in locust loc. year 90	-0.0415***	-0.0326		-0.0355***	-0.391***	
	(0.00900)	(0.125)		(0.00838)	(0.140)	
Born in locust loc. year 89	-0.0493***	-0.0140		-0.0346***	-0.305**	
	(0.00967)	(0.126)		(0.00911)	(0.139)	
Born in locust loc. year 88	-0.0487***	0.0627		-0.0356***	-0.346**	
	(0.00934)	(0.127)		(0.00814)	(0.139)	
Born in locust loc. year 87	-0.0422***	0.00280		-0.0262***	-0.263*	
	(0.0109)	(0.127)		(0.00956)	(0.146)	
Born in locust loc. year 86	-0.0349***	0.0222	-0.0121	-0.0250***	-0.324**	-0.0563
	(0.00979)	(0.129)	(0.0381)	(0.00843)	(0.143)	(0.0413)
Born in locust loc. year 85	-0.0327***	-0.0530	-0.00580	-0.0104	-0.403***	-0.0355
	(0.00980)	(0.132)	(0.0386)	(0.00883)	(0.150)	(0.0422)
Born in locust loc. year 84	-0.0208**	-0.102	-0.0124	-0.0143*	-0.482***	-0.0684
	(0.00987)	(0.134)	(0.0384)	(0.00802)	(0.146)	(0.0428)
Born in locust loc. year 83	-0.0214**	-0.188	-0.0208	-0.0112	-0.379**	-0.0468
	(0.00879)	(0.132)	(0.0381)	(0.00735)	(0.159)	(0.0436)
Born in locust loc. year 82	0.0211**	-0.0559	-0.00791	0.00581	-0.527***	-0.0715
	(0.00840)	(0.149)	(0.0433)	(0.00701)	(0.168)	(0.0469)
Born in locust loc. year 81	0.0102	-0.238*	-0.0917**	0.000821	-0.665***	-0.107**
	(0.00825)	(0.142)	(0.0428)	(0.00726)	(0.170)	(0.0477)
Born in locust loc. year 80	0.0199**	-0.208	-0.0613	0.00655	-0.462***	-0.0959**
	(0.00839)	(0.142)	(0.0427)	(0.00688)	(0.155)	(0.0443)
Born in locust loc. year 79	0.0189**	-0.0503	-0.00901	0.00784	-0.335**	-0.0669
	(0.00951)	(0.153)	(0.0444)	(0.00752)	(0.168)	(0.0492)
Born in locust loc. year 78	0.00782	-0.0441	-0.0247	-0.00183	-0.360**	-0.0553
	(0.00794)	(0.140)	(0.0411)	(0.00644)	(0.157)	(0.0455)
Born in locust loc. year 77	0.0267***	0.0173	-0.0142	-0.000730	-0.195	-0.00875
	(0.00989)	(0.151)	(0.0458)	(0.00744)	(0.170)	(0.0494)
Born in locust loc. year 76	0.0118	0.0805	0.0116	0.00369	-0.272*	-0.0257
	(0.00864)	(0.149)	(0.0427)	(0.00689)	(0.160)	(0.0469)
Born in locust loc. year 75	0.0140	0.0108	-0.00966	-0.00352	-0.332*	-0.0225
	(0.00915)	(0.153)	(0.0471)	(0.00698)	(0.174)	(0.0490)
Born in locust loc. year 74	0.00563	0.0101	-0.0209	0.00326	-0.230	-0.0247
	(0.00962)	(0.163)	(0.0456)	(0.00789)	(0.167)	(0.0500)
Born in locust loc. year 73	0.0127	0.0310	0.00884	-0.00358	-0.338**	-0.0378
	(0.00863)	(0.143)	(0.0424)	(0.00664)	(0.165)	(0.0470)

Table 3 continued.

VARIABLES	(1) Boys School enrol.	(2) Boys Grade	(3) Boys Comp. prim.	(4) Girls School enrol.	(5) Girls Grade	(6) Girls Comp. prim.
Born in locust loc. year 72	0.0175*	0.242	0.0408	-0.00546	-0.350**	-0.0636
	(0.0101)	(0.160)	(0.0497)	(0.00710)	(0.170)	(0.0488)
Born in locust loc. year 71	0.000610	0.105	0.0508	-0.00603	-0.246	-0.0558
	(0.00980)	(0.154)	(0.0455)	(0.00744)	(0.167)	(0.0517)
Born in locust loc. year 70	2.06e-05	0.00733	0.0107	-0.00718	-0.296*	-0.00664
	(0.00919)	(0.151)	(0.0433)	(0.00700)	(0.177)	(0.0505)
Born in locust loc. year 69	0.0119	0.0530	0.0476	-0.00111	-0.142	-0.0172
	(0.0114)	(0.161)	(0.0491)	(0.00778)	(0.184)	(0.0547)
Born in locust loc. year 68	-0.00154	-0.0533	0.00298	-0.000667	-0.319**	0.00547
	(0.00839)	(0.144)	(0.0432)	(0.00681)	(0.160)	(0.0449)
Born in locust loc. year 67	0.0106	-0.0445	-0.00911	0.0121	-0.299	-0.00781
	(0.0118)	(0.164)	(0.0482)	(0.00945)	(0.186)	(0.0547)
Born in locust loc. year 66	0.0119	0.0968	0.0275	-0.00121	0.0257	0.0442
	(0.00973)	(0.148)	(0.0437)	(0.00739)	(0.167)	(0.0509)
Born in locust loc. year 65	0.0106	-0.166	-0.0138	0.0105	-0.166	0.0233
	(0.0108)	(0.156)	(0.0452)	(0.00889)	(0.169)	(0.0524)
Born in locust loc. year 64	0.00404	0.126	0.0540	0.00407	-0.399**	-0.0617
	(0.0110)	(0.153)	(0.0464)	(0.00834)	(0.178)	(0.0515)
Born in locust loc. year 63	-0.00734	-0.0859	-0.00324	-0.00836	-0.199	-0.0176
	(0.00824)	(0.152)	(0.0434)	(0.00662)	(0.157)	(0.0464)
Born in locust loc. year 62	0.00525	-0.156	-0.0131	-0.00523	-0.154	0.0393
	(0.0103)	(0.151)	(0.0448)	(0.00746)	(0.187)	(0.0537)
Constant	0.0823***	4.317***	0.409***	0.0274***	4.023***	0.313***
	(0.00276)	(0.0396)	(0.0118)	(0.00187)	(0.0528)	(0.0148)
Rainfall control variables	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes
Observations	258471	88385	64008	267593	60814	41902
Number of localities	10113	7913	7522	10112	7073	6444
R^2	0.080	0.432	0.104	0.094	0.370	0.065

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 4: Impact of locust invasion on education, boys and girls, urban localities.

	(1)	(2)	(3)	(4)	(5)	(6)
	Boys	Boys	Boys	Girls	Girls	Girls
VARIABLES	School enrol.	Grade	Comp. prim.	School enrol.	Grade	Comp. prim.
Born in locust loc. year 91	-0.0164	0.0986		-0.00320	0.104	
	(0.0250)	(0.172)		(0.0224)	(0.168)	
Born in locust loc. year 90	-0.0529**	0.0839		0.00908	0.0747	
	(0.0252)	(0.172)		(0.0278)	(0.169)	
Born in locust loc. year 89	-0.0196	0.0512		0.0253	0.0751	
	(0.0269)	(0.164)		(0.0279)	(0.156)	
Born in locust loc. year 88	-0.0206	-0.0349		-0.0162	-0.0416	
	(0.0275)	(0.161)		(0.0281)	(0.154)	
Born in locust loc. year 87	-0.0143	-0.0275		0.0326	-0.0952	
	(0.0329)	(0.164)		(0.0279)	(0.162)	
Born in locust loc. year 86	-0.000463	-0.141	0.0180	-0.00249	-0.162	0.00199
	(0.0291)	(0.158)	(0.0472)	(0.0275)	(0.154)	(0.0507)
Born in locust loc. year 85	-0.00553	-0.101	0.0148	0.0231	-0.0644	0.0203
	(0.0296)	(0.165)	(0.0477)	(0.0276)	(0.156)	(0.0486)
Born in locust loc. year 84	-0.0152	-0.291*	-0.0384	0.0120	-0.193	-0.0164
	(0.0281)	(0.175)	(0.0468)	(0.0264)	(0.181)	(0.0521)
Born in locust loc. year 83	-0.0605**	-0.201	-0.0223	-0.00898	-0.0588	0.00722
	(0.0274)	(0.158)	(0.0475)	(0.0229)	(0.187)	(0.0575)
Born in locust loc. year 82	-0.0144	-0.0523	-0.0121	0.00225	-0.158	-0.0507
	(0.0258)	(0.176)	(0.0568)	(0.0232)	(0.165)	(0.0516)
Born in locust loc. year 81	-0.0398	-0.110	-0.0187	0.0144	-0.00860	-0.00441
	(0.0259)	(0.171)	(0.0503)	(0.0225)	(0.182)	(0.0566)
Born in locust loc. year 80	0.00974	-0.136	-0.0323	0.000238	-0.166	0.00776
	(0.0287)	(0.147)	(0.0468)	(0.0214)	(0.182)	(0.0542)
Born in locust loc. year 79	-0.00240	0.0140	0.0151	0.0214	-0.237	-0.0552
	(0.0312)	(0.166)	(0.0502)	(0.0255)	(0.195)	(0.0580)
Born in locust loc. year 78	-0.0312	-0.171	-0.0358	-0.0165	-0.216	-0.0564
	(0.0252)	(0.186)	(0.0523)	(0.0209)	(0.184)	(0.0600)
Born in locust loc. year 77	0.0183	-0.126	-0.0262	0.00725	-0.0443	-0.00248
	(0.0274)	(0.187)	(0.0603)	(0.0255)	(0.198)	(0.0614)
Born in locust loc. year 76	-0.0150	-0.0982	0.000547	-0.00413	-0.137	-0.0354
	(0.0279)	(0.192)	(0.0568)	(0.0193)	(0.179)	(0.0588)
Born in locust loc. year 75	0.00126	-0.102	-0.00338	-0.00349	-0.174	-0.0318
	(0.0249)	(0.178)	(0.0544)	(0.0227)	(0.204)	(0.0604)
Born in locust loc. year 74	-0.0104	-0.144	-0.0501	0.00955	-0.167	-0.0260
	(0.0256)	(0.199)	(0.0564)	(0.0252)	(0.218)	(0.0584)
Born in locust loc. year 73	-0.0270	-0.0279	0.0476	-0.00235	-0.0563	-0.00505
	(0.0235)	(0.180)	(0.0531)	(0.0195)	(0.198)	(0.0569)

Table 4 continued.

VARIABLES	(1) Boys School enrol.	(2) Boys Grade	(3) Boys Comp. prim.	(4) Girls School enrol.	(5) Girls Grade	(6) Girls Comp. prim.
Born in locust loc. year 72	-0.00608	0.0925	0.0216	0.0100	-0.138	-0.00436
	(0.0280)	(0.189)	(0.0613)	(0.0207)	(0.196)	(0.0556)
Born in locust loc. year 71	-0.00525	-0.112	-0.00834	-0.0174	-0.0817	0.00988
	(0.0288)	(0.189)	(0.0573)	(0.0227)	(0.196)	(0.0638)
Born in locust loc. year 70	-0.0500*	-0.315*	-0.0341	-0.0127	-0.0850	-0.0103
	(0.0270)	(0.189)	(0.0550)	(0.0207)	(0.210)	(0.0646)
Born in locust loc. year 69	-0.00434	0.0542	0.0505	-0.00782	-0.293	-0.0834
	(0.0321)	(0.205)	(0.0618)	(0.0241)	(0.217)	(0.0626)
Born in locust loc. year 68	-0.0128	0.131	0.0237	-0.000688	-0.194	-0.0123
	(0.0253)	(0.181)	(0.0564)	(0.0210)	(0.165)	(0.0524)
Born in locust loc. year 67	0.0343	0.154	0.0933	0.0137	-0.0795	0.0609
	(0.0339)	(0.212)	(0.0644)	(0.0245)	(0.211)	(0.0701)
Born in locust loc. year 66	-0.00347	-0.102	-0.0156	-0.0139	-0.242	-0.0400
	(0.0286)	(0.169)	(0.0516)	(0.0184)	(0.197)	(0.0631)
Born in locust loc. year 65	0.0379	-0.0986	0.0318	0.0123	-0.0564	-0.00535
	(0.0302)	(0.185)	(0.0536)	(0.0221)	(0.198)	(0.0589)
Born in locust loc. year 64	-0.00164	-0.0943	0.0244	0.0137	-0.233	-0.0131
	(0.0298)	(0.203)	(0.0623)	(0.0220)	(0.224)	(0.0650)
Born in locust loc. year 63	-0.0166	-0.134	0.0250	-0.00700	-0.0529	0.0101
	(0.0261)	(0.225)	(0.0610)	(0.0191)	(0.175)	(0.0535)
Born in locust loc. year 62	-0.0186	-0.110	-0.00417	-0.0104	0.165	0.0436
	(0.0243)	(0.194)	(0.0559)	(0.0212)	(0.219)	(0.0670)
Constant	0.275***	4.962***	0.615***	0.149***	4.817***	0.531***
	(0.0121)	(0.0668)	(0.0214)	(0.0101)	(0.0735)	(0.0225)
Rainfall control variables	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes
Observations	9913	7791	6352	10032	7357	5976
Number of localities	340	317	311	340	314	307
R^2	0.317	0.686	0.259	0.409	0.598	0.178

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 5: Impact of locust invasion on education, boys and girls, rural localities.

	(1)	(2)	(3)	(4)	(5)	(6)
	Boys	Boys	Boys	Girls	Girls	Girls
VARIABLES	School enrol.	Grade	Comp. prim.	School enrol.	Grade	Comp. prim.
Born in locust loc. year 91	-0.0120	0.0534		-0.0301***	-0.543**	
	(0.00922)	(0.173)		(0.00800)	(0.214)	
Born in locust loc. year 90	-0.0498***	0.0494		-0.0512***	-0.434**	
	(0.00957)	(0.171)		(0.00858)	(0.215)	
Born in locust loc. year 89	-0.0619***	0.0512		-0.0537***	-0.348	
	(0.0101)	(0.174)		(0.00928)	(0.216)	
Born in locust loc. year 88	-0.0605***	0.127		-0.0495***	-0.436**	
	(0.00975)	(0.177)		(0.00833)	(0.215)	
Born in locust loc. year 87	-0.0583***	0.0354		-0.0478***	-0.341	
	(0.0113)	(0.177)		(0.00972)	(0.225)	
Born in locust loc. year 86	-0.0480***	0.0548	0.0157	-0.0391***	-0.427*	-0.0399
	(0.0102)	(0.180)	(0.0532)	(0.00870)	(0.221)	(0.0629)
Born in locust loc. year 85	-0.0471***	-0.0718	0.00410	-0.0253***	-0.591**	-0.0406
	(0.0102)	(0.183)	(0.0542)	(0.00912)	(0.231)	(0.0647)
Born in locust loc. year 84	-0.0329***	-0.0658	0.000343	-0.0276***	-0.649***	-0.0899
	(0.0103)	(0.184)	(0.0539)	(0.00828)	(0.219)	(0.0647)
Born in locust loc. year 83	-0.0284***	-0.216	-0.0213	-0.0204***	-0.587**	-0.0801
	(0.00926)	(0.183)	(0.0535)	(0.00775)	(0.237)	(0.0645)
Born in locust loc. year 82	0.0154*	-0.151	-0.0339	-4.70e-05	-0.824***	-0.116
	(0.00893)	(0.206)	(0.0594)	(0.00740)	(0.257)	(0.0713)
Born in locust loc. year 81	0.00480	-0.406**	-0.149**	-0.00644	-1.085***	-0.188***
	(0.00873)	(0.195)	(0.0601)	(0.00771)	(0.251)	(0.0709)
Born in locust loc. year 80	0.0132	-0.289	-0.0822	0.00132	-0.636***	-0.158**
	(0.00877)	(0.199)	(0.0606)	(0.00733)	(0.233)	(0.0660)
Born in locust loc. year 79	0.0109	-0.185	-0.0420	-0.00138	-0.462*	-0.103
	(0.00993)	(0.219)	(0.0641)	(0.00787)	(0.255)	(0.0747)
Born in locust loc. year 78	0.00521	-0.0411	-0.0255	-0.00512	-0.482**	-0.0677
	(0.00843)	(0.191)	(0.0574)	(0.00689)	(0.237)	(0.0673)
Born in locust loc. year 77	0.0197*	0.0450	-0.00737	-0.00836	-0.359	-0.0173
	(0.0106)	(0.213)	(0.0638)	(0.00780)	(0.259)	(0.0742)
Born in locust loc. year 76	0.00868	0.113	0.0160	0.000279	-0.383	-0.0215
	(0.00917)	(0.208)	(0.0595)	(0.00745)	(0.238)	(0.0695)
Born in locust loc. year 75	0.0109	0.0560	-0.00678	-0.00888	-0.414	-0.00904
	(0.00989)	(0.219)	(0.0682)	(0.00742)	(0.262)	(0.0731)
Born in locust loc. year 74	0.00419	0.0561	-0.00241	-0.00219	-0.246	-0.0256
	(0.0104)	(0.230)	(0.0646)	(0.00839)	(0.247)	(0.0780)
Born in locust loc. year 73	0.0137	0.0331	0.000896	-0.00571	-0.462*	-0.0487
	(0.00930)	(0.198)	(0.0596)	(0.00718)	(0.245)	(0.0699)

Table 5 continued.

VARIABLES	(1) Boys School enrol.	(2) Boys Grade	(3) Boys Comp. prim.	(4) Girls School enrol.	(5) Girls Grade	(6) Girls Comp. prim.
Born in locust loc. year 72	0.0176	0.324	0.0620	-0.0105	-0.502*	-0.105
	(0.0109)	(0.229)	(0.0710)	(0.00763)	(0.263)	(0.0764)
Born in locust loc. year 71	9.80e-05	0.197	0.0867	-0.00748	-0.333	-0.0783
	(0.0105)	(0.218)	(0.0645)	(0.00795)	(0.253)	(0.0772)
Born in locust loc. year 70	0.00326	0.121	0.0374	-0.00911	-0.424	-0.00353
	(0.00982)	(0.207)	(0.0599)	(0.00757)	(0.268)	(0.0761)
Born in locust loc. year 69	0.0131	0.0618	0.0525	-0.00367	-0.0377	0.00230
	(0.0122)	(0.229)	(0.0704)	(0.00835)	(0.281)	(0.0858)
Born in locust loc. year 68	-0.000832	-0.110	-0.00463	-0.00207	-0.360	0.0193
	(0.00895)	(0.197)	(0.0593)	(0.00734)	(0.245)	(0.0677)
Born in locust loc. year 67	0.00689	-0.108	-0.0372	0.0101	-0.489*	-0.0597
	(0.0127)	(0.231)	(0.0680)	(0.0103)	(0.286)	(0.0820)
Born in locust loc. year 66	0.0126	0.190	0.0532	-0.00175	0.0942	0.0810
	(0.0104)	(0.208)	(0.0617)	(0.00803)	(0.252)	(0.0765)
Born in locust loc. year 65	0.00487	-0.161	-0.0206	0.00933	-0.213	0.0353
	(0.0117)	(0.224)	(0.0652)	(0.00973)	(0.260)	(0.0831)
Born in locust loc. year 64	0.00349	0.266	0.0904	0.00160	-0.512*	-0.0837
	(0.0118)	(0.212)	(0.0648)	(0.00909)	(0.265)	(0.0781)
Born in locust loc. year 63	-0.00614	-0.0358	-0.000789	-0.00844	-0.261	-0.0261
	(0.00881)	(0.201)	(0.0590)	(0.00715)	(0.235)	(0.0689)
Born in locust loc. year 62	0.00871	-0.198	-0.0226	-0.00649	-0.288	0.0390
	(0.0112)	(0.208)	(0.0626)	(0.00803)	(0.288)	(0.0813)
Constant	0.0752***	4.248***	0.384***	0.0232***	3.894***	0.276***
	(0.00282)	(0.0449)	(0.0134)	(0.00188)	(0.0646)	(0.0180)
Rainfall control variables	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes
Observations	248558	80594	57656	257561	53457	35926
R^2	0.076	0.416	0.097	0.086	0.349	0.057
Number of localities	9773	7596	7211	9772	6759	6137

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 6: Impact of locust invasion on education, boys and girls bel. to farmer households, rural localities.

VARIABLES	(1) Boys School enrol.	(2) Boys Grade	(3) Boys Comp. prim.	(4) Girls School enrol.	(5) Girls Grade	(6) Girls Comp. prim.
Born in locust loc. year 91	-0.00801	0.103		-0.0165*	-0.611**	
	(0.0107)	(0.194)		(0.00860)	(0.269)	
Born in locust loc. year 90	-0.0477***	0.125		-0.0436***	-0.468*	
	(0.0112)	(0.191)		(0.00895)	(0.270)	
Born in locust loc. year 89	-0.0591***	0.0722		-0.0430***	-0.446*	
	(0.0123)	(0.195)		(0.0101)	(0.269)	
Born in locust loc. year 88	-0.0628***	0.171		-0.0400***	-0.569**	
	(0.0111)	(0.194)		(0.00908)	(0.268)	
Born in locust loc. year 87	-0.0572***	0.105		-0.0317***	-0.399	
	(0.0134)	(0.194)		(0.0103)	(0.285)	
Born in locust loc. year 86	-0.0439***	0.182	0.0406	-0.0243**	-0.512*	-0.160*
	(0.0120)	(0.202)	(0.0601)	(0.00978)	(0.269)	(0.0827)
Born in locust loc. year 85	-0.0400***	0.0417	0.0277	-0.0147	-0.686**	-0.141
	(0.0124)	(0.199)	(0.0622)	(0.0100)	(0.286)	(0.0866)
Born in locust loc. year 84	-0.0302**	0.00278	0.0282	-0.0185**	-0.679**	-0.186**
	(0.0121)	(0.204)	(0.0622)	(0.00891)	(0.284)	(0.0869)
Born in locust loc. year 83	-0.0295***	-0.157	-0.00625	-0.0146*	-0.800***	-0.234***
	(0.0111)	(0.204)	(0.0600)	(0.00782)	(0.287)	(0.0842)
Born in locust loc. year 82	0.0182	-0.111	-0.0346	0.0124	-0.834***	-0.230**
	(0.0112)	(0.231)	(0.0683)	(0.00817)	(0.312)	(0.0908)
Born in locust loc. year 81	0.000276	-0.236	-0.0797	0.00359	-1.158***	-0.315***
	(0.0106)	(0.228)	(0.0706)	(0.00780)	(0.305)	(0.0880)
Born in locust loc. year 80	0.0176	-0.107	-0.0457	0.00726	-0.715**	-0.291***
	(0.0108)	(0.220)	(0.0677)	(0.00753)	(0.296)	(0.0863)
Born in locust loc. year 79	0.0185	-0.110	-0.0354	0.00551	-0.546*	-0.222**
	(0.0131)	(0.255)	(0.0727)	(0.00807)	(0.322)	(0.0973)
Born in locust loc. year 78	0.00895	0.0894	0.0176	0.00706	-0.709**	-0.236***
	(0.0104)	(0.215)	(0.0656)	(0.00721)	(0.292)	(0.0889)
Born in locust loc. year 77	0.0403***	0.0151	-0.00671	-0.000823	-0.536*	-0.167*
	(0.0136)	(0.250)	(0.0721)	(0.00802)	(0.316)	(0.0930)
Born in locust loc. year 76	0.0110	0.137	0.0678	0.00741	-0.444	-0.178*
	(0.0116)	(0.249)	(0.0716)	(0.00763)	(0.285)	(0.0919)
Born in locust loc. year 75	0.0130	0.172	0.0304	0.000257	-0.620*	-0.155
	(0.0118)	(0.247)	(0.0758)	(0.00760)	(0.342)	(0.0976)
Born in locust loc. year 74	0.00700	0.189	0.0240	0.0137	-0.420	-0.0946
	(0.0125)	(0.249)	(0.0761)	(0.00906)	(0.314)	(0.101)
Born in locust loc. year 73	0.0114	0.0642	0.0204	0.00341	-0.474	-0.130
	(0.0109)	(0.219)	(0.0676)	(0.00734)	(0.303)	(0.0913)

Table 6 continued.

VARIABLES	(1) Boys School enrol.	(2) Boys Grade	(3) Boys Comp. prim.	(4) Girls School enrol.	(5) Girls Grade	(6) Girls Comp. prim.
Born in locust loc. year 72	0.00967	0.162	-0.0149	-0.00338	-0.512	-0.231**
	(0.0123)	(0.254)	(0.0781)	(0.00771)	(0.344)	(0.0985)
Born in locust loc. year 71	-0.00334	0.325	0.124*	0.000957	-0.475	-0.169*
	(0.0122)	(0.246)	(0.0728)	(0.00828)	(0.303)	(0.0941)
Born in locust loc. year 70	-0.000981	0.272	0.0790	-0.00183	-0.343	-0.0876
	(0.0116)	(0.234)	(0.0700)	(0.00780)	(0.330)	(0.0982)
Born in locust loc. year 69	0.00948	0.0198	0.0563	0.00608	-0.131	-0.129
	(0.0148)	(0.256)	(0.0764)	(0.00914)	(0.340)	(0.110)
Born in locust loc. year 68	0.00426	0.0705	0.0222	0.0125	-0.536*	-0.145*
	(0.0102)	(0.219)	(0.0671)	(0.00761)	(0.285)	(0.0869)
Born in locust loc. year 67	0.0109	-0.120	-0.0371	0.0230*	-0.481	-0.183*
	(0.0151)	(0.264)	(0.0736)	(0.0120)	(0.335)	(0.104)
Born in locust loc. year 66	0.0115	0.232	0.0951	0.0103	-0.0152	-0.0451
	(0.0125)	(0.249)	(0.0721)	(0.00829)	(0.315)	(0.100)
Born in locust loc. year 65	0.00994	-0.0140	-0.00134	0.0209*	-0.329	-0.0541
	(0.0138)	(0.262)	(0.0769)	(0.0112)	(0.332)	(0.104)
Born in locust loc. year 64	0.0148	0.325	0.145**	0.00606	-0.585*	-0.184*
	(0.0150)	(0.234)	(0.0726)	(0.00989)	(0.314)	(0.102)
Born in locust loc. year 63	-0.00124	0.0652	0.0351	0.00249	-0.372	-0.149*
	(0.0103)	(0.229)	(0.0708)	(0.00732)	(0.286)	(0.0872)
Born in locust loc. year 62	0.0215	-0.166	-0.000836	0.00356	-0.179	-0.0300
	(0.0132)	(0.248)	(0.0727)	(0.00950)	(0.358)	(0.105)
Constant	0.0739***	4.189***	0.357***	0.0229***	3.827***	0.248***
	(0.00303)	(0.0489)	(0.0147)	(0.00198)	(0.0718)	(0.0199)
Rainfall control variables	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes
Observations	233612	72945	51247	243782	46788	30489
R^2	0.073	0.414	0.092	0.081	0.341	0.053
Number of localities	9679	7374	6954	9685	6506	5838

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 7: Impact of locust invasion on education, Children belonging to breeder and shopkeeper households, rural localities.

	(1)	(2)	(3)	(4)	(5)	(6)
	Child. bree.	Child. bree.	Child. bree.	Child. shopk.	Child. shopk.	Child. shopk.
VARIABLES	School enrol.	Grade	Comp. prim.	School enrol.	Grade	Comp. prim.
Born in locust l. year 91	-0.00644	-0.342		-0.0541	-0.278	
	(0.0146)	(0.848)		(0.0533)	(0.645)	
Born in locust l. year 90	-0.0180	-1.067		-0.0571	-0.340	
	(0.0149)	(0.833)		(0.0530)	(0.642)	
Born in locust l. year 89	-0.00668	-0.637		-0.0667	-0.332	
	(0.0172)	(0.832)		(0.0587)	(0.651)	
Born in locust l. year 88	-0.00928	-0.824		-0.110**	-0.276	
	(0.0160)	(0.826)		(0.0522)	(0.632)	
Born in locust l. year 87	-0.0219	-0.887		-0.0392	-0.177	
	(0.0180)	(0.844)		(0.0638)	(0.665)	
Born in locust l. year 86	-0.00270	-0.908	0.0148	-0.0812	-0.434	-0.100
	(0.0165)	(0.854)	(0.227)	(0.0546)	(0.672)	(0.221)
Born in locust l. year 85	-0.00316	-1.408	-0.119	-0.0413	-0.423	-0.0921
	(0.0150)	(0.860)	(0.225)	(0.0546)	(0.647)	(0.216)
Born in locust l. year 84	0.00284	-0.421	0.140	-0.0854	-0.649	-0.178
	(0.0165)	(0.864)	(0.240)	(0.0550)	(0.654)	(0.236)
Born in locust l. year 83	-0.000867	-1.330	0.00112	-0.0713	-0.249	-0.00728
	(0.0148)	(0.852)	(0.233)	(0.0545)	(0.627)	(0.221)
Born in locust l. year 82	0.0172	-1.154	-0.0702	-0.0347	-0.467	-0.106
	(0.0160)	(0.902)	(0.246)	(0.0543)	(0.735)	(0.252)
Born in locust l. year 81	-0.00155	-1.612*	-0.0593	-0.0329	-0.888	-0.267
	(0.0153)	(0.891)	(0.232)	(0.0521)	(0.756)	(0.231)
Born in locust l. year 80	0.000165	-0.971	-0.133	-0.0328	-0.135	-0.180
	(0.0149)	(0.869)	(0.249)	(0.0500)	(0.663)	(0.248)
Born in locust l. year 79	0.0165	-1.391	-0.0811	0.00844	0.0533	-0.0245
	(0.0179)	(0.879)	(0.239)	(0.0543)	(0.711)	(0.233)
Born in locust l. year 78	0.00170	-0.288	0.0230	-0.0172	0.259	-0.0193
	(0.0137)	(0.910)	(0.229)	(0.0500)	(0.734)	(0.234)
Born in locust l. year 77	-0.0219	-0.182	0.258	-0.0304	0.153	0.160
	(0.0155)	(0.875)	(0.226)	(0.0546)	(0.863)	(0.268)
Born in locust l. year 76	0.00609	-0.355	0.0223	-0.0306	0.418	0.154
	(0.0156)	(0.927)	(0.266)	(0.0499)	(0.799)	(0.252)
Born in locust l. year 75	0.00599	-0.632	-0.173	0.00869	-0.481	-0.0966
	(0.0173)	(0.927)	(0.263)	(0.0593)	(0.693)	(0.219)
Born in locust l. year 74	-0.000902	-0.308	0.0499	-0.0299	-0.340	-0.307
	(0.0146)	(1.176)	(0.329)	(0.0590)	(0.748)	(0.242)
Born in locust l. year 73	0.00105	-1.385	-0.0852	-0.0345	-0.139	-0.101
	(0.0140)	(0.902)	(0.244)	(0.0522)	(0.661)	(0.225)

Table 7 continued.

VARIABLES	(1) Child. bree. School enrol.	(2) Child. bree. Grade	(3) Child. bree. Comp. prim.	(4) Child. shopk. School enrol.	(5) Child. shopk. Grade	(6) Child. shopk. Comp. prim.
Born in locust l. year 71	-0.00615	-2.020*	-0.390	-0.0178	0.00380	0.0675
Born in locust l. year 72	0.0166	-0.351	-0.167	-0.0177	0.0699	-0.00863
	(0.0175)	(1.072)	(0.298)	(0.0591)	(0.774)	(0.225)
	(0.0144)	(1.083)	(0.247)	(0.0581)	(0.708)	(0.242)
Born in locust l. year 70	0.00430	-0.775	0.0518	0.0183	-0.296	-0.0894
	(0.0146)	(0.897)	(0.232)	(0.0558)	(0.704)	(0.261)
Born in locust l. year 69	-0.0280*	-1.475	-0.862**	0.0103	0.0972	0.119
	(0.0165)	(1.073)	(0.389)	(0.0678)	(0.912)	(0.270)
Born in locust l. year 68	-0.00497	-0.591	0.124	-0.0254	-0.452	-0.0517
	(0.0133)	(0.941)	(0.285)	(0.0494)	(0.756)	(0.249)
Born in locust l. year 67	0.00123	-0.0445	0.493	-0.0213	-0.610	-0.166
	(0.0186)	(1.355)	(0.366)	(0.0757)	(0.811)	(0.273)
Born in locust l. year 66	0.00748	-0.468	0.0992	-0.0472	0.616	0.169
	(0.0166)	(1.063)	(0.360)	(0.0594)	(0.663)	(0.251)
Born in locust l. year 65	-0.0275*	-2.745***	-0.0685	-0.0479	-0.547	-0.0877
	(0.0144)	(0.777)	(0.218)	(0.0684)	(0.781)	(0.269)
Born in locust l. year 64	0.0198	0.193	-0.00454	-0.0809	0.734	0.122
	(0.0199)	(1.030)	(0.287)	(0.0645)	(0.755)	(0.271)
Born in locust l. year 63	-0.00467	-1.642*	-0.323	-0.0387	-0.148	-0.0747
	(0.0143)	(0.988)	(0.265)	(0.0479)	(0.839)	(0.266)
Born in locust l. year 62	-0.0159	-0.586	0.103	-0.0117	-1.220*	-0.264
	(0.0162)	(1.093)	(0.244)	(0.0567)	(0.695)	(0.242)
Constant	0.0139***	3.712***	0.400***	0.0950***	4.827***	0.570***
	(0.00474)	(0.483)	(0.116)	(0.0147)	(0.191)	(0.0655)
Rainfall control variables	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes
Observations	51296	3035	1738	26368	7358	4685
Number of localities	4859	1133	839	3291	1658	1381
R^2	0.018	0.419	0.147	0.092	0.477	0.125

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 8: Rainfall coefficients boys, rural localities.

VARIABLES	(1) Boys School enrollment	(2) Boys Grade	(3) Boys bel. to farmer hous. School enrollment	(4) Boys bel. to farmer hous. Grade
rainfall birth year - 3	0.0320***	0.00765	0.0320***	0.0258
	(0.00274)	(0.0327)	(0.00307)	(0.0360)
rainfall birth year - 2	0.0286***	0.0367	0.0286***	0.0192
	(0.00276)	(0.0325)	(0.00312)	(0.0355)
rainfall birth year - 1	0.0221***	0.0354	0.0202***	0.0269
	(0.00274)	(0.0323)	(0.00310)	(0.0354)
rainfall birth year	0.0206***	-0.00124	0.0203***	0.00291
	(0.00257)	(0.0320)	(0.00291)	(0.0352)
rainfall birth year + 1	0.0122***	0.0219	0.0138***	0.00649
	(0.00268)	(0.0313)	(0.00299)	(0.0346)
rainfall birth year + 2	0.0210***	0.0343	0.0194***	0.0102
	(0.00258)	(0.0310)	(0.00293)	(0.0338)
rainfall birth year + 3	0.0112***	0.0801**	0.0105***	0.0642*
	(0.00261)	(0.0317)	(0.00293)	(0.0343)
rainfall birth year + 4	0.0103***	0.0340	0.0113***	0.0113
	(0.00254)	(0.0308)	(0.00291)	(0.0335)
rainfall birth year + 5	0.00100	0.0460	0.00121	0.0282
	(0.00250)	(0.0311)	(0.00285)	(0.0338)
rainfall birth year + 6	0.00408	0.0388	0.00604**	0.0667*
	(0.00256)	(0.0315)	(0.00288)	(0.0344)
rainfall birth year + 7	0.00681***	-0.0160	0.00819***	-0.0145
	(0.00261)	(0.0322)	(0.00298)	(0.0347)
Rainfall control variables	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes
Observations	248558	80594	233612	72945
Number of localities	9773	7596	9679	7374
R^2	0.076	0.416	0.073	0.414

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table 9: Rainfall coefficients girls, rural localities.

VARIABLES	(1) Girls School enrollment	(2) Girls Grade	(3) Girls bel. to farmer hous. School enrollment	(4) Girls bel. to farmer hous. Grade
rainfall birth year - 3	0.0267***	0.0327	0.0264***	0.0373
	(0.00201)	(0.0416)	(0.00226)	(0.0460)
rainfall birth year - 2	0.0171***	-0.0268	0.0168***	-0.00919
	(0.00194)	(0.0397)	(0.00218)	(0.0448)
rainfall birth year - 1	0.0145***	0.0802**	0.0129***	0.107**
	(0.00191)	(0.0403)	(0.00210)	(0.0445)
rainfall birth year	0.0118***	0.0420	0.00987***	0.0614
	(0.00176)	(0.0386)	(0.00201)	(0.0443)
rainfall birth year + 1	0.00783***	0.0424	0.00613***	0.0333
	(0.00184)	(0.0389)	(0.00207)	(0.0446)
rainfall birth year + 2	0.00994***	0.0556	0.00914***	0.0497
	(0.00176)	(0.0381)	(0.00201)	(0.0436)
rainfall birth year + 3	0.00596***	0.111***	0.00389*	0.125***
	(0.00179)	(0.0394)	(0.00200)	(0.0436)
rainfall birth year + 4	0.00477***	-0.0143	0.00432**	0.00684
	(0.00177)	(0.0399)	(0.00204)	(0.0438)
rainfall birth year + 5	0.00124	-0.00673	-0.000388	0.00925
	(0.00175)	(0.0386)	(0.00196)	(0.0427)
rainfall birth year + 6	0.00273	0.0229	0.00350*	0.0326
	(0.00179)	(0.0392)	(0.00201)	(0.0429)
rainfall birth year + 7	0.00312*	0.0127	0.00405**	0.0181
	(0.00180)	(0.0400)	(0.00201)	(0.0448)
Rainfall control variables	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes
Observations	257561	53457	243782	46788
R^2	0.086	0.349	0.081	0.341
Number of localities	9772	6759	9685	6506

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

Table A.1: Impact of locust invasion on education without rainfall variables, rural localities.

	(1)	(2)	(3)	(4)
	Boys	Boys	Boys bel. to farmer hous.	Boys bel. to farmer hous.
VARIABLES	Schooll enrollment	Grade	Schooll enrollment	Grade
Born in locust loc. year 91	-0.0364***	0.0214	-0.0335***	0.0648
	(0.00894)	(0.171)	(0.0104)	(0.192)
Born in locust loc. year 90	-0.0770***	0.0440	-0.0754***	0.117
	(0.00923)	(0.168)	(0.0108)	(0.188)
Born in locust loc. year 89	-0.0962***	0.0346	-0.0951***	0.0532
	(0.00981)	(0.171)	(0.0119)	(0.191)
Born in locust loc. year 88	-0.0986***	0.0895	-0.102***	0.148
	(0.00941)	(0.173)	(0.0107)	(0.189)
Born in locust loc. year 87	-0.0907***	-0.0235	-0.0893***	0.0678
	(0.0109)	(0.173)	(0.0130)	(0.189)
Born in locust loc. year 86	-0.0794***	0.00906	-0.0761***	0.145
	(0.00987)	(0.177)	(0.0117)	(0.198)
Born in locust loc. year 85	-0.0774***	-0.122	-0.0714***	0.0109
	(0.00984)	(0.179)	(0.0120)	(0.194)
Born in locust loc. year 84	-0.0642***	-0.125	-0.0620***	-0.0434
	(0.0100)	(0.180)	(0.0117)	(0.201)
Born in locust loc. year 83	-0.0527***	-0.273	-0.0541***	-0.207
	(0.00895)	(0.179)	(0.0108)	(0.200)
Born in locust loc. year 82	-0.00544	-0.184	-0.00433	-0.137
	(0.00866)	(0.204)	(0.0109)	(0.228)
Born in locust loc. year 81	-0.0117	-0.439**	-0.0177*	-0.258
	(0.00853)	(0.194)	(0.0104)	(0.227)
Born in locust loc. year 80	-0.00256	-0.336*	0.000788	-0.158
	(0.00854)	(0.197)	(0.0105)	(0.217)
Born in locust loc. year 79	-0.00974	-0.201	-0.00289	-0.133
	(0.00960)	(0.217)	(0.0128)	(0.252)
Born in locust loc. year 78	-0.0104	-0.0529	-0.00713	0.0791
	(0.00823)	(0.190)	(0.0102)	(0.214)
Born in locust loc. year 77	0.00189	0.0287	0.0219	-0.00531
	(0.0104)	(0.212)	(0.0135)	(0.249)
Born in locust loc. year 76	-0.00868	0.102	-0.00665	0.125
	(0.00895)	(0.207)	(0.0114)	(0.247)
Born in locust loc. year 75	-0.00876	0.0302	-0.00633	0.148
	(0.00959)	(0.217)	(0.0115)	(0.246)
Born in locust loc. year 74	-0.0142	0.0353	-0.0103	0.181
	(0.0101)	(0.229)	(0.0123)	(0.248)
Born in locust loc. year 73	-0.00220	-0.00408	-0.00324	0.0327
	(0.00906)	(0.197)	(0.0106)	(0.218)

Table A.1 continued.

VARIABLES	(1) Boys Schooll enrollment	(2) Boys Grade	(3) Boys bel. to farmer hous. Schooll enrollment	(4) Boys bel. to farmer hous. Grade
Born in locust loc. year 72	-0.00473	0.297	-0.0118	0.139
	(0.0107)	(0.228)	(0.0122)	(0.253)
Born in locust loc. year 71	-0.0164	0.166	-0.0192	0.304
	(0.0103)	(0.217)	(0.0121)	(0.244)
Born in locust loc. year 70	-0.0154	0.0971	-0.0193*	0.248
	(0.00967)	(0.206)	(0.0114)	(0.232)
Born in locust loc. year 69	-0.00819	0.0412	-0.0123	0.00273
	(0.0121)	(0.228)	(0.0147)	(0.256)
Born in locust loc. year 68	-0.0224**	-0.142	-0.0183*	0.0433
	(0.00873)	(0.195)	(0.00999)	(0.217)
Born in locust loc. year 67	-0.0140	-0.131	-0.00915	-0.138
	(0.0125)	(0.230)	(0.0149)	(0.263)
Born in locust loc. year 66	-0.00251	0.172	-0.00329	0.218
	(0.0103)	(0.207)	(0.0124)	(0.247)
Born in locust loc. year 65	-0.00625	-0.167	-0.000807	-0.0129
	(0.0115)	(0.224)	(0.0136)	(0.261)
Born in locust loc. year 64	-0.00381	0.257	0.00745	0.320
	(0.0118)	(0.211)	(0.0149)	(0.234)
Born in locust loc. year 63	-0.0121	-0.0539	-0.00750	0.0489
	(0.00871)	(0.201)	(0.0102)	(0.229)
Born in locust loc. year 62	0.00563	-0.197	0.0186	-0.158
	(0.0112)	(0.208)	(0.0132)	(0.248)
Constant	0.0892***	4.280***	0.0877***	4.218***
	(0.00255)	(0.0427)	(0.00271)	(0.0467)
Rainfall control variables	no	no	no	no
Fixed effect locality	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes
Observations	248558	80594	233612	72945
Number of localities	9773	7596	9679	7374
R^2	0.074	0.416	0.072	0.414

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses.

Cohort of reference: 1961

Standard errors corrected for clustering and auto-correlation by clustering at the village level.

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