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THE 1987-89 LOCUST PLAGUE IN MALI: EVIDENCES OF THE HETEROGENEOUS IMPACT OF INCOME SHOCKS ON EDUCATION OUTCOMES[1]

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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 find a clear and strong impact on educational outcomes of children living in rural areas but no impact at all on children living in urban areas. School enrollment of children born or aged less than seven years old at the time of shock is found to be impacted. Children born in 1988-1989, the main years of invasion, are those whose school enrollment has been the most affected by the plague. The negative impact on school enrollment of boys is higher than for girls, but on the other hand, girls attending school and living in rural areas have a lower level of school attainment than boys. Controlling for the potentially selective migration behavior of individuals, differences in educational amenities do not dampen our results. Our results are also robust to different variations of the cut-off cohort

Keywords: Education, Shocks, Mali, Locust.

Résumé

L'objet de ce travail est d'estimer l'impact à long terme de chocs de revenu à travers l'analyse des effets de l'invasion de criquets qui a eu lieu de 1987 à 1989 au Mali sur différents indicateurs d'éducation. En mobilisant des données exhaustives de recensement de la population, nous construisons des cohortes d'individus selon leur date de naissance et leur lieu de résidence. Nous examinons les écarts de scolarisation des enfants impactés en double différence. Nous montrons un impact fort et significatif du choc sur les enfants des zones rurales et aucun effet sur les enfants des villes. Les enfants nés ou âgés de moins de sept ans lors des invasions de criquets ont des taux de scolarisation inférieurs aux autres. L'impact est à la fois plus fort pour les enfants qui sont nés en 1988 et 1989 c'est-à-dire les années de plus fortes invasions de criquets et pour les garçons. Cependant, parmi les enfants scolarisés, la durée de scolarisation est plus réduite du fait des invasions de criquets pour les filles que pour les garçons. Ces résultats sont maintenus lorsque l'on contrôle du biais potentiel de migration, des différences possibles d'évolution des niveaux d'infrastructures entre villages et lorsque l'on fait varier le seuil des cohortes incluses dans l'échantillon.

Mots Clés : Education, chocs, Mali, criquets.

JEL Codes : I21, O12, O55.

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"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, socioeconomic status, income, cognitive ability, disease, height or life expectancy. They confirm the fetal origins hypothesis (Barker, 1992): poor environmental conditions during in-utero and early childhood that induce 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, Fertig and Paxson, 2005; Alderman, Hoddinott and Kinsey, 2006; Almond *et al.*, 2007; Maccini and Yang, 2009; Leon, 2009; Grimard and Laszlo, 2010; Gorgens, Meng and Vaithianathan, 2011; Akresh, Vervimp and Bundervoet, 2011). 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 and Baez, de la Fuente and Santos (2010) assess available empirical evidence on the ex-post microeconomic effects of natural disasters.

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 of in-utero influenza exposure on several American adult outcomes. He estimates that children whose mother had 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 by age 20 children of wine-growing families born during Phylloxera crisis were 0.6 to 0.9 centimeters shorter than others. Gorgens, Meng and Vaithianathan (2011) estimate the long run impact of the China's Great Famine on survivor health outcomes. Contrary to Almond *et al.* (2007) who exploit the 1959-61 Chinese great famine as an exogenous event, Gorgens, Meng and Vaithianathan (2011) use the variation in the regional intensity of food shortage derived from an institutional determinant of the Great Famine. Controlling for selection, they find 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. Alderman, Hoddinott et Kinsey (2006) use the 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. Akresh, Vervimp and Bundervoet (2011) analyse the impact of civil war and crop failure on child stunting in Rwanda. They find that boys and girls born during the conflict in regions experiencing fighting are negatively impacted (height for z-scores 1.05 standard deviations lower), whereas only girls are impacted by crop failure. 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.

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 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 older cohorts which education was not impacted by the plague, while controlling for rainfall variations, using historical climate data.

Beyond being the first paper to estimate the long term impact of locust invasion, the main contribution of this study is to offer some insight on the likely effects 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 deal with the impact of such shocks.

We find that children whose household has been exposed to locust invasion while they were in age of school admission or younger have a lower probability of going to school than other children. Indeed, the proportion of boys born during the shock and who later enrolled at school is reduced by 7.5% and 5% for girls. Regarding educational attainment, we find a negative impact on the number of years of education and on the probability to achieve the primary level for children in age of starting school at the time of plague. The shock has impacted more deeply and widely the girls educational attainment than that of boys, with a respective drop of one and 0.44 grade in the schooling achievement of children living in invaded communities. Among enrolled children, more than 10% have not achieved their primary level if they experienced the shock at the time of school admission.

Our main results are found for rural areas and the resident population sample, i.e people who have never moved from their birth place. We assess the robustness of our results to these choices. First, we check the zero impact of locust invasions in urban areas, which is expected if, as argued in the paper, the locust swarms have no major macroeconomic consequences. Second, we use simulation to check that holding account of the migrant population does not alter previous findings. Third, we investigate potential divergences in education infrastructures trends between invaded and non invaded areas by further controlling, for each cohort, for the level of infrastructures in the village at the time of the cohort school admission. This additional control actually does not modify the results. Last, we check whether our findings are driven by the cohort cut-off point of the sample, and find that this is not the case.

Our paper is organized as follows. Section 2 discusses the causes and consequences of locust invasions. Section 3 presents the empirical strategy and the data. Section 4 presents the results and section 5 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).

[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%.

Among these shocks, locust invasions 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, waves of 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 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. Households 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 and data

3.1 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 impact 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 and between potentially impacted and non impacted cohorts. If locust invasions have non negligible macroeconomic impacts, then the comparison between treated and untreated units will tend to under-estimate 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. We will check this assumption in the robustness check section of this paper, by estimating our model on urban areas. If our assumption is correct, we should not find any impact of the locust swarms on the cohorts of this sample.

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:

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

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. The treatment impact is captured by the interaction between the treatment dummy at the village level and birth cohorts.

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 locusts 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. Note that rainfall levels vary with geographical areas and cohorts. We also add a village fixed effect in order to account for fixed differences between villages in the availability of schools and other relevant infrastructure.

$$\begin{aligned} S_{cv} = \alpha + \beta_c.1_{\{C=c\}} + \delta_c.1_{\{C=c\}}.T_v + \textstyle\sum_{l=1}^{L}(\eta_{-l}.R_{cv-l} + \eta_{+l}.R_{cv+l}) \\ +\eta.R_{cv} + \mu_v + \varepsilon_{cv} \end{aligned} \tag{2}$$

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 they are computed varies from one village to another. In order to hold account of this heteroskedasticity we employ robust estimates of the variance-covariance matrix.

3.2 Data

Locust localization and rainfall data

The information on locust swarms localization is 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 960 villages and towns 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 variations in locust invasions and not to regional heterogeneity in the warning system. In the 1980s, the reporting of locusts attacks was mainly based on phone calls of people that observed locust swarms in their place. 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. Table 1 shows the average population size of urban and rural localities according to their treatment status and for the cohort 1988. The fact that we observe that the locusts affected localities are, on average and in 1998, larger than others confirms the previous hypothesis. However, the difference is large between affected and non affected urban localities, but not between rural ones. As we restrict our baseline specification to rural areas, the reporting bias should not be too important in our estimates. In any case, incomplete observation of swarms attacks will lead to an under-evaluation of the impact, as some of the villages taken as controls will also be affected by the locust plague.

[insert table 1 and 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

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

[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 swarms.

levels are available from 1901 to 2006 on a 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 and the natural log of mean annual precipitations calculated over the 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 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 when individuals are in age of school admission.[4] We implement this specification for school enrollment. When dealing with grade attainment or primary level achievement, we complete the model with rainfall shock variables occurring between age 8 and 13 and that may influence the educational attainment of shocked individuals.

Educational variables

We construct a panel of birth cohorts using the exhaustive 1998 Population Census of Mali. 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 first 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. On the other hand, we might over-estimate the impact of the shock if migrants originating from the locusts impacted areas are significantly more educated than those originating from the non impacted areas. In the robustness checks section we undertake simulations to reallocate migrants in the villages of their birth *cercle* proportionally to the village size and discuss to what extent migration impacts our results.

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. We limit the sample to individuals from 33 to 7 years-old in 1998, that is to say individuals born from 1965 to 1991. Table 2 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 include less people than the youngest ones. Second, due to errors in the declaration of age and approximations around

[4]Since children enter school at 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.

10, 15, 20, etc. years old, cohorts 1988, 1983, 1978, 1973 and 1968 are more numerous than the cohorts close to them. For instance, the average number of 25 years old people (cohort 1973) per locality is 14 individuals compared to 7 individuals for the 1972 or 1974 cohorts. Nevertheless, cohorts 1990 to 1986 have been potentially affected by the 1987-89 locust plagues while in-utero and/or during early childhood, whereas children born between 1985 to 1976 were at the age of primary schooling during the 1987-89 locust invasions.

[insert table 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 1965 to 1991) for all rural localities included in this analysis and separately for villages affected and not affected by locust invasions. As can be seen, the school enrollment of the cohorts born 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. Diara *et al.* (2001) report a "non linear evolution" of the gross enrollment rate in Mali since independence, mainly due to a lack of investment. First, it has increased rapidly during the 1960-1970s, then slowed down until decreasing during the 1980s before improving again during the 1990s 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 24% for boys and 15% for girls at the middle of the 1990s (people born between 1986 and 91). The boys enrollment rate is approximately twice that of girls which mirrors the gender gap observed in the country. Indeed in Mali, as in many other developing countries, males are fully responsible of their family material needs, and are in charge of providing income; therefore their education is considered more of a priority than that of girls. Moreover, some religious and traditional values, like early wedding and the gender allocation of domestic chores, do not promote girls school enrollment and attainment but keep them mainly in charge of household activities (Soumare, 1994; Diarra and Lange, 2000). Hence, in times of economic difficulties, we suspect girls education to be more 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.

An other important feature is that, whatever the cohort of birth, less than 50% of boys and 31% of girls that attended primary school have achieved the Primary level (see the third graphs of figures 4 and 5).[5]

[insert figure 4 and figure 5 about here]

For the primary school enrollment rate the graph show a similar trend between locusts affected and non affected areas, for boys and girls until cohort 1982. But a sizable divergence emerges 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 younger children.

For the number of classes completed and the proportion of children that completed primary school (both computed on the sub-population of enrolled children), the results are less clear cut. But we can observe, both for boys and girls, that in locust affected areas the proportion of children that completed primary school and the number of grades completed are lower for cohorts 1979 to 1981, that is for children that were beginning primary school when the locust invasion occurred.

The spectacular increase in school enrollment rates that we observe from cohorts 1983 onwards is due to an unprecedented effort to build schools, as will be documented later in the paper. The large difference in school enrollment trends between invaded and non invaded villages could result from differences between educational infrastructure availability, if the number of schools increases less rapidly in locust affected villages than in non affected ones. For that matter, our village fixed effects strategy prevents our results from being biased by a constant difference between invaded and non invaded villages, but it cannot capture the potential differentiated dynamics between the two areas. In the robustness check section, we use data from the Malian Population and Infrastructures Census to assess the impact of variations in school availability on our results. As these data do not cover the entire country, we choose not to include this information in our baseline specification.

4 Results

The results are presented in table 3. Regressions are run only on rural localities. We distinguish between boys and girls educational outcomes. The first three columns are results on the

[5]Since in Mali school starts at seven and the primary level is composed of six grades, only cohorts born before 1985 could have achieved the primary level in 1998

boys sample and columns 4 to 6 are those for the girls. Columns 1 and 4 shows the results obtained when average school enrollment at the locality level is the dependent variable. In columns 2 and 5, the dependent variable is the average grade attainment and, in columns 3 and 6, the proportion of children that completed primary school both among those enrolled. All regressions include controls for rainfalls, together with birth cohort dummies and village fixed effects. Robust standard errors are reported.

[insert table 3 about here]

The striking result is the strong and significant negative impact of locust swarms on the enrollment of children born after 1982. The strongest impact is found for cohorts 1988 and 1989, that is for children that were potentially in-utero and up to two years old during the locusts invasion.[6] For boys, the proportion of children born in 1988-1989 ever enrolled at school is reduced by 7.5 percentage points if they lived in a rural community invaded by locusts. For girls the impact size is smaller at 5.0%, but remains significant. In relative terms the impact on each gender is of similar amplitude, with a 25% decrease in the proportion of enrolled children from cohort 1989.

Also striking is the fact that before 1983 for boys and for girls living in rural areas, the cohort times locust invasion interaction dummy coefficient is never found significant on school enrollment. 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 1982 cohort coefficient is not found negative, if locusts invasions have a negative effect on the probability to enter school and if those children that did not enroll are also more likely to report their age less precisely. In order to check for this explanation figure 6 reports the average cohort size at the locality level for enrolled and non enrolled children separately. If our intuition is correct, then one should observe more pronounced peaks around cohorts that, in 1998, correspond to an age that is a multiple of five (that is 1973, 1978, 1983, 1988) in the uneducated population than in the educated one. The results are striking and

[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).

confirm our intuition: the curve for the enrolled population appears much smoother than that of the unenrolled population and the difference is larger precisely for the birth years that are 25, 20, 15 and 10 years before 1998. Such reporting mistakes could also explain why those that were declared born in 1990 and 1991 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.

Columns 2 and 4 present the results on grade attainment. We find that for all girls cohorts born after 1977 (column 6), exception made of cohort 1987, the number of completed years of schooling is lower if in 1988-1989 they lived in a rural community attacked by locusts. The major significant effect at the 1% level is found for cohort 1981 which completed up to one lower grade than the reference cohort (1969), *ceteris paribus*.

Looking now at the coefficients obtained when the dependent variable is the proportion of enrolled children that completed primary school in the locality (columns 3 and 6) we find a negative impact for boys and girls in age of entering school at the time of the plague i.e cohorts 1980-1982: for cohort 1981 in rural areas the proportion of boys and girls that completed primary school among those enrolled is reduced by 16 and 13%, when compared with the reference cohort.

5 Robustness checks

To strengthen the confidence in our results, we perform in this section several robustness checks. We first test if locust invasions impact urban localities. We second address the resident selection issue in our population and provide answers on how this affects our results through more detailed descriptive statistics and the implementation of a strategy to hold account for migration. We further address the remaining doubt that the estimated impact of locust invasions may result from significant differences in the dynamics of educational environments between invaded and non invaded areas, by controlling for trends in educational infrastructures per locality. Finally, we check the robustness of our results to variations in the cut-off point cohort sample.

5.1 Urban impact

As said in section 2, we argue that locust invasions should impact mainly rural localities. 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. Moreover, the variation in aggregate crop production and food supply shown in figure 2 indicates that locust invasions are not expected to have much macroeconomic impact. This is an important assumption to check, since if locusts have a negative macroeconomic impact, then our estimates will be downward biased due to the contamination of the control population. In order to check this assumption, we run our estimation on the urban localities. [7] 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. Among 340 "cities" of the sample, 74 have been invaded by locust swarms. [8]

[insert table 4 about here]

As can be seen in table 4, almost no effect is found in urban areas, which confirms that the partial destruction of harvests had no sizable macroeconomic effect. We find negative coefficients only for boys of cohort 1983 (school enrollment rate) and cohort 1984 on the number of grade achieved at the primary level and on the primary level achievement rate. Surprisingly we also find some positive impacts on girls' education. If this results were confirmed by other studies, more investigation would be needed to understand why locust invasions might have a positive impact on girls' schooling in urban areas of Mali.

5.2 Migration bias

Migrants may be a peculiar category of individuals within the population and their decision to migrate might be correlated with these specific characteristics and/or with locust invasion. Hence, a more precise discussion on their characteristics and their potential divergence among treated and untreated localities can be helpful to understand our findings.

Migrants are defined as people whose age in 1998 is higher than the duration of residence in their present place of living. As every individual was asked about its birth place and, if in Mali, about its birth *cercle*, we test the robustness of our results, by reallocating migrants in their birth *cercle* and, inside the *cercle*, by choosing randomly their locality of birth.[9] A total of 40 simulations are done. Table 5 sets migrants characteristics according to their gender, living area at birth time, group of birth cohorts[10] and treatment status. The number

[7] Urban localities are defined by the National Office of Statistics as localities having more than 5,000 inhabitants.

[8] Big cities are "split" in neighborhoods in our estimation.

[9] For each locality the probability to be selected among all localities of a given *cercle* is based on its relative population. Reallocation of migrants among *cercles* depends on each *cercle* emigration rate.

[10] We distinguish between two groups of cohorts : 1980-1991 and 1979-1965, in order to identify potential heterogeneity that might be linked to different educational or economic environments.

of migrants per locality and the migrants school enrollment are averages computed over the 40 simulations. For school enrollment we test for the difference in the average enrollment of migrants between locust affected and non affected localities (test 1) and between migrants and non migrants in locust affected and non affected localities (test 2). For each test we report the number of times the difference is found statistically significant over the 40 simulations.

As the proportion of migrants is small relative to that of non migrants, we take the estimated enrollment rates for the non migrant population as the reference to which the migrants enrollment rate should be compared. Unsurprisingly the results show that in rural areas migrants are much more educated than non migrants, both in locust invaded and non invaded localities. In urban areas no such difference is found. If we now compare the estimated enrollment rates between locust invaded and non invaded localities, the non migrant enrollment rate show that in rural areas, locust invaded localities exhibit lower rates, consistently with what is shown in the top panel of figures 4 and 5. However this is not the case for migrants: for girls those coming from locusts invaded localities have a higher or an equivalent rate of school enrollment than those coming from non invaded localities. Thus migration appears to have been selective, indeed, with the non migrant population more likely to be less educated than the population at large in invaded localities. For school enrollment, this selective migration is likely to upward bias in absolute terms the estimated negative impact of the locust plague. For other educational outcomes, the prediction is less clear: either migrants are impacted at least as much as non migrants which potentially motivates their decision to move, then we would underestimate the impact, or migrants, being a more educated hence reactive population, able to leave and adapt some place else, are less impacted than non migrants, then we would overestimate the impact.

In order to assess the amplitude and direction of the possible biases, for each of the 40 simulated reallocations of migrants, we estimate our model on the resulting simulated population and check whether it significantly changes our results. Figure 7 for boys and figure 8 for girls show, for each cohort, the 95% confidence interval of the locusts estimated impact on school enrollment when migrants are reallocated within their birth *cercle*, together with the median of the 40 estimates, when it is significantly different from zero at least one time. Different markers are employed depending on the proportion of non zero estimates. When significant we also add to this graph the estimated coefficients found with the non migrant population and reported in table 3.

[insert Table 5 and Figures 6 and 7 about here]

What can be seen at first is that with the exception of cohorts 1984 for girls and 1991 for boys, the coefficient estimated on the non migrant population always lies within the bounds of the 95% confidence interval built from the estimations obtained with the simulated populations. The median of the simulated coefficients is also found very close to the estimates and for cohorts 1983 to 1990 for boys and 1986, 1988, 1989 and 1990 for girls, the simulated coefficients are found significantly different from zero in at least 90% of the cases in the total and rural populations. The same exercise has been done for the urban population (bottom part of the panels). The simulated results are also coherent with our estimates, since the proportion of non zero simulated coefficients is only higher than 50% for cohort 1983 and for the boys sample, for which the estimate is also found significant. For girls, the simulated coefficients are never found significant for the urban population, which confirms our estimates and the results are not reported in the graphs. The only significant discrepancy is for cohort 1968 in the boys population, for which a significant coefficient is found in more than 90% of the simulations, while the estimate reported in table 3 is not significant. Similar results are obtained for other educational outcomes (results not shown).

We can then conclude that holding account for selective migration does not alter our previous results : in rural areas the school enrollment of children potentially in-utero or in early childhood during the shock is the most impacted while educational attainments are lowered for children in age to enter school at the time of the locust plague. As expected the shock did not have lasting consequences on the children's education in urban areas.

5.3 Divergences in education infrastructures trends

The educational context in Mali experiences a break in its trend at the very beginning of the 1990s, as is illustrated by the jump in school enrollment observed with cohort 1983 on figures 4 and 5. This jump might result from an increase in the school infrastructure that Mali experienced over the 1990s. Using the three available rounds of the Malian Population and Infrastructures Census (1976, 1987, 1998) we compute for each year and for each locality for which the data are available the ratio of the number of schools to the population. That is 8,671 rural localities, among which 712 belong to the treated group against 9,771 localities and 911 treated localities for the full sample. No change is observed between 1976 and 1987, with an average number of schools per inhabitant equal to 0,0118 in both years. In 1998 however, the number of schools is found much higher, with an average of 0,0322 school per inhabitant. Comparing affected and non affected localities shows that for these rural localities the number of schools increased, in average, less rapidly in affected than in non affected localities. This could induce an upward bias in our estimates. In order to check for the robustness of our results to these differences in trends we use information from the 3 infrastructure censuses to estimate, for each cohort, the number of schools per inhabitant in the locality when this cohort was in age of school admission (7 years old). For the cohorts between infrastructure census years, we extrapolate the level of schools by applying the average growth rate of each sub-period. We then add this built variable as an additional control in our regression.

Tables 6 and 7 present the results for the school enrollment rates of boys and girls respectively. As the sub sample is different from the whole population, estimations of our baseline specification (without including education infrastructures trends) have been first performed on this sub sample (columns 1, 3 and 5). We find a pattern of results quite similar to that obtained with the entire population. The main difference is that we now find unexpected negative effects for the school enrollment rates of boys born in 1976, 1974 and 1971, and two positive coefficients, one on cohort 1972 for the primary grade attainment of boys and the other on cohort 1971 for the primary level achievement of boys too. For girls, there is no significant difference. Nevertheless, the main conclusion is the fact that controlling for educational amenities does not change the results. There is no difference between coefficients of columns 1 and 2, 3 and 4 as well as 5 and 6 of tables 6 and 7. Cohorts that have been found significantly affected when not controlling for educational infrastructures are still found affected, without any change in the scale of the coefficients, whatever the educational variable. For instance, the 1983 threshold cohort for school enrollment rate is robust to this additional control, and primary level achievement rates of cohorts 80 and 81 are negatively impacted by locust invasions for boys and girls.

[insert tables 6 and 7 about here]

5.4 Cut-off point cohort sample

We further check the robustness of our identification strategy by testing whether the observed results would be driven by the arbitrary cut-off point cohort (cohort 1965) of the sample. To perform our Difference-in-Difference strategy correctly, we first need to identify non impacted individuals within treated localities and compare their education with that of potentially affected ones. Non impacted individuals within affected localities are individuals that were "too old" during the shock for their education to be impacted by the plague. Hence we consider that the education of children aged more than eighteen during the shock, i.e cohorts born before 1971, could not have been affected. We decide to include in our sample cohorts up to 1965, since the education of older cohorts may have been impacted by the previous locust plague which ended in 1962. Doing so we also limit differences in the environmental contexts between potentially affected and non affected cohorts.

However, we check whether this decision influences our results. We run our specifications on 4 populations, different from our base one and allow the cut-off point cohort to vary from 1966 to 1969. Findings attest that our results are robust to variations of the cut-off point cohort (table 8). Between cohorts and outcomes, the same pattern is found for all specifications, using enrollment rates as outcome.[11]

[insert table 8 about here]

6 Conclusion

This paper finds that the large and negative income shock induced by the 1987-1989 locust plague in Mali has a long run impact on the 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 and temporal variation of locust invasions. In our study, we allow for a heterogeneous impact of shocks along age and sex and pay also attention to differences between urban and rural households.

We find a clear and strong impact on the school enrollment of children living in rural localities and born or aged less than seven years old when the shock occurred. Children born in 1988-1989, the main years of invasion, are those whose school enrollment has been the most affected by the plague. A negative impact is also clearly detected on the educational attainment of children that were in age to enter school during the plague. Boys are more strongly affected than girls, but on the other hand, the schooling achievement of girls seems to be more sensitive to the shock, as we find a significant and negative impact on the grade achieved for all cohorts born after 1977. Indeed, the treatment effect on the grade attainment of girls born in 1981 is broadly twice that of those born two years apart. We can attribute this gender bias to the fact that boys' education is considered more of a priority than that of girls'.

[11] We find exactly the same results on grade attainment and primary level achievement (results not shown).

As we expected we find no impact in urban areas, which confirms the low macroeconomic impact of locust invasions.

Our results reveal a strong impact of economic shocks on the education of children impacted, especially those experiencing it during their earliest childhood. They also 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 peculiarly girls, who are more vulnerable members within a household. The difference in impacts between boys and girls claims that some consequences may result from a discriminative behavior.

This paper contributes to the literature by studying the impact of a shock that is aggregate at the village level and against which households have difficulties to get protected if inter-village insurance markets are deficient (Jacoby and Skoufias, 1997). The microeconomic impact of locusts invasions has been so far underestimated due to the concomitance of this local shock with good rains and a high level of crop production at the macroeconomic level. Our results show that for the stricken households the consequences of the shock might be adverse and important, even in the long term. This militates in favour of safety nets that would protect the rural households against the adverse consequences of locust invasions. As the number of concerned households is relatively marginal and since it is easy to check the reality of the shock, such device should not be too costly to enforce.

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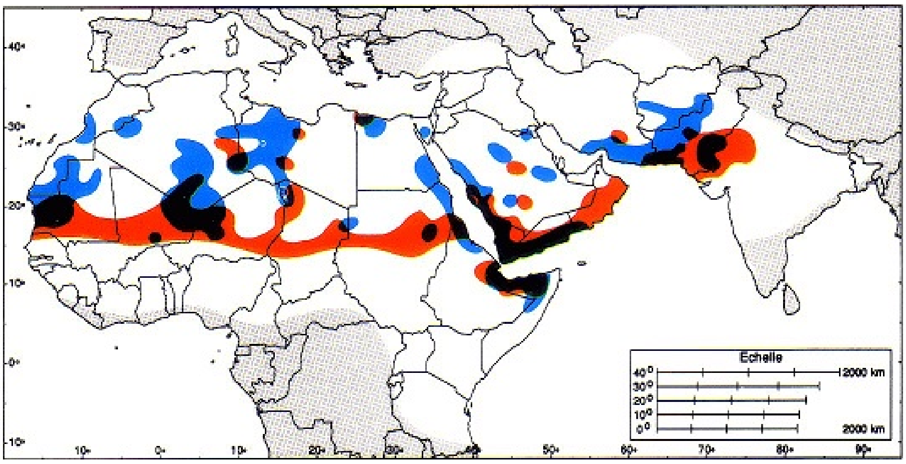
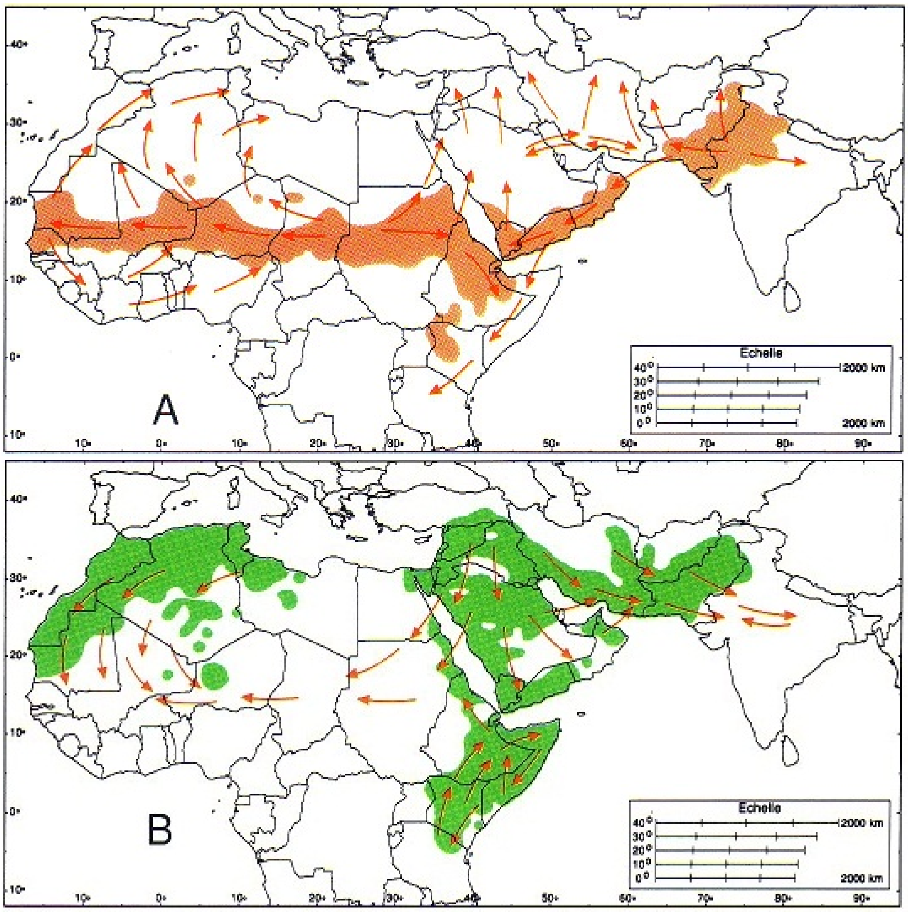
Figure 1: Locust invasion in Africa



Breeding areas during remission period



Breeding areas and swarms flowing:

A. Summer breeding during invasion

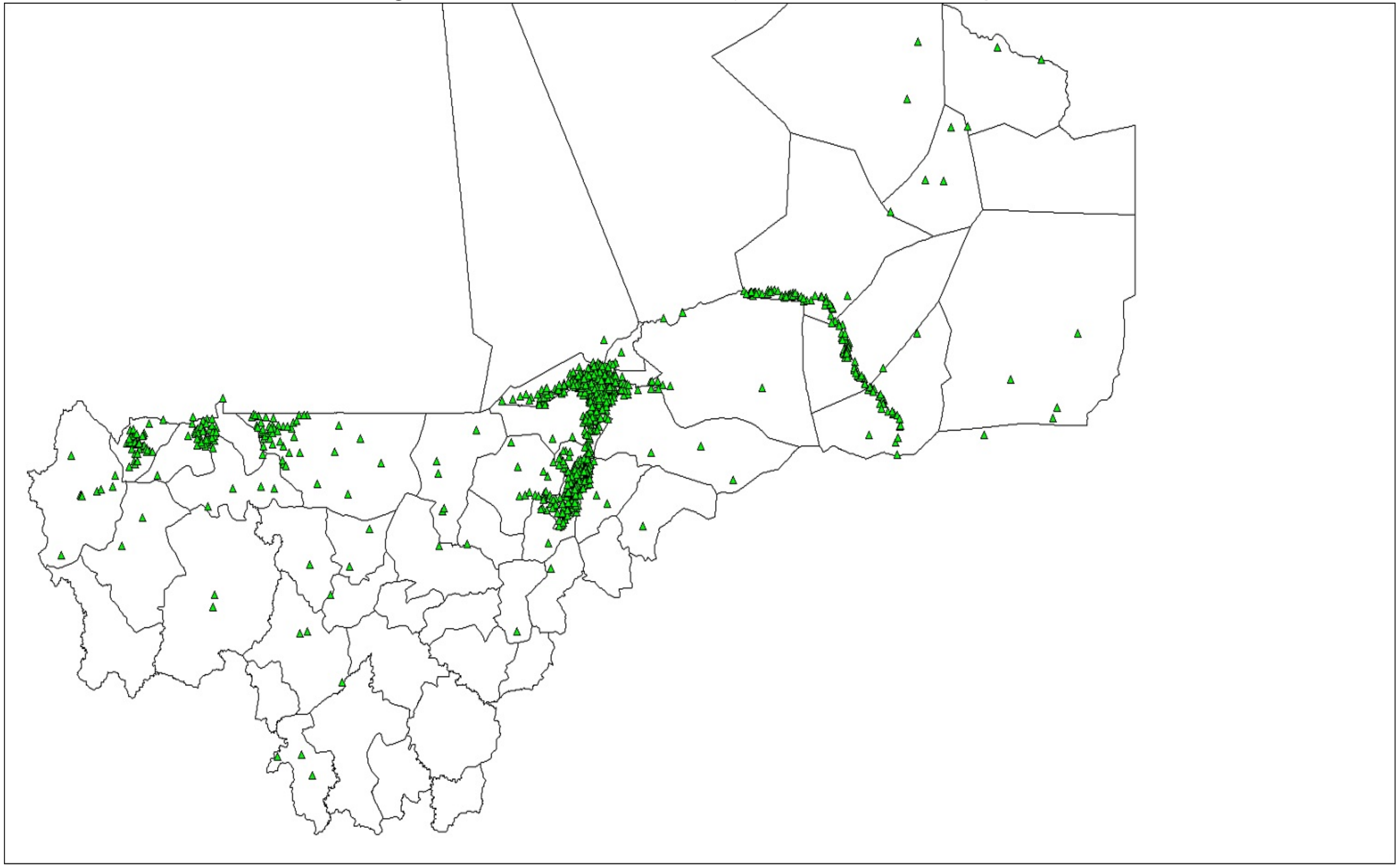
B. Spring breeding during invasion

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

Figure 2: Crop and food production indexes

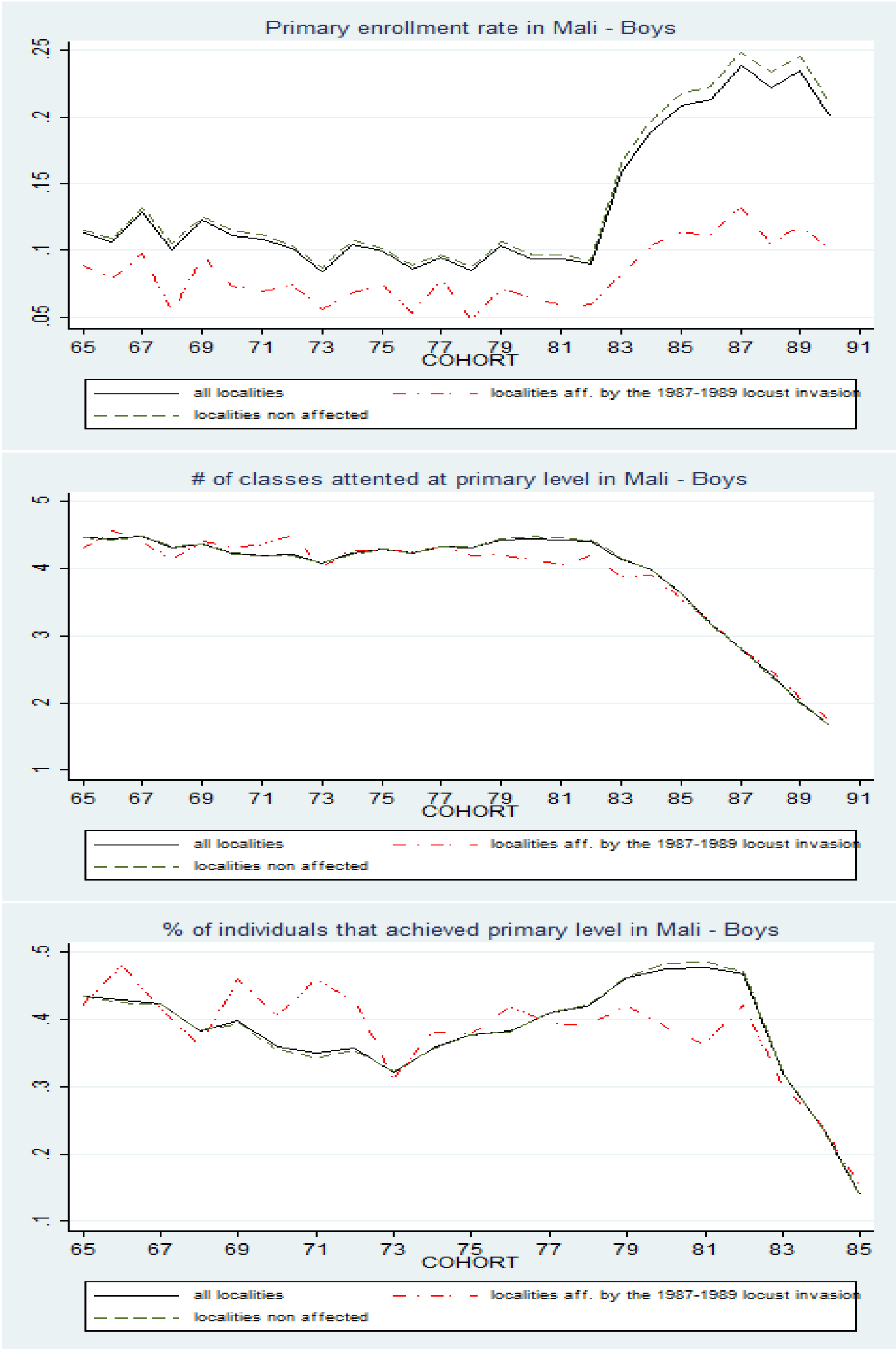
Source:http://countrystat.org/mli/cont/pxwebquery/ma/133cpd010/fr, authors' calculations.

Figure 3: Malian Localities affected by the 1987-1989 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, Rural Mali, Boys born in 1965 - 1991

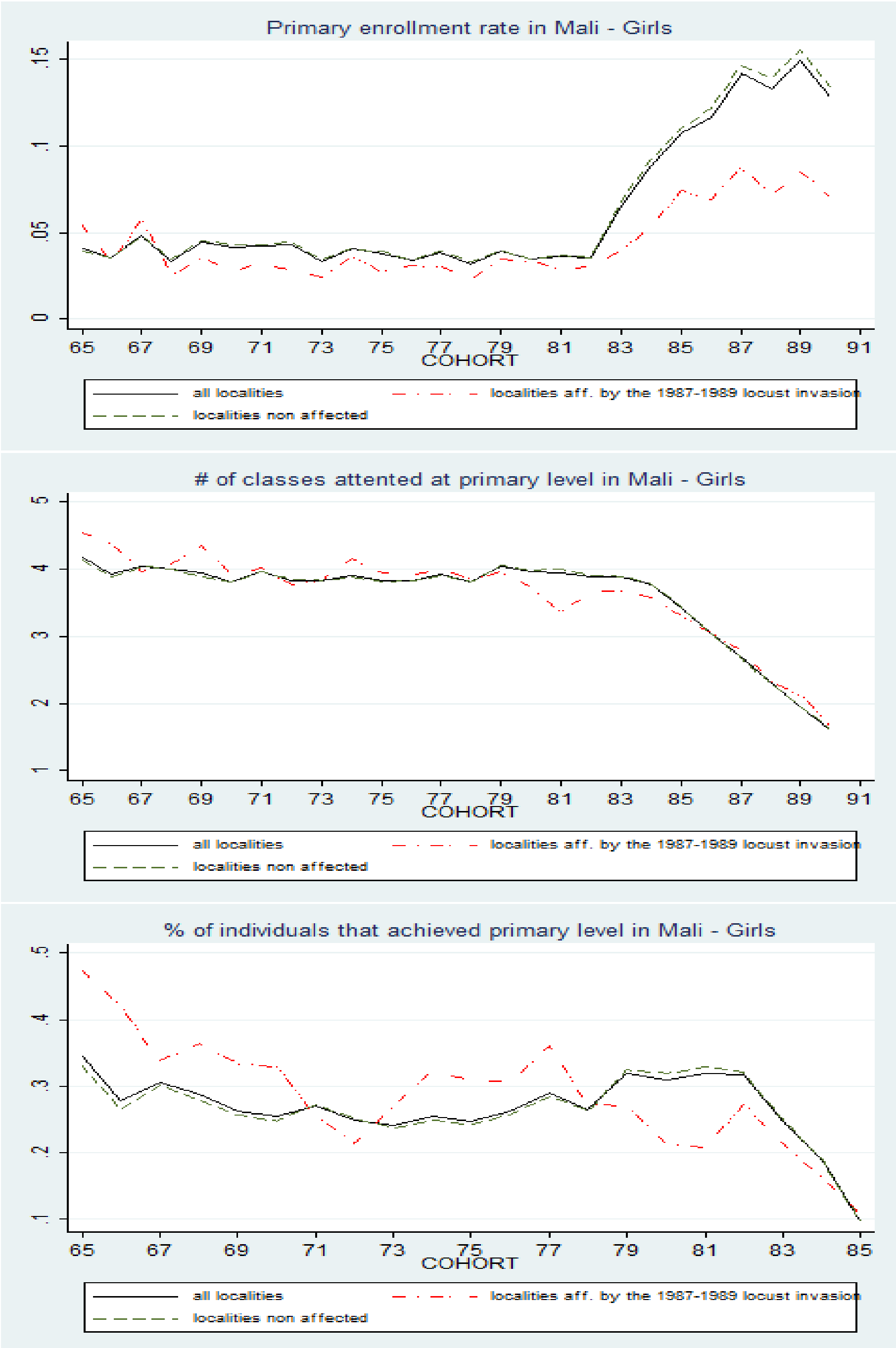


Note: These graphs are computed on a sample of people that never moved from the place they live in 1998. Moreover, people that live in Bamako are excluded from the sample.

COHORT identifies the birth of year i.e COHORT 1981 identifies individuals born in 1981, allowed to enter school from 1988 (7 years old) and aged 17 in 1998, year of data collection used for our calculations.

Source: Malian Population Census data, 1998, our own calculation.

Figure 5: Educational variables, Rural Mali, Girls born in 1965 - 1991

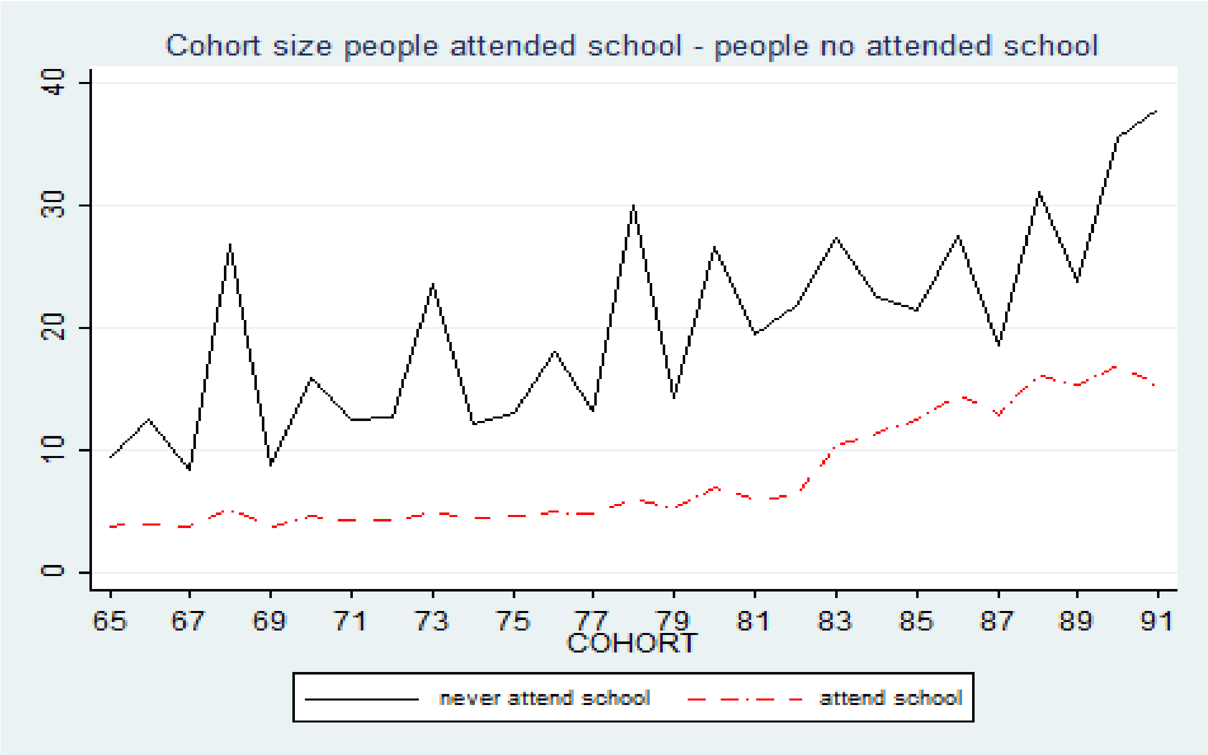


Note: These graphs are computed on a sample of people that never moved from the place they live in 1998. Moreover, people that live in Bamako are excluded from the sample.

COHORT identifies the birth of year i.e COHORT 1981 identifies individuals born in 1981, allowed to enter school from 1988 (7 years old) and aged 17 in 1998, year of data collection used for our calculations.

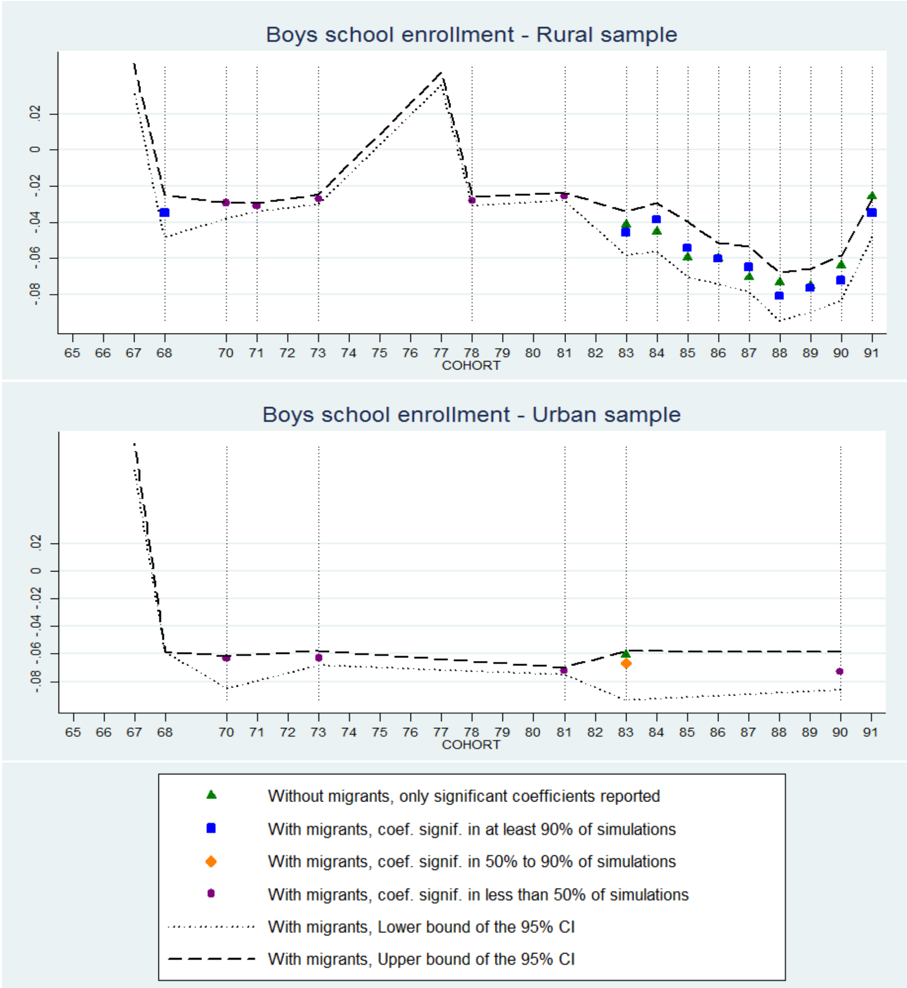
Source: Malian Population Census data, 1998, our own calculation.

Figure 6: Cohort size, 1965-1991, Rural Mali



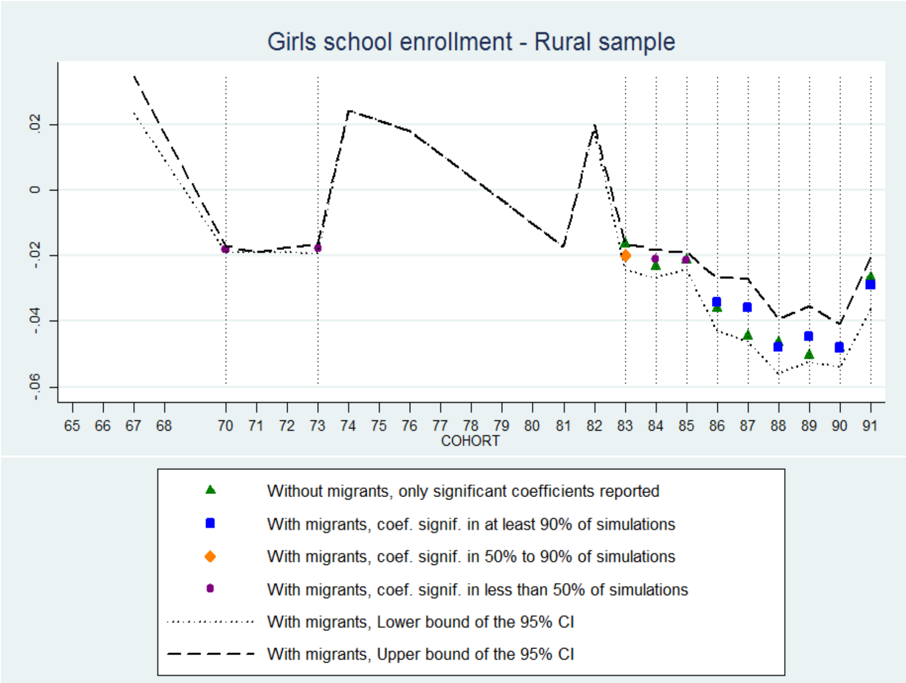
Source: Malian Population Census data, 1998, our own calculation.

Figure 7: Coefficients comparison - Samples with and without migrants



Note: Simulations randomly assign migrants in a locality belonging to their birth *cercle*, weighted by its relative population within *cercle*. Simulations are performed 40 times.
Cohort reference : 1969.
Source: Malian Population Census data, 1998, our own calculation.

Figure 8: Coefficients comparison - Samples with and without migrants



Note: Simulations randomly assign migrants in a locality belonging to their birth *cercle*, weighted by its relative population within *cercle*. Simulations are performed 40 times.
Cohort reference : 1969.
Graph for urban girls not shown due to lack of significant coefficients.
Source: Malian Population Census data, 1998, our own calculation.

Table 1: Breakdown of the sample according to urban and rural areas$^{(a)}$.

	Locust localities /Treatment group	Other localities /Control group	Total
Urban localities	74 (168)	263 (113)	337 (125)
Rural localities	886 (24)	8,761 (22)	9,647 (22)
Total	960 (35)	9,024 (25)	9,984 (26)

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

Table 2: Number of treated and controlled rural localities and average number of individuals by cohort.

Cohort	Locust localities /Treatment group	Other localities /Control group	Total
1991	881 (26)	8,783 (25)	9,664 (25)
1990	883 (25)	8,775 (24)	9,658 (25)
1989	858 (16)	8,683 (17)	9,541 (17)
1988	886 (24)	8,761 (22)	9,647 (22)
1987	805 (12)	8,563 (14)	9,368 (14)
1986	864 (20)	8,677 (20)	9,541 (20)
1985	825 (15)	8,639 (14)	9,464 (15)
1984	834 (15)	8,615 (15)	9,449 (15)
1983	869 (17)	8,725 (20)	9,594 (18)
1982	832 (14)	8,589 (14)	9,421 (14)
1981	827 (12)	8,522 (12)	9,349 (12)
1980	868 (17)	8,668 (16)	9,536 (16)
1979	752 (8)	8,194 (9)	8,946 (9)
1978	878 (22)	8,701 (17)	9,579 (17)
1977	715 (7)	8,004 (8)	8,719 (8)

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

Table 2 continued

Cohort	Locust localities /Treatment group	Other localities /Control group	Total
1976	835 (10)	8,471 (11)	9,306 (11)
1975	753 (7)	8,147 (8)	8,900 (8)
1974	742 (7)	7,954 (7)	8,696 (7)
1973	870 (19)	8,576 (13)	9,446 (14)
1972	765 (7)	8,136 (7)	8,901 (7)
1971	782 (7)	8,151 (7)	8,933 (7)
1970	817 (10)	8,370 (9)	9,187 (9)
1969	668 (5)	7,399 (5)	8,067 (5)
1968	877 (23)	8,670 (15)	9,547 (15)
1967	611 (5)	7,273 (5)	7,884 (5)
1966	805 (8)	8,151 (7)	8,956 (7)
1965	680 (5)	7,593 (6)	8,273 (6)

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

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

	(1)	(2)	(3)	(4)	(5)	(6)
	School enrol.	Grade att.	Prim. l. achie.	School enrol.	Grade att.	Prim. l. achie.
	Boys	Boys	Boys	Girls	Girls	Girls
Born in locust loc. year 91	-0.0257**	-0.00551		-0.0267***	-0.524***	
	(0.0108)	(0.171)		(0.00660)	(0.192)	
Born in locust loc. year 90	-0.0639***	-0.00306		-0.0482***	-0.415**	
	(0.0108)	(0.170)		(0.00715)	(0.192)	
Born in locust loc. year 89	-0.0752***	-0.0273		-0.0504***	-0.339*	
	(0.0112)	(0.170)		(0.00787)	(0.190)	
Born in locust loc. year 88	-0.0731***	0.0610		-0.0464***	-0.431**	
	(0.0110)	(0.170)		(0.00713)	(0.185)	
Born in locust loc. year 87	-0.0705***	-0.0262		-0.0445***	-0.320	
	(0.0118)	(0.170)		(0.00835)	(0.198)	
Born in locust loc. year 86	-0.0600***	-0.00735		-0.0359***	-0.418**	
	(0.0115)	(0.169)		(0.00731)	(0.189)	
Born in locust loc. year 85	-0.0593***	-0.137	-0.0228	-0.0213***	-0.572***	-0.0119
	(0.0108)	(0.175)	(0.0228)	(0.00761)	(0.198)	(0.0282)
Born in locust loc. year 84	-0.0453***	-0.106	-0.0214	-0.0233***	-0.631***	-0.0613**
	(0.0115)	(0.176)	(0.0264)	(0.00694)	(0.200)	(0.0309)
Born in locust loc. year 83	-0.0411***	-0.257	-0.0366	-0.0164***	-0.582***	-0.0517*
	(0.0104)	(0.173)	(0.0263)	(0.00615)	(0.195)	(0.0303)
Born in locust loc. year 82	0.00254	-0.203	-0.0521	0.00299	-0.801***	-0.0804**
	(0.0103)	(0.202)	(0.0357)	(0.00586)	(0.225)	(0.0401)
Born in locust loc. year 81	-0.00754	-0.433**	-0.160***	-0.00195	-1.036***	-0.132***
	(0.00987)	(0.198)	(0.0381)	(0.00606)	(0.222)	(0.0404)
Born in locust loc. year 80	0.000101	-0.351*	-0.105***	0.00578	-0.615***	-0.111***
	(0.0104)	(0.189)	(0.0341)	(0.00588)	(0.211)	(0.0347)
Born in locust loc. year 79	-0.00239	-0.233	-0.0577	0.00254	-0.471**	-0.0663
	(0.0112)	(0.195)	(0.0395)	(0.00639)	(0.208)	(0.0456)
Born in locust loc. year 78	-0.00756	-0.0696	-0.0400	-0.00157	-0.454**	-0.0185
	(0.00997)	(0.177)	(0.0335)	(0.00551)	(0.221)	(0.0377)
Born in locust loc. year 77	0.00616	0.0274	-0.0227	-0.00493	-0.294	0.0295
	(0.0118)	(0.202)	(0.0408)	(0.00684)	(0.256)	(0.0574)

Table 3 continued.

	(1)	(2)	(3)	(4)	(5)	(6)
	School enrol.	Grade att.	Prim. l. achie.	School enrol.	Grade att.	Prim. l. achie.
	Boys	Boys	Boys	Girls	Girls	Girls
Born in locust loc. year 76	-0.00526	0.0850	-0.00403	0.00446	-0.371	0.00121
	(0.0107)	(0.198)	(0.0410)	(0.00595)	(0.226)	(0.0413)
Born in locust loc. year 75	-0.00383	0.0179	-0.0207	-0.00584	-0.420*	0.0207
	(0.0117)	(0.206)	(0.0425)	(0.00614)	(0.244)	(0.0508)
Born in locust loc. year 74	-0.0100	0.0119	-0.0305	0.000733	-0.218	0.00261
	(0.0113)	(0.205)	(0.0437)	(0.00687)	(0.237)	(0.0534)
Born in locust loc. year 73	-8.86e-05	0.0376	-0.00740	-0.00220	-0.431**	-0.0257
	(0.0107)	(0.188)	(0.0342)	(0.00563)	(0.213)	(0.0418)
Born in locust loc. year 72	0.00387	0.283	0.0424	-0.00722	-0.482**	-0.0784*
	(0.0116)	(0.203)	(0.0460)	(0.00622)	(0.243)	(0.0464)
Born in locust loc. year 71	-0.0128	0.166	0.0712	-0.00380	-0.332	-0.0580
	(0.0114)	(0.197)	(0.0471)	(0.00631)	(0.235)	(0.0491)
Born in locust loc. year 70	-0.0100	0.102	0.0169	-0.00562	-0.386	0.0316
	(0.0109)	(0.187)	(0.0392)	(0.00588)	(0.243)	(0.0475)
Born in locust loc. year 68	-0.0138	-0.149	-0.0204	0.00140	-0.360*	0.0454
	(0.0105)	(0.188)	(0.0365)	(0.00581)	(0.207)	(0.0379)
Born in locust loc. year 67	-0.00659	-0.145	-0.0559	0.0134	-0.455*	-0.0159
	(0.0137)	(0.211)	(0.0460)	(0.00889)	(0.242)	(0.0577)
Born in locust loc. year 66	-0.000622	0.137	0.0241	0.00175	0.133	0.124**
	(0.0112)	(0.195)	(0.0403)	(0.00665)	(0.238)	(0.0556)
Born in locust loc. year 65	-0.00945	-0.173	-0.0348	0.0122	-0.176	0.0781
	(0.0125)	(0.229)	(0.0479)	(0.00906)	(0.257)	(0.0584)
Constant	0.122***	4.365***	0.427***	0.0429***	3.910***	0.302***
	(0.00313)	(0.0461)	(0.0143)	(0.00193)	(0.0621)	(0.0181)
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	220,684	74,540	51,602	227,963	50,099	32,568
Number of localities	9,771	7,480	7,047	9,772	6,652	6,000
R^2	0.082	0.434	0.104	0.090	0.363	0.059

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

Robust standard errors in parentheses.

Cohort of reference: 1969.

Observations correspond to number of Cohorts times number of localities.

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)
	School enrol.	Grade att.	Prim. l. achie.	School enrol.	Grade att.	Prim. l. achie.
	Boys	Boys	Boys	Girls	Girls	Girls
Born in locust loc. year 91	-0.0120	0.0317		0.00537	0.430**	
	(0.0300)	(0.167)		(0.0231)	(0.206)	
Born in locust loc. year 90	-0.0480	0.0260		0.0163	0.395**	
	(0.0310)	(0.164)		(0.0269)	(0.197)	
Born in locust loc. year 89	-0.0174	-0.00790		0.0333	0.372*	
	(0.0330)	(0.169)		(0.0269)	(0.191)	
Born in locust loc. year 88	-0.0189	-0.0824		-0.0116	0.282	
	(0.0297)	(0.163)		(0.0252)	(0.200)	
Born in locust loc. year 87	-0.0180	-0.0932		0.0356	0.225	
	(0.0332)	(0.168)		(0.0274)	(0.203)	
Born in locust loc. year 86	-0.00171	-0.189		0.00197	0.172	
	(0.0317)	(0.158)		(0.0265)	(0.192)	
Born in locust loc. year 85	-0.00397	-0.190	-0.0353	0.0279	0.343*	0.0682**
	(0.0333)	(0.168)	(0.0297)	(0.0248)	(0.193)	(0.0313)
Born in locust loc. year 84	-0.0158	-0.327*	-0.0740**	0.0146	0.138	0.0198
	(0.0346)	(0.178)	(0.0322)	(0.0246)	(0.231)	(0.0353)
Born in locust loc. year 83	-0.0604**	-0.256	-0.0569	-0.00653	0.258	0.0494
	(0.0294)	(0.167)	(0.0351)	(0.0218)	(0.209)	(0.0369)
Born in locust loc. year 82	-0.0105	-0.107	-0.0486	0.00762	0.225	0.000368
	(0.0323)	(0.176)	(0.0432)	(0.0226)	(0.208)	(0.0448)
Born in locust loc. year 81	-0.0336	-0.168	-0.0561	0.0213	0.380*	0.0431
	(0.0328)	(0.172)	(0.0426)	(0.0205)	(0.211)	(0.0457)
Born in locust loc. year 80	0.0130	-0.197	-0.0716*	0.00510	0.206	0.0500
	(0.0309)	(0.176)	(0.0385)	(0.0212)	(0.197)	(0.0380)
Born in locust loc. year 79	0.00153	-0.0305	-0.0139	0.0276	0.126	-0.00292
	(0.0310)	(0.166)	(0.0367)	(0.0271)	(0.179)	(0.0428)
Born in locust loc. year 78	-0.0242	-0.234	-0.0729*	-0.00794	0.252	0.00780
	(0.0297)	(0.176)	(0.0389)	(0.0212)	(0.181)	(0.0401)
Born in locust loc. year 77	0.0231	-0.184	-0.0602	0.0140	0.379	0.0448
	(0.0341)	(0.172)	(0.0464)	(0.0232)	(0.233)	(0.0463)

Table 4 continued.

	(1) School enrol. Boys	(2) Grade att. Boys	(3) Prim. l. achie. Boys	(4) School enrol. Girls	(5) Grade att. Girls	(6) Prim. l. achie. Girls
Born in locust loc. year 76	-0.0109	-0.127	-0.0279	0.00142	0.191	-0.00193
	(0.0336)	(0.193)	(0.0464)	(0.0205)	(0.186)	(0.0388)
Born in locust loc. year 75	0.00398	-0.152	-0.0315	0.00270	0.221	0.0232
	(0.0325)	(0.209)	(0.0489)	(0.0209)	(0.220)	(0.0415)
Born in locust loc. year 74	-0.00285	-0.209	-0.0864*	0.0175	0.262	0.0267
	(0.0291)	(0.175)	(0.0442)	(0.0249)	(0.246)	(0.0475)
Born in locust loc. year 73	-0.0235	-0.0617	0.0202	0.00516	0.264	0.0270
	(0.0258)	(0.151)	(0.0395)	(0.0201)	(0.212)	(0.0411)
Born in locust loc. year 72	-0.00136	0.0453	-0.00442	0.0159	0.164	0.0327
	(0.0304)	(0.188)	(0.0447)	(0.0204)	(0.236)	(0.0432)
Born in locust loc. year 71	-0.000529	-0.174	-0.0452	-0.0110	0.258	0.0558
	(0.0322)	(0.185)	(0.0429)	(0.0231)	(0.227)	(0.0487)
Born in locust loc. year 70	-0.0431	-0.372**	-0.0663	-0.00572	0.283	0.0377
	(0.0307)	(0.188)	(0.0437)	(0.0205)	(0.231)	(0.0482)
Born in locust loc. year 68	-0.00449	0.102	-0.000869	0.00722	0.114	0.0272
	(0.0278)	(0.183)	(0.0408)	(0.0222)	(0.200)	(0.0411)
Born in locust loc. year 67	0.0393	0.0546	0.0480	0.0203	0.309	0.115**
	(0.0342)	(0.210)	(0.0507)	(0.0229)	(0.231)	(0.0519)
Born in locust loc. year 66	0.00421	-0.153	-0.0460	-0.00568	0.105	-0.00328
	(0.0323)	(0.184)	(0.0430)	(0.0221)	(0.188)	(0.0440)
Born in locust loc. year 65	0.0452	-0.161	0.00305	0.0207	0.251	0.0287
	(0.0342)	(0.181)	(0.0446)	(0.0240)	(0.208)	(0.0475)
Constant	0.325***	4.969***	0.608***	0.235***	4.849***	0.572***
	(0.0111)	(0.0805)	(0.0262)	(0.0101)	(0.0866)	(0.0256)
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	8,685	6,904	5,465	8,770	6,548	5,167
Number of localities	340	317	310	340	314	307
R^2	0.322	0.719	0.291	0.414	0.637	0.206

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

Robust standard errors in parentheses.

Cohort of reference: 1969.

Observations correspond to number of Cohorts times number of localities.

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

Table 5: Migrants characteristics and divergences between samples.

	Rural localities				Urban localities			
	Cohorts 1980-1991		Cohorts 1965-1979		Cohorts 1980-1991		Cohorts 1965-1979	
	Locust affected	Non affected	Locust affected	Non affected	Locust affected	Non affected	Locust affected	Non affected
MALES								
Migrants population	6 534	58 248	9 286	87 050	3 992	11 520	5 966	16 061
Non migrants population	95 681	938 251	50 626	492 592	63 791	158 735	36 903	90 286
Average nb of migrants per loc.	1.7	1.53	1.8	1.63	5.5	4.7	6.5	5.2
Average nb of non mig. per loc.	9.8	9.3	5.1	4.6	76.2	47.9	34.4	23.2
Migrants school enrollment	0.43	0.42	0.3	0.3	0.495	0.449	0.35	0.33
Non migrants school enrol.	0.094	0.18	0.07	0.105	0.47	0.48	0.33	0.32
Signif. diff. btw mig. of locust affected and non affected loc.$^{(a)}$	6	.$^{(b)}$	0	.$^{(b)}$	38	.$^{(b)}$	0	.$^{(b)}$
Signif. diff. btw migrants and non migrants$^{(c)}$	40	40	40	40	6	36	19	1
FEMALES								
Migrants population	6 751	65 697	9 661	85 896	4 273	13 046	6 082	16 228
Non migrants population	90 774	894 796	71 525	611 865	62 437	152 279	43 839	98 650
Average nb of migrants per loc.	1.7	1.6	1.9	1.6	5.9	5.2	6.6	5.2
Average nb of non mig. per loc.	9.4	9	6.8	5.5	70.4	46.1	40.5	25
Migrants school enrollment	0.31	0.27	0.19	0.17	0.36	0.31	0.22	0.19
Non migrants school enrol.	0.06	0.1	0.03	0.04	0.36	0.36	0.21	0.21
Signif. diff. btw mig. of locust affected and non affected loc.$^{(a)}$	40	.$^{(b)}$	40	.$^{(b)}$	37	.$^{(b)}$	30	.$^{(b)}$
Signif. diff. btw migrants and non migrants$^{(c)}$	40	40	40	40	1	40	2	30

(a): t-test is performed on every 40 migrants reallocation simulations. Are reported the number of significant differences, over 40 simulations, between migrants average school enrollment of locust affected and non affected villages.
(b): t-test is performed over locust affected and non affected villages. t-value is reported in the locust affected column.
(c): t-test is performed on every 40 migrants reallocation simulations. Are reported the number of significant diff., over 40 simulations, between average sch. enroll. of migrants
(c): and non migrants.

Table 6: Impact of locust invasion on school enrol. controlling for school trends, boys, Rural localities.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	School enrol.	School enrol.	Grade att.	Grade att.	Prim. l. achie.	Prim. l. achie.
Nber of Schools p. 10,000 inh.		0.176***		0.310***		0.0975*
		(0.0377)		(0.118)		(0.0564)
Born in locust loc. year 91	-0.0300**	-0.0277**	0.0582	0.0612		
	(0.0125)	(0.0124)	(0.180)	(0.180)		
Born in locust loc. year 90	-0.0652***	-0.0631***	0.0591	0.0616		
	(0.0124)	(0.0124)	(0.178)	(0.178)		
Born in locust loc. year 89	-0.0749***	-0.0754***	0.0542	0.0518		
	(0.0130)	(0.0130)	(0.180)	(0.179)		
Born in locust loc. year 88	-0.0754***	-0.0757***	0.131	0.129		
	(0.0126)	(0.0126)	(0.179)	(0.179)		
Born in locust loc. year 87	-0.0677***	-0.0683***	0.0496	0.0475		
	(0.0136)	(0.0136)	(0.180)	(0.180)		
Born in locust loc. year 86	-0.0694***	-0.0700***	0.0974	0.0953		
	(0.0129)	(0.0129)	(0.176)	(0.176)		
Born in locust loc. year 85	-0.0604***	-0.0609***	-0.0216	-0.0233	-0.0180	-0.0182
	(0.0125)	(0.0124)	(0.183)	(0.182)	(0.0245)	(0.0245)
Born in locust loc. year 84	-0.0527***	-0.0532***	-0.0674	-0.0690	-0.0146	-0.0147
	(0.0130)	(0.0130)	(0.184)	(0.183)	(0.0283)	(0.0283)
Born in locust loc. year 83	-0.0507***	-0.0514***	-0.174	-0.175	-0.0322	-0.0322
	(0.0121)	(0.0121)	(0.181)	(0.181)	(0.0288)	(0.0288)
Born in locust loc. year 82	-0.00696	-0.00748	-0.0594	-0.0606	-0.0448	-0.0448
	(0.0118)	(0.0117)	(0.207)	(0.207)	(0.0381)	(0.0381)
Born in locust loc. year 81	-0.0174	-0.0178	-0.351*	-0.352*	-0.157***	-0.157***
	(0.0114)	(0.0114)	(0.200)	(0.200)	(0.0405)	(0.0405)
Born in locust loc. year 80	-0.0113	-0.0114	-0.240	-0.241	-0.105***	-0.105***
	(0.0120)	(0.0120)	(0.196)	(0.196)	(0.0369)	(0.0368)
Born in locust loc. year 79	-0.0145	-0.0152	-0.132	-0.133	-0.0524	-0.0522
	(0.0126)	(0.0126)	(0.208)	(0.208)	(0.0427)	(0.0427)
Born in locust loc. year 78	-0.0176	-0.0180	-0.0480	-0.0485	-0.0451	-0.0448
	(0.0117)	(0.0116)	(0.180)	(0.180)	(0.0363)	(0.0363)
Born in locust loc. year 77	0.00126	0.000799	0.0530	0.0524	-0.0181	-0.0179
	(0.0136)	(0.0136)	(0.212)	(0.212)	(0.0434)	(0.0434)

Table 6 continued.

VARIABLES	(1) School enrol.	(2) School enrol.	(3) Grade att.	(4) Grade att.	(5) Prim. l. achie.	(6) Prim. l. achie.
Born in locust loc. year 76	-0.0204*	-0.0209*	0.0828	0.0817	0.00327	0.00341
	(0.0119)	(0.0119)	(0.205)	(0.205)	(0.0438)	(0.0437)
Born in locust loc. year 75	-0.0134	-0.0137	0.0552	0.0559	-0.0103	-0.00979
	(0.0133)	(0.0133)	(0.217)	(0.217)	(0.0453)	(0.0454)
Born in locust loc. year 74	-0.0233*	-0.0236*	0.138	0.138	-0.0119	-0.0114
	(0.0128)	(0.0128)	(0.215)	(0.215)	(0.0477)	(0.0477)
Born in locust loc. year 73	-0.0108	-0.0112	0.0635	0.0630	-0.00156	-0.00123
	(0.0124)	(0.0124)	(0.198)	(0.198)	(0.0366)	(0.0366)
Born in locust loc. year 72	-0.0116	-0.0118	0.368*	0.368*	0.0420	0.0426
	(0.0130)	(0.0130)	(0.217)	(0.217)	(0.0507)	(0.0507)
Born in locust loc. year 71	-0.0247*	-0.0249*	0.262	0.263	0.0893*	0.0899*
	(0.0132)	(0.0132)	(0.206)	(0.206)	(0.0511)	(0.0511)
Born in locust loc. year 70	-0.0198	-0.0200	0.122	0.123	0.0155	0.0161
	(0.0125)	(0.0125)	(0.194)	(0.194)	(0.0418)	(0.0418)
Born in locust loc. year 68	-0.0199	-0.0198	-0.0344	-0.0335	0.00177	0.00239
	(0.0122)	(0.0122)	(0.195)	(0.195)	(0.0388)	(0.0388)
Born in locust loc. year 67	-0.0149	-0.0149	-0.0608	-0.0589	-0.0550	-0.0541
	(0.0156)	(0.0156)	(0.220)	(0.220)	(0.0486)	(0.0486)
Born in locust loc. year 66	-0.00706	-0.00708	0.200	0.201	0.0351	0.0359
	(0.0131)	(0.0131)	(0.205)	(0.204)	(0.0432)	(0.0432)
Born in locust loc. year 65	-0.0113	-0.0113	-0.161	-0.162	-0.0412	-0.0408
	(0.0143)	(0.0143)	(0.235)	(0.235)	(0.0505)	(0.0505)
Constant	0.123***	0.120***	4.338***	4.329***	0.422***	0.419***
	(0.00329)	(0.00332)	(0.0416)	(0.0417)	(0.0151)	(0.0151)
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	197,532	197,532	67,336	67,336	46,713	46,713
Number of localities	8,671	8,671	6,698	6,698	6,317	6,317
R^2	0.082	0.083	0.434	0.434	0.103	0.103

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

Robust standard errors in parentheses.

Cohort of reference: 1969.

Observations correspond to number of Cohorts times number of localities.

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

Table 7: Impact of locust invasion on school enrol. controlling for schools, girls, Rural localities.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	School enrol.	School enrol.	Grade att.	Grade att.	Prim. l. achie.	Prim. l. achie.
Nber of Schools p. 10,000 inh.		0.172***		0.148		-0.0522
		(0.0342)		(0.186)		(0.0963)
Born in locust loc. year 91	-0.0252***	-0.0229***	-0.487**	-0.486**		
	(0.00740)	(0.00736)	(0.199)	(0.198)		
Born in locust loc. year 90	-0.0485***	-0.0463***	-0.378*	-0.377*		
	(0.00799)	(0.00796)	(0.198)	(0.198)		
Born in locust loc. year 89	-0.0458***	-0.0463***	-0.274	-0.276		
	(0.00882)	(0.00879)	(0.195)	(0.194)		
Born in locust loc. year 88	-0.0419***	-0.0422***	-0.388**	-0.390**		
	(0.00813)	(0.00812)	(0.190)	(0.190)		
Born in locust loc. year 87	-0.0428***	-0.0433***	-0.250	-0.252		
	(0.00942)	(0.00940)	(0.206)	(0.205)		
Born in locust loc. year 86	-0.0340***	-0.0346***	-0.361*	-0.363*		
	(0.00841)	(0.00841)	(0.197)	(0.197)		
Born in locust loc. year 85	-0.0211**	-0.0215**	-0.490**	-0.491**	0.00450	0.00473
	(0.00850)	(0.00849)	(0.202)	(0.202)	(0.0298)	(0.0298)
Born in locust loc. year 84	-0.0235***	-0.0239***	-0.596***	-0.597***	-0.0703**	-0.0701**
	(0.00780)	(0.00778)	(0.204)	(0.204)	(0.0315)	(0.0315)
Born in locust loc. year 83	-0.0207***	-0.0212***	-0.569***	-0.571***	-0.0485	-0.0485
	(0.00670)	(0.00670)	(0.199)	(0.199)	(0.0320)	(0.0320)
Born in locust loc. year 82	0.00375	0.00332	-0.713***	-0.714***	-0.0701	-0.0700
	(0.00673)	(0.00673)	(0.235)	(0.235)	(0.0431)	(0.0431)
Born in locust loc. year 81	-0.00164	-0.00201	-1.056***	-1.057***	-0.139***	-0.139***
	(0.00691)	(0.00690)	(0.230)	(0.230)	(0.0424)	(0.0424)
Born in locust loc. year 80	0.00160	0.00157	-0.592***	-0.593***	-0.115***	-0.115***
	(0.00670)	(0.00669)	(0.218)	(0.218)	(0.0377)	(0.0377)
Born in locust loc. year 79	0.000463	1.93e-05	-0.408*	-0.410*	-0.0469	-0.0467
	(0.00724)	(0.00724)	(0.215)	(0.215)	(0.0494)	(0.0494)
Born in locust loc. year 78	-0.00298	-0.00335	-0.480**	-0.482**	-0.0146	-0.0145
	(0.00627)	(0.00627)	(0.228)	(0.228)	(0.0401)	(0.0401)
Born in locust loc. year 77	-0.00680	-0.00707	-0.343	-0.344	0.0243	0.0243
	(0.00771)	(0.00771)	(0.267)	(0.266)	(0.0599)	(0.0599)

Table 7 continued.

VARIABLES	(1) School enrol.	(2) School enrol.	(3) Grade att.	(4) Grade att.	(5) Prim. l. achie.	(6) Prim. l. achie.
Born in locust loc. year 76	0.00407	0.00370	-0.428*	-0.429*	-0.0185	-0.0186
	(0.00690)	(0.00691)	(0.232)	(0.232)	(0.0433)	(0.0433)
Born in locust loc. year 75	-0.00830	-0.00858	-0.304	-0.305	0.0351	0.0349
	(0.00695)	(0.00698)	(0.254)	(0.253)	(0.0536)	(0.0536)
Born in locust loc. year 74	-0.000633	-0.000892	-0.214	-0.214	0.0112	0.0109
	(0.00784)	(0.00785)	(0.252)	(0.252)	(0.0573)	(0.0573)
Born in locust loc. year 73	-0.00554	-0.00580	-0.394*	-0.394*	-0.0167	-0.0169
	(0.00646)	(0.00646)	(0.214)	(0.214)	(0.0433)	(0.0433)
Born in locust loc. year 72	-0.0103	-0.0105	-0.297	-0.298	-0.0481	-0.0483
	(0.00687)	(0.00688)	(0.251)	(0.251)	(0.0516)	(0.0516)
Born in locust loc. year 71	-0.00504	-0.00522	-0.279	-0.279	-0.0460	-0.0464
	(0.00715)	(0.00716)	(0.242)	(0.242)	(0.0503)	(0.0503)
Born in locust loc. year 70	-0.00720	-0.00743	-0.340	-0.340	0.0505	0.0502
	(0.00674)	(0.00675)	(0.258)	(0.258)	(0.0518)	(0.0518)
Born in locust loc. year 68	0.00317	0.00334	-0.376*	-0.376*	0.0360	0.0356
	(0.00662)	(0.00661)	(0.212)	(0.212)	(0.0397)	(0.0398)
Born in locust loc. year 67	0.0154	0.0153	-0.488*	-0.489*	-0.0369	-0.0373
	(0.0101)	(0.0101)	(0.252)	(0.252)	(0.0590)	(0.0590)
Born in locust loc. year 66	0.000759	0.000794	0.0377	0.0373	0.0767	0.0764
	(0.00769)	(0.00768)	(0.253)	(0.253)	(0.0591)	(0.0591)
Born in locust loc. year 65	0.0105	0.0104	-0.130	-0.132	0.0960	0.0961
	(0.00998)	(0.00999)	(0.272)	(0.272)	(0.0625)	(0.0625)
Constant	0.0433***	0.0412***	3.925***	3.920***	0.315***	0.317***
	(0.00202)	(0.00206)	(0.0569)	(0.0573)	(0.0191)	(0.0196)
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	204,020	204,020	45,336	45,336	29,537	29,537
Number of localities	8,672	8,672	5,993	5,993	5,398	5,398
R-squared	0.090	0.092	0.362	0.362	0.058	0.058

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

Robust standard errors in parentheses.

Cohort of reference: 1969.

Observations correspond to number of Cohorts times number of localities.

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

Table 8: Robustness test: sample year cut-off, School enrollment rate, Rural localities.

	Boys				Girls			
	Coh. 91 - 66	Coh. 91- 67	Coh. 91 - 68	Coh. 91 - 69	Coh. 91 - 66	Coh. 91 - 67	Coh. 91 - 68	Coh. 91 - 69
Born in locust loc. year 91	-0.0259**	-0.0258**	-0.0256**	-0.0234**	-0.0270***	-0.0269***	-0.0272***	-0.0255***
	(0.0108)	(0.0108)	(0.0108)	(0.0108)	(0.00660)	(0.00661)	(0.00662)	(0.00664)
Born in locust loc. year 90	-0.0639***	-0.0635***	-0.0621***	-0.0609***	-0.0480***	-0.0481***	-0.0474***	-0.0469***
	(0.0108)	(0.0108)	(0.0108)	(0.0108)	(0.00715)	(0.00716)	(0.00716)	(0.00719)
Born in locust loc. year 89	-0.0737***	-0.0727***	-0.0725***	-0.0705***	-0.0498***	-0.0495***	-0.0494***	-0.0481***
	(0.0112)	(0.0112)	(0.0112)	(0.0112)	(0.00787)	(0.00788)	(0.00789)	(0.00792)
Born in locust loc. year 88	-0.0721***	-0.0712***	-0.0704***	-0.0688***	-0.0458***	-0.0456***	-0.0448***	-0.0438***
	(0.0110)	(0.0111)	(0.0111)	(0.0111)	(0.00713)	(0.00715)	(0.00716)	(0.00718)
Born in locust loc. year 87	-0.0703***	-0.0687***	-0.0676***	-0.0663***	-0.0445***	-0.0443***	-0.0439***	-0.0427***
	(0.0118)	(0.0118)	(0.0118)	(0.0118)	(0.00835)	(0.00836)	(0.00837)	(0.00838)
Born in locust loc. year 86	-0.0593***	-0.0582***	-0.0577***	-0.0564***	-0.0354***	-0.0352***	-0.0343***	-0.0332***
	(0.0115)	(0.0115)	(0.0115)	(0.0115)	(0.00731)	(0.00732)	(0.00733)	(0.00734)
Born in locust loc. year 85	-0.0583***	-0.0569***	-0.0570***	-0.0543***	-0.0208***	-0.0203***	-0.0198***	-0.0181**
	(0.0108)	(0.0109)	(0.0109)	(0.0109)	(0.00761)	(0.00762)	(0.00762)	(0.00762)
Born in locust loc. year 84	-0.0440***	-0.0429***	-0.0419***	-0.0394***	-0.0225***	-0.0219***	-0.0208***	-0.0194***
	(0.0115)	(0.0115)	(0.0115)	(0.0116)	(0.00694)	(0.00694)	(0.00695)	(0.00700)
Born in locust loc. year 83	-0.0404***	-0.0386***	-0.0369***	-0.0360***	-0.0160***	-0.0150**	-0.0143**	-0.0139**
	(0.0104)	(0.0104)	(0.0104)	(0.0105)	(0.00614)	(0.00615)	(0.00615)	(0.00616)
Born in locust loc. year 82	0.00446	0.00488	0.00482	0.00553	0.00401	0.00393	0.00404	0.00453
	(0.0103)	(0.0103)	(0.0103)	(0.0104)	(0.00585)	(0.00588)	(0.00588)	(0.00590)
Born in locust loc. year 81	-0.00762	-0.00751	-0.00816	-0.00767	-0.00178	-0.00190	-0.00158	-0.00114
	(0.00987)	(0.00988)	(0.00990)	(0.00992)	(0.00606)	(0.00607)	(0.00608)	(0.00609)
Born in locust loc. year 80	0.000694	0.00109	0.00110	0.00242	0.00611	0.00656	0.00645	0.00709
	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.00588)	(0.00590)	(0.00590)	(0.00592)
Born in locust loc. year 79	-0.00103	-0.000655	-6.07e-05	-0.000230	0.00312	0.00290	0.00327	0.00262
	(0.0112)	(0.0112)	(0.0112)	(0.0112)	(0.00639)	(0.00640)	(0.00641)	(0.00644)
Born in locust loc. year 78	-0.00681	-0.00701	-0.00749	-0.00729	-0.00138	-0.00158	-0.00214	-0.00181
	(0.00997)	(0.00998)	(0.00999)	(0.0100)	(0.00550)	(0.00551)	(0.00553)	(0.00555)
Born in locust loc. year 77	0.00637	0.00549	0.00499	0.00514	-0.00475	-0.00578	-0.00594	-0.00580
	(0.0118)	(0.0118)	(0.0118)	(0.0119)	(0.00683)	(0.00685)	(0.00687)	(0.00690)

Table 8 continued.

	Boys				Girls			
	Coh. 91 - 66	Coh. 91- 67	Coh. 91 - 68	Coh. 91 - 69	Coh. 91 - 66	Coh. 91 - 67	Coh. 91 - 68	Coh. 91 - 69
Born in locust loc. year 76	-0.00575	-0.00521	-0.00472	-0.00443	0.00409	0.00437	0.00426	0.00445
	(0.0107)	(0.0107)	(0.0107)	(0.0107)	(0.00596)	(0.00597)	(0.00598)	(0.00601)
Born in locust loc. year 75	-0.00270	-0.00309	-0.00348	-0.00273	-0.00529	-0.00556	-0.00615	-0.00558
	(0.0117)	(0.0117)	(0.0117)	(0.0118)	(0.00616)	(0.00616)	(0.00618)	(0.00621)
Born in locust loc. year 74	-0.0103	-0.0106	-0.0108	-0.0114	0.000985	0.000421	0.000419	0.000238
	(0.0113)	(0.0114)	(0.0114)	(0.0114)	(0.00687)	(0.00687)	(0.00688)	(0.00690)
Born in locust loc. year 73	7.90e-05	0.000257	-0.000108	0.000165	-0.00216	-0.00202	-0.00275	-0.00217
	(0.0107)	(0.0107)	(0.0107)	(0.0108)	(0.00563)	(0.00564)	(0.00566)	(0.00568)
Born in locust loc. year 72	0.00473	0.00452	0.00458	0.00438	-0.00675	-0.00714	-0.00704	-0.00708
	(0.0117)	(0.0117)	(0.0117)	(0.0117)	(0.00621)	(0.00623)	(0.00625)	(0.00628)
Born in locust loc. year 71	-0.0127	-0.0123	-0.0128	-0.0127	-0.00402	-0.00416	-0.00465	-0.00424
	(0.0114)	(0.0114)	(0.0114)	(0.0115)	(0.00630)	(0.00631)	(0.00632)	(0.00634)
Born in locust loc. year 70	-0.00936	-0.00967	-0.00976	-0.00948	-0.00532	-0.00570	-0.00590	-0.00559
	(0.0109)	(0.0109)	(0.0109)	(0.0109)	(0.00588)	(0.00587)	(0.00589)	(0.00591)
Born in locust loc. year 68	-0.0126	-0.0126	-0.0130		0.00198	0.00181	0.00139	
	(0.0105)	(0.0105)	(0.0105)		(0.00581)	(0.00582)	(0.00583)	
Born in locust loc. year 67	-0.00625	-0.00625			0.0137	0.0133		
	(0.0137)	(0.0137)			(0.00888)	(0.00889)		
Born in locust loc. year 66	-0.000765				0.00160			
	(0.0112)				(0.00665)			
Constant	0.123***	0.124***	0.124***	0.124***	0.0434***	0.0437***	0.0436***	0.0442***
	(0.00314)	(0.00315)	(0.00316)	(0.00317)	(0.00194)	(0.00196)	(0.00196)	(0.00199)
Rainfall control variables	yes	yes	yes	yes	yes	yes	yes	yes
Fixed effect locality	yes	yes	yes	yes	yes	yes	yes	yes
Fixed effect cohort	yes	yes	yes	yes	yes	yes	yes	yes
Observations	214,100	206,816	200,679	192,015	221,057	213,012	206,618	197,437
R-squared	0.085	0.088	0.092	0.095	0.091	0.092	0.095	0.095
Number of localities	9,771	9,771	9,770	9,763	9,772	9,771	9,771	9,769

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

Robust standard errors in parentheses.

Cohort of reference: 1969.

Observations correspond to number of Cohorts times number of localities.

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